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Volume 3

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Research Topics in Agricultural and Applied Economics

Volume 3

Editor

Anthony N. Rezitis

University of Western Greece

CONTENTS

FOREWORD

This volume of "Research Topics in Agricultural and Applied Economics," edited by Professor Anthony Rezitis, maintains the standards set in the previous two volumes by presenting 9 papers which report high quality applied economic research. Several of the papers adopt modern empirical approaches, such as neuro-fuzzy techniques, stochastic DEA, and choice experiments, while others are based on recent theoretical developments in the areas of new institutional economics, transaction cost economics, information and contract design. Most of the applications focus on the agricultural sector. These include 'traditional' topics, including the study of sector efficiency, the Common Agricultural Policy, and the agri-food chain, as well as the analysis of agri-environmental issues, such as waste disposal, the role of energy crops, and the governance of agro-ecosystem services. The volume concludes with two papers with a broader application, namely carbon offset projects and transportation infrastructure.

Readers should find much of value here, whether their interests lie in economic theory, applied techniques, policy issues or the details of the specific applications presented. The volume, together with its two predecessors, offers a very worthwhile contribution to the literature.

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PREFACE

The aim of the e-book series of *Research Topics in Agricultural & Applied Economics (RTAAE)* is to publish high quality economic research applied in both the agricultural and non-agricultural sectors of the economy. Subject matter areas of this e-book series include, among others, supply and demand analysis, technical change and productivity, industrial organization, labor economics, growth and development, environmental economics, marketing, business economics and finance. By covering a broad variety of economic research topics, this e-book series is addressed to a wide spectrum of an academic agricultural and applied economic researchers and scientists but it could also be useful to industry specialists and government policymakers. The present volume of *RTAAE (Vol. 3*) contains the following 9 chapters:

Chapter 1: entitled “Milk production forecasting by a neuro-fuzzy model”, uses a hybrid intelligent system called ANFIS (Adaptive Neuro Fuzzy Inference System) for predicting milk production. The results indicate the superiority of the ANFIS model when compared with the two conventional models: an Autoregressive (AR) and an Autoregressive Moving Average model (ARMA).

Chapter 2: entitled “The role of production contracts in the co-ordination of agri-food chain: evidence and future issues for the durum wheat chain in Italy”, explores the role of production contracts in the co-ordination of the agri-food chain, taking into account evidence from the particular case of the durum wheat chain in Italy.

Chapter 3: entitled “Effects of the European Union Farm Credit Programs on Efficiency and Productivity of the Greek Agricultural Sector: A Stochastic DEA Application”, examines technical efficiency and productivity growth of Greek farms participating in the 1994 European Union Farm Credit Programs using the approach developed by Simar and Wilson to bootstrapping both DEA efficiency measures and Malmquist productivity indices.

Chapter 4: entitled “Institutional Innovations in the Common Agricultural Policy: A Theoretical Approach based on Legitimacy”, analyzes the role of different exogenous and endogenous factors which have been boosted or slowed down by CAP reforms. The main results show that the EU institutional structure is a fundamental factor.

Chapter 5: entitled “Agricultural Externalities and Environmental Regulation: The Case of Manure Management and Spreading Land Allocation”, describes how the measures are introduced by the European regulation on manure management are incorporated into the theoretical analysis framework for studying the issue of nonpoint externality especially, agricultural runoff.

Chapter 6: entitled “Energy Crops Situation in Castile and Leon: Incentives and Barriers to Success”, examines the current situation and the possibilities of development energy crops by Castile and Leon farmers using the Rural Rapid Appraisal (RRA) and Strengths, Weaknesses, Opportunities, Threats (SWOT) methods.

Chapter 7: entitled “Governing of Agro-Ecosystem Services in Bulgaria”, incorporates interdisciplinary New Institutional and Transaction Costs Economics and analyzes the governance of agro-ecosystem services in Bulgaria.

Chapter 8: entitled “Ex Post Liability for Loss vs. Ex Ante Liability Insurance as Solutions to Reversal Risk in Carbon Offset Projects”, examines how *ex-post* liability rules and *ex ante* liability insurance requirements can affect the nature of contractual agreement between an investor and a host, and the induced level of effort under asymmetric information.

Chapter 9: entitled "A Choice Experiments Application in Transport Infrastructure: A Case Study on Travel Time Savings, Accidents and Pollution Reduction", presents the results of a Choice Experiment aiming to value different characteristics relating to the construction of a public highway in Greece.

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CHAPTER 1

Milk Production Forecasting by a Neuro-Fuzzy Model

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Abstract: Many fields are increasingly applying Neuro-fuzzy techniques such as in model identification and forecasting of linear and non-linear systems. This chapter presents a neuro-fuzzy model for forecasting milk production of two producers. The model utilizes a time series of daily data. The milk forecasting model is based on Adaptive Neural Fuzzy Inference System (ANFIS). ANFIS uses a hybrid learning technique that combines the least-squares method and the back propagation gradient descent method to estimate the optimal milk forecast parameters. The results indicate the superiority of ANFIS model when compared with two conventional models: an Autoregressive (AR) and an Autoregressive Moving Average model (ARMA).

Keywords: Milk forecasting, neuro-fuzzy, ANFIS, AR, ARMA, forecasting, milk production.

INTRODUCTION

The process of identifying and forecasting milk time series is a very complex one due to the unstable behavior brought about by environmental conditions. If we consider that milk production time series is only affected internally, the future production can be forecasted by the following formula (1):

$$y_{t+1} = f(y_{t-k}, \ldots.., y_t) \qquad \textbf{(1)}$$

where y_{t+1} is the rate to be predicted and y_{t-k} is the influence factor. Traditional models that have been used to forecast time series milk production are all based on the probability theory and statistical analysis with a certain number of distributions assumed in advance. In most cases these assumptions are unreasonable and non-realistic. Moreover the linear structure of these models does not guarantee accuracy of prediction.

Recent studies have addressed the problem of time series prediction by using different methods including artificial neural network and model based approaches due to the significant properties of handling non-linear data with self learning capabilities (Hornik, 1991; Jain, 1997; Skapura, 1996). The neural networks have been accused of being 'black boxes' by the researchers hence the degree that an input influences the output of the model cannot be known (Shapiro, 2002; Pao, 1989). Fuzzy logic is an effective rule-based modeling system applied in soft computing, that not only tolerates imprecise information, but also formulates a framework for approximate reasoning. The disadvantage of fuzzy logic is the lack of self learning capability. The combination of fuzzy logic and neural network can overcome the disadvantages of the above approaches. This chapter proposes the use of a hybrid intelligent system called ANFIS (Adaptive Neuro Fuzzy Inference System) for predicting milk production. ANFIS combines both the learning capabilities of a neural network and reasoning capabilities of fuzzy logic in order to provide enhanced prediction capabilities, as compared to using a single methodology alone. ANFIS has been used by many researchers to forecast various time series (Atsalakis G. & Atsalaki I., 2010; Atsalakis & Valavanis, 2009; Atsalakis, 2009; Atsalakis *et al.*, 2008; Atsalakis *et al.*, 2007; Atsalakis & Minoudaki, 2007; Atsalakis & Ucenic, 2006; Atsalakis, 2005; Jang *et al.*, 1997; Lucas, 2001, Ucenic & Atsalakis, 2008; Ucenic & Atsalakis, 2006).

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THEORETICAL BACKGROUND

One of the most important tests of any model is how well it forecasts. This can involve either in-sample or out-of-sample forecasts. Generally, the out-of-sample forecasts are viewed as the most informative, as the data used for the forecast is not included in the estimation of the model used for the forecast. Some of the most important forecasting models are the following:

ANFIS Model

A neuro-fuzzy system is defined as a combination of Artificial Neural Networks (ANN) and a Fuzzy Inference System (FIS) in such a way that neural network learning algorithms are used to determine the parameters of FIS (Jang, 1993; 1995). The Adaptive Neural Fuzzy Inference System (ANFIS) is a system that belongs to the neuro-fuzzy category.

Functionally, there are almost no constraints on the node functions of an adaptive network except piecewise differentiability. Structurally, the only limitation of network configuration is that it should be of feed forward type. Due to this minimal restriction, the adaptive network's applications are immediate and immense in various areas. In this section, we proposed a class of adaptive networks, which are functionally equivalent to fuzzy inference systems.

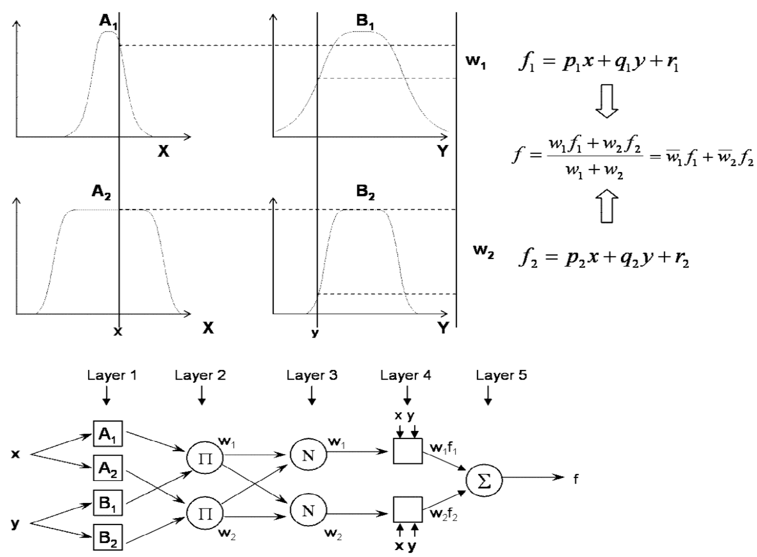

Figure 1: The reasoning mechanism for a Sugeno-type model and the corresponding ANFIS architecture (Jang, 1993).

For simplicity, it is assumed that the fuzzy inference system under consideration has two inputs x and y, and one output f. Suppose that the rule base contains two fuzzy if-then rules of Takagi and Sugenos' type (2, 3).

$$\text{Rule1: If } x \text{ is } A_1 \text{ and } y \text{ is } B_1 \text{ then } f_1 = p_1 \cdot x + q_1 \cdot y + r_1 \quad \textbf{(2)}$$

$$\text{Rule2: If } x \text{ is } A_2 \text{ and } y \text{ is } B_2 \text{ then } f_2 = p_2 \cdot x + q_2 \cdot y + r_2 \quad \textbf{(3)}$$

The ANFIS architecture and the reasoning mechanism are depicted in Fig. (**1**). The node functions in the same layer are of the same function family as described below:

Layer 1: node i in this layer is a square node with a node function (4).

$$O_i^1(x) = \mu_{A_i}(x) \quad \textbf{(4)}$$

where x = the input to node i A_i = the linguistic label (small, large, *etc.*) associated with this node function. In other words, O_i^1 is the membership function of A_i and it specifies the degree to which the given x satisfies the quantifier A_i. In this case $\mu_{A_i}(x)$ is trapezoidal-shaped with a maximum equal to 1 and a minimum equal to 0, such as the generalized trapezoidal function (5).

$$\mu_{A_i}(x) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right) \quad \textbf{(5)}$$

Where a_i, b_i, c_i, d_i is the parameter set. As the values of these parameters change, the trapezoidal-shaped functions vary accordingly, thus exhibiting various forms of the membership function on linguistic label A_i. Parameters in this layer are referred to as *premise parameters*.

Layer 2: Every node in this layer is a circle node labeled prod, which multiplies the incoming signal and sends the product out (6).

$$O_{2,i} = w_i = \mu_{Ai}(x) * \mu_{Bi}(y), \; i = 1, 2. \quad \textbf{(6)}$$

Layer 3: Every node in this layer is a circle node labeled N. The i-th node calculates the ratio of the i-th rules firing strength to the sum of all rules' firing strengths (7).

$$O_i^3 = \overline{w}_i = \frac{w_i}{w_1 + w_2}, \quad i = 1, 2. \quad \textbf{(7)}$$

For convenience, the output of this layer will be called the *normalized firing strengths.*

Layer 4: Every node i in this layer is a square node with a node function (8).

$$O_i^4(x) = \overline{w}_i \cdot f_i = \overline{w}_i(p_1 \cdot x + q_i \cdot y + r_i) \quad \textbf{(8)}$$

Where: $\overline{w}_i$ = the output of layer 3 $\{p_i, q_i, r_i\}$ - the parameter set. Parameters in this layer will be referred to as *consequent parameters*.

Layer 5: The single node in this layer is a circle node labelled sum that computes the overall output as the summation of all incoming signals (9).

$$O_i^5(x) = overalloutput \quad O_i^5(x) = \sum_i \overline{w}_i \cdot f_i = \frac{\sum_i w_i \cdot f_i}{\sum_i w_i} \quad \textbf{(9)}$$

Consider using all possible parameters whose number is a function of both the number of inputs and the number of membership functions which can then be defined as the number of all rules (10).

$$Rule_n = \prod_{i=1}^{I_{n_n}} M \cdot f_i \quad \textbf{(10)}$$

And if premispara$_n$ is the number of all parameters which are necessary for the membership function, then the number of all parameters is defined in (11).

$$para_n = premispara_n \sum_{i=1} I_{n_n} \cdot M \cdot f_i + Rule_n(I_{n_n} + 1) \quad \textbf{(11)}$$

AUTOREGRESSIVE MODEL

The autoregressive (AR) models are used in time series analysis to describe stationary time series. These models represent time series that are generated by passing the white noise through a recursive linear filter. The output of such a filter at the moment t is a weighted sum of m previous values of the filter output. The integer parameter m is called the order of the AR-model. The AR-model of a random process y(t) in discrete time t is defined by the following expression (12):

$$y(t) = \sum_{i=1}^{m} a(i) \cdot y(t-i) + \varepsilon(t) \qquad \textbf{(12)}$$

where α_1, α_2,..,α_m are the coefficients of the recursive filter, m is the order of the model and ε(t) are output uncorrelated errors.

The moving average (MA) models represent time-series that are generated by passing the white noise through a non-recursive linear filter. The MA-model of a random process y(t) in discrete time t is defined by the following expression (13):

$$y(t) = \sum_{i=1}^{n} b(i) \cdot x(t-i) + \varepsilon(t) \qquad \textbf{(13)}$$

where b_i, i=0,1,…,n are the coefficients of the linear non-recursive filter, n is the order of the MA-model, x(t) are elements of the (input) white noise and ε(t) are output uncorrelated errors.

Autoregressive Moving Average Model

The autoregression and moving average (ARMA) models are used in time series analysis to describe stationary time series. These models represent time series that are generated by passing white noise through a recursive and through a non- recursive linear filter, consecutively. In other words, the ARMA model is a combination of an autoregressive (AR) model and a moving average (MA) model.

The order of the ARMA model in discrete time t is described by two integers (m,n), that are the orders of the AR- and MA- parts, respectively. The general expression for an ARMA-process y(t) is the following (14):

$$y(t) = \sum_{i=1}^{m} a(i) \cdot y(t-i) + \sum_{i=0}^{n} b(i) \cdot x(t-i) + \varepsilon(t) \qquad \textbf{(14)}$$

where m is the order of the AR-part of the ARMA model, α_1, α_2,..,α_m are the coefficients of the AR-part of the model (of the recursive linear filter), n is the order of the MA-part of the ARMA model, b_0,b_1,…,b_n are the coefficients of the MA-part of the model (of the non-recursive linear filter), x(t) are elements of the (input) white noise and ε(t) are output uncorrelated errors.

MODEL PRESENTATION

In this paper an ANFIS model is used to predict the daily milk production. We chose a one step ahead prediction (next day). The parameters of the system are presented in Table **1**. Upon applying many tests, seven-membership functions of trapezoidal shape were chosen and seven rules were applied. The Sugeno type ANFIS was employed, and method utilized was the product, whereby the or method was the max, the defuzzification method was the weight average, the implication method was the product and the aggregation method was the max. Thirty two nodes, 14 linear parameters 28 non-linear parameters, and 42 total parameters were applied.

The model uses a hybrid-learning algorithm to identify the parameters for the Sugeno-type fuzzy inference systems. It applies a combination of the least-squares method and the back propagation gradient descent method for training the Fuzzy Inference System (FIS) membership function parameters to emulate a given training data set. Furthermore, it uses a checking data set for checking the model over fitting. In order to compare the results of the ANFIS model, an AR model and an ARMA model, both of the first order is created.

Table 1: ANFIS parameter types and their values used for training.

ANFIS parameter type	Value
MF type	trapezoidal
Number of MFs	7
Output MF	Linear
Number of Nodes	32
Number of linear parameters	14
Number of nonlinear parameters	28
Total number of parameters	42
Number of training data pairs (producer_2)	1212
Number of testing data pairs (producer_2)	304
Number of checking data pairs	200
Number of fuzzy rules	7

MODEL PERFORMANCE

The input variable consists of daily milk production time series. In order to train the ANFIS we implemented one input variable with one trapezoidal shape membership functions. The output variable consisted of the daily data of the next day in every step. The data of producer_1 spanned the period from 18/11/2004 to 30/07/2010 and the data of producer_2 ranged the period from 25/10/2005 to 30/07/2010. Both farmers halt production for two months every year. The initial 80% of the data was used to train the model and the remaining 20% to test the model.

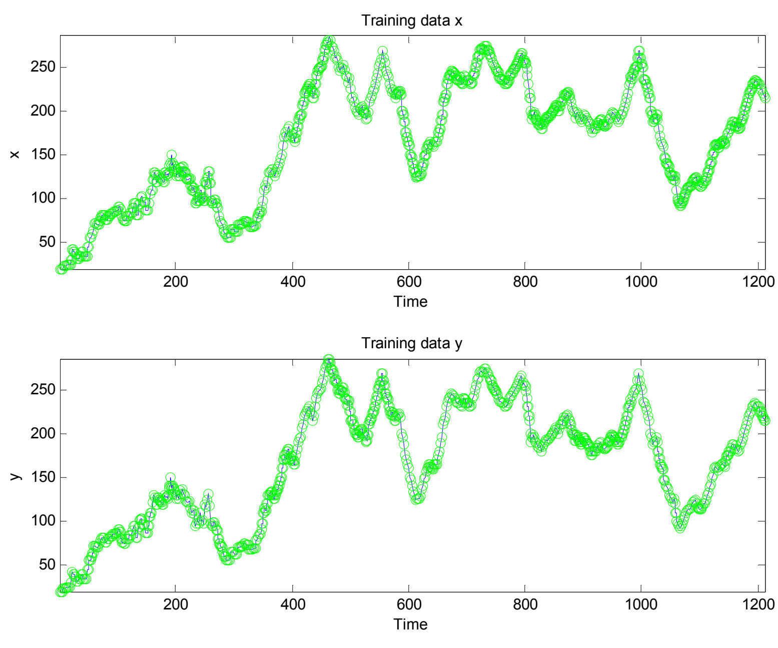

Figure 2: An illustration of the row training data (producer_2).

Fig. (**2**) presents the row training data. The initial step size was set at 0.1. The training error goal was set at 0. The model was tested many times using different time epochs. Finally, the best results were obtained at 250 epochs. Fig. (**3**) depicts the form of the membership functions before and after training of the model.

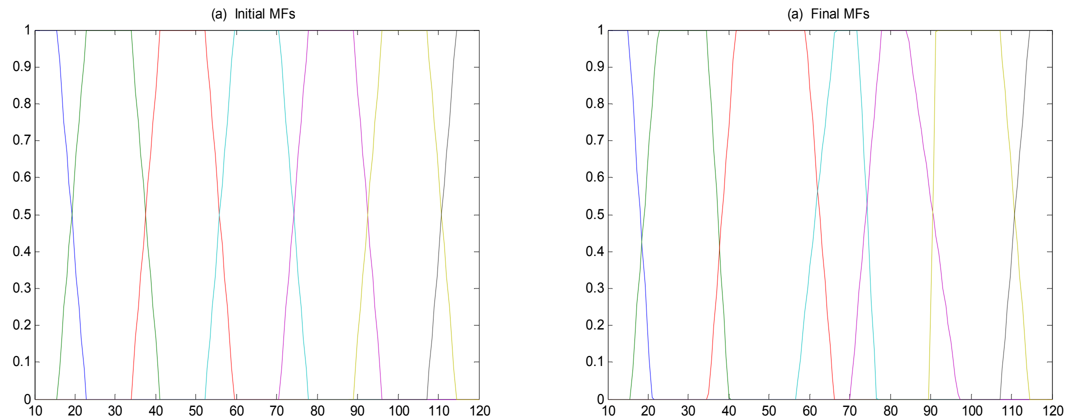

Figure 3: Trapezoidal shape membership functions before and after training (producer_2).

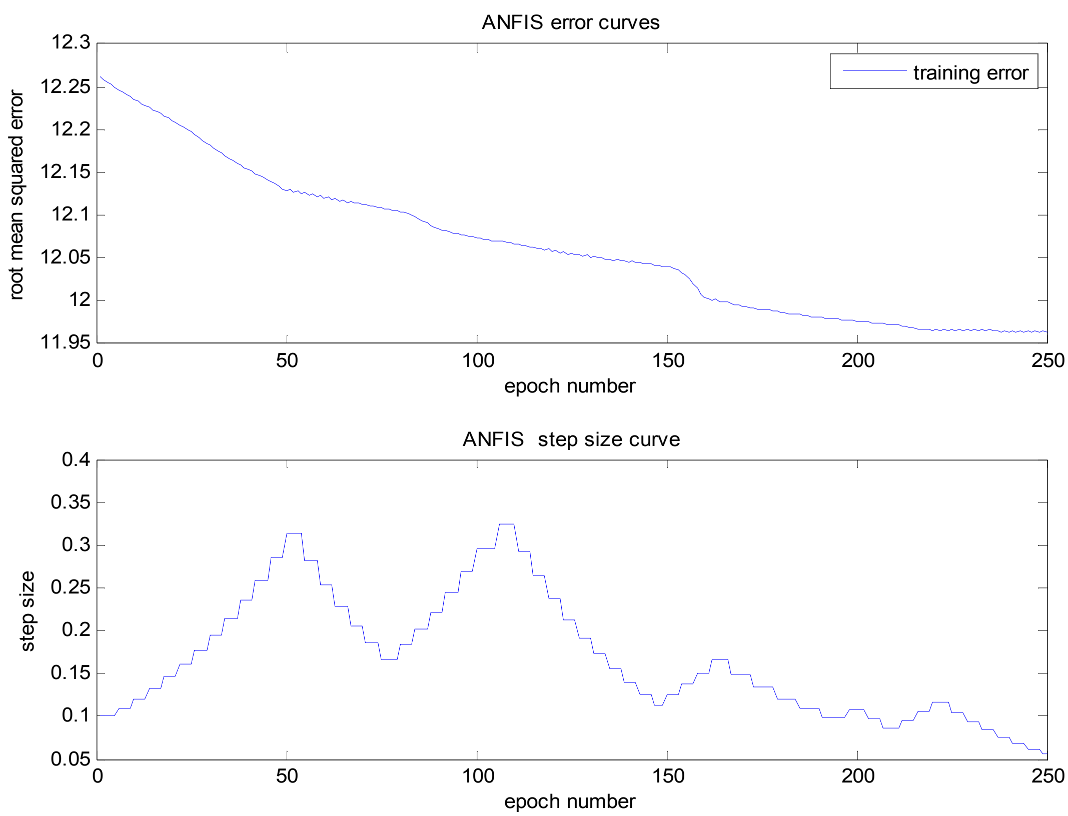

Figure 4: RMSE and step size during the training (producer_2).

Fig. (**4**) depicts the RMSE and the step size against the number of training epochs, during the training phase (producer_2). Figs. (**5** to **7**) depict a graphical representation of the forecasting results of the ANFIS, AR and ARMA models.

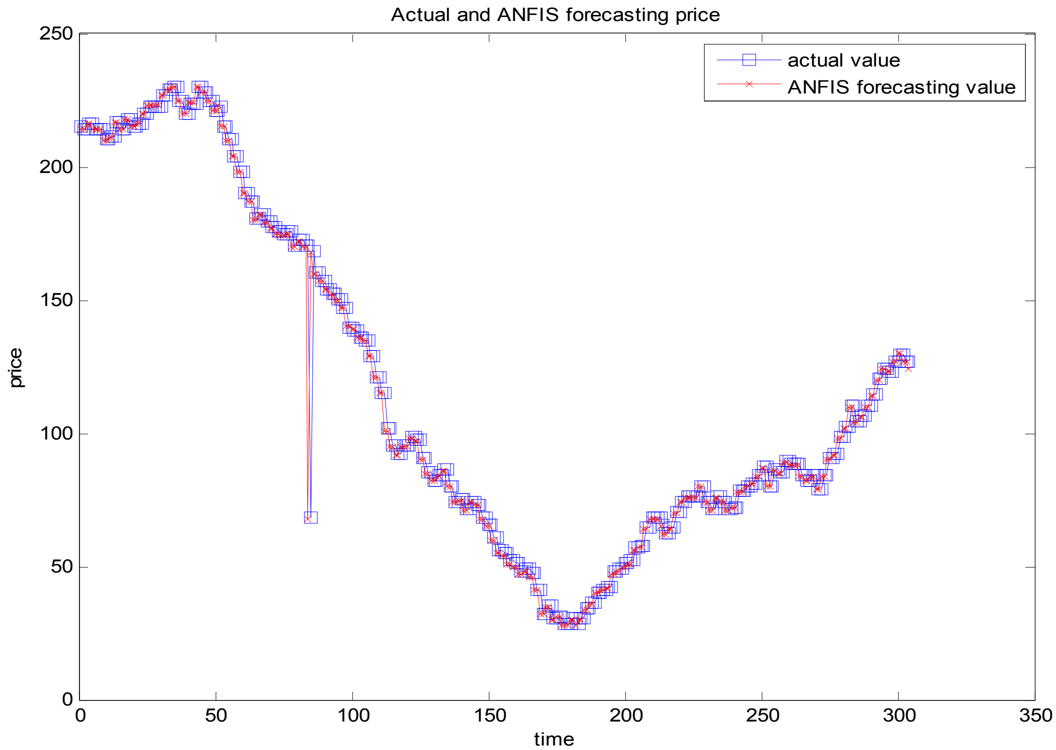

Figure 5: ANFIS forecasting values and actual values (producer_2).

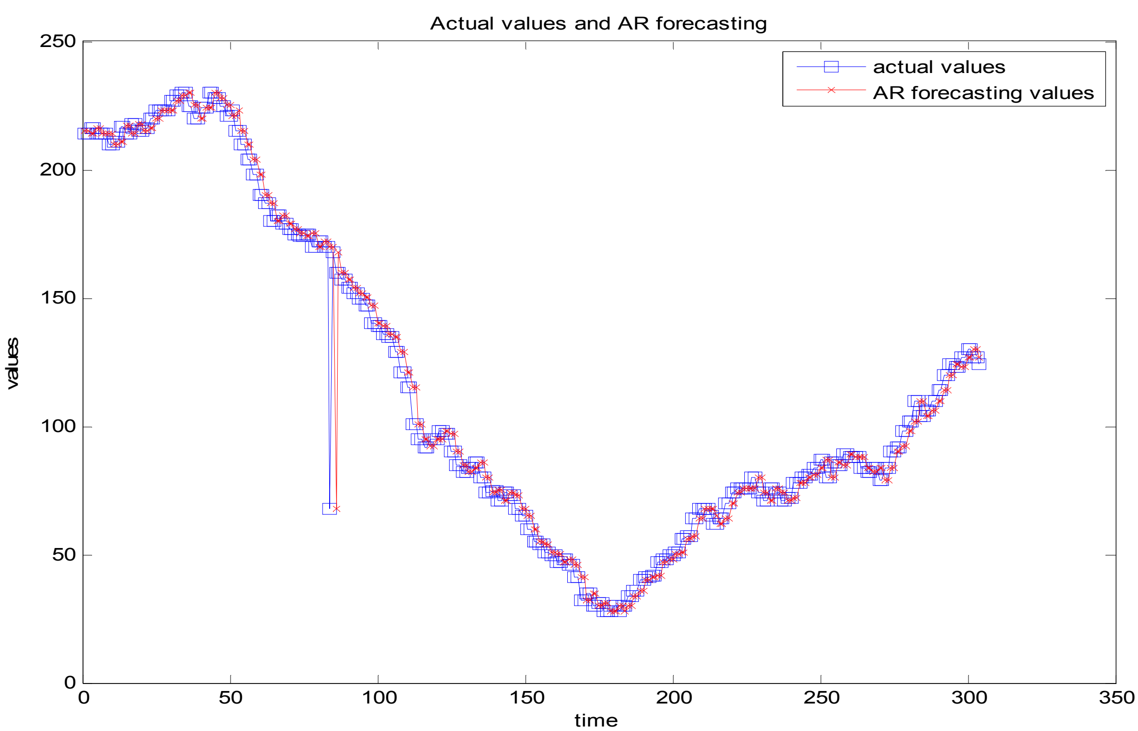

Figure 6: AR forecasting values and actual values (producer_2).

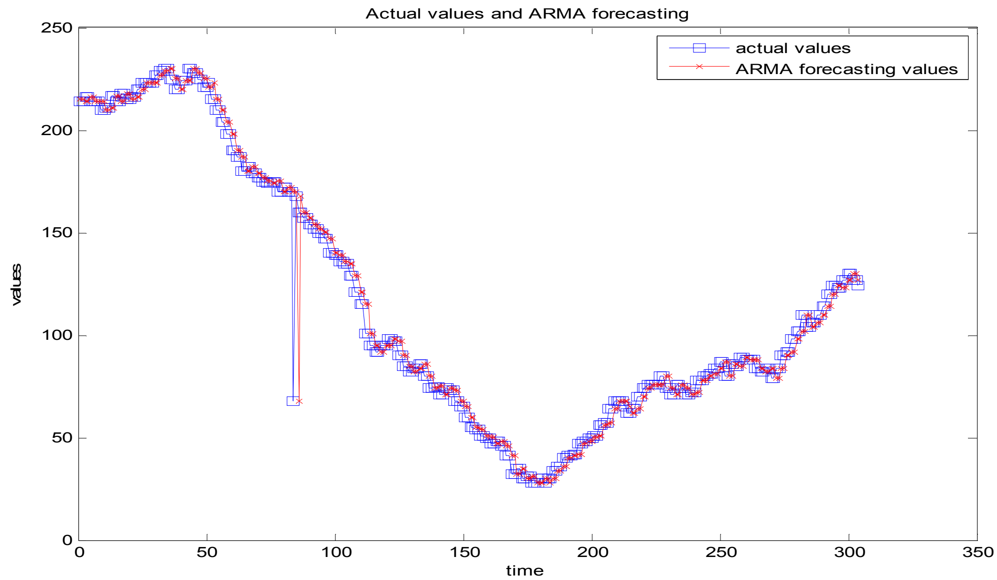

Figure 7: ARMA forecasting values and actual values (producer_2).

The performance of the forecasting models has been examined by using the main classic error measurements (Makridakis, 1983). The results are presented in the following tables.

Table 2: Errors of milk production forecasting for producer_1.

Producer_1	MSE	RMSE	MAE	MAPE
AR	15.6612	3.9574	2.9258	5.3127
ARMA	15.6616	3.9575	2.9258	5.3126
ANFIS	**12.3017**	**3.5074**	**2.6506**	**4.7446**

Table 3: Errors of milk production forecasting for producer_2.

Producer_2	MSE	RMSE	MAE	MAPE
AR	93.5912	9.6743	5.0068	5.7072
ARMA	93.7654	9.6833	5.0073	5.7072
ANFIS	**79.9558**	**8.9418**	**4.0399**	**4.6049**

Tables **2**, and **3** state that the ANFIS milk production forecasting model provide higher forecasting accuracy (the lowest error – in bold) compared with the classic forecasting models of AR and ARMA in terms of the well known statistical errors of the Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE). Producer_1 incurred a more stable production without many fluctuations than producer_2. Hence the forecasts of producer_1 were affected by less overall error.

CONCLUSIONS

This work presents an Adaptive Neural Fuzzy Inference forecasting System (ANFIS) that is dependent on the previous day's milk production. For comparison purposes, an AR and an ARMA model were developed. The results were presented and compared based on four different kinds of error. The system was applied to two milk producers. The ANFIS model provided better results than the AR and the ARMA model in the production of the milk. Based on the above results, the suggested neuro-fuzzy model could be an efficient system for the purposes of forecasting milk production time series.

Further work can be done by taking into consideration the seasonality of the data and by applying other modeling techniques.

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CHAPTER 2

The Role of Production Contracts in the Coordination of Agri-Food Chain: Evidence and Future Issues for the Durum Wheat Chain in Italy

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Abstract: The economics of contracts has undergone major developments in the recent decades. At the same time, the issue of co-ordination among actors in the same product chain through contractual instruments has attracted significant attention. In addition, the recent volatility of agricultural prices has made the role of contracts in risk allocation more important across different stages of the production chain. The paper explores the role of production contracts in the co-ordination of agri-food chain, considering evidence from the particular case of the durum wheat chain in Italy. After a review of the literature and brief examination of the sector and institutional context of Italian wheat production, the paper considers the present and potential role of production contracts, through a Delphi exercise. Based on this, proposals for action priorities (policy) are discussed along with an agenda for future research. The outcome of the Delphi exercise confirms the perceived need of improving the use of contracts in the Italian wheat sector. It also confirms the difficulties in addressing this issue. Solutions and needs for further research are identified at two main levels: a) detailed contract design; and b) wider chain governance.

Keywords: Durum wheat, production contracts, Italy.

INTRODUCTION

The economics of contracts has undergone major developments in the recent decades. At the same time, the issue of coordination among actors in the same product chain, by way of contractual instruments, has significant major attention and raised the case for policy intervention (Bogetoft and Olesen, 2004).

This is particularly relevant for crops in which typicality, quality and territorial identity of both production and processing are very important. In addition, the increased volatility of agricultural prices has made the role of contracts in risk allocation more important across different stages of the production chain.

In fact, the use of some type of contracting is presently advocated in the technical literature in Italy as a solution to several issues, particularly the negative effects of price volatility on farm income, risk allocation and supply security, as well as to provide incentives towards improving the quality of crop production. Recent examples concerning this argumentation for the wheat chain are available in Frascarelli (2010), Ghlefi *et al.* (2010) and Corticelli (2010).

This paper explores the role of production contracts in the coordination of the agri-food chain, considering evidence from the case of the durum wheat chain in Italy.

In the last decade, new contractual models have been tested in this chain, with an eye to increasing confidence, reducing market risks, improving supply stability, product quality and chain coordination (Vacondio, 2008). Initially, contracts designed to reward the quality of grain, according to the minimum standards required by processors, were introduced. An additional premium (related to additional amounts of

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protein content) was applied to the official price. More recently, incentives aimed at guaranteeing farmers a more acceptable distribution of risks have been introduced. In particular, forward contracts prescribing a minimum price for the product have been proposed, with the aim of helping farmers to recover their production costs and encouraging them to engage in production under contract, hence ensuring regular product supply.

After a review of the literature and a brief focus on the sector and institutional context of Italian wheat production, the paper evaluates the present and potential, role of production contracts through a Delphi exercise. Based on this, proposals for action are discussed priorities (policy) along with an agenda for future research.

LITERATURE

Vertical integration and coordination is a long-standing issue in both chain management and production economics. While chain analysis tends to focus on macroscopic aspects of integration, contract economics tend to address more explicitly the micro issues in contract design.

Worley and McCluskey (2000) list contracts as one of the four main types of vertical coordination:

- inter-firm alliance;
- vertical contracts;
- ownership integration;
- joint ventures.

Vertical contracts, in comparison with the other options, are characterised by a lack of both equity engagement and asset synergy. They are limited in time (usually short-term) with particularly variable (low to high) exit costs. Opportunistic behaviour is expected, which implies that the contracts also include control and enforcement measures, with *ex-ante* agreements on obligations and legal recourse in case of breach. Output or performance are usually measured.

Bogetoft and Olesen (2004) provide a comprehensive overview of different contractual regimes that align efforts with enterprise goals, combining incentives and insurance aspects in a joint contract. According to the authors, the practice of contracting indicates that contracts facilitate coordination, risk sharing and the use of local information, and that they ensure a high level of food safety through a reinforced input control. The advantages of contracting between producers and manufacturers are organised in a hierarchy of several variables, to consider in contract design. The overall goal is the maximization of the integrated profit of the chain. Three main objectives contribute to obtain this goal: coordination (the right products are produced at the right times and places), motivation (each player undertakes individually actions that increase the integrated profit integrated) and transaction cost reduction (direct costs, related to the design and monitoring of the contracts, are minimised). The authors also show the relevance of product and location specificities in contract design.

The analysis of individual contracts cannot be carried out effectively if contracts are considered in isolation. For example, Hendrikse (2007) discusses the connections between spot transactions and contracts in the same market. He points out that externalities are generated by production contracts in spot markets and emphasizes the need for contract analysis to be contextualised in the overall chain strategies.

The issue of contracting and vertical integration in the wheat chain had already attracted attention in the literature by the ‘90s and has been further developed in the last decade (*e.g.* Duval and Biere, 1998; Wilson *et al.*, 2004; Bushel and MacAulay, 2007; Bolotova and Patterson, 2008).

From an analysis of previous literature, Worley and McCluskey (2000) identify three main types of contracts:

1. marketing contracts,
2. production management contracts; and

3. production contracts with specified resources provided.

The three options are ordered according to an increasing degree of control of the contractor over the producer, and an increasing transfer of risk from the producer to the contractor: while in type 1 contracts the provision concerns only engagement in purchases at a specified price or price conditions, type 3 also includes the provision of input and technical support by the contractor.

The authors also discuss the motivation of subscribing contracts from the perspective of farmers. In synthesis, this can be represented by the trade-off between risk and independence, on the one hand, and income stability and confined market access on the other. This emphasises that, for farmers, there are motivations for and against engaging in contracts, each of which has different relevance depending on the different market and production chain conditions, as well as farmer/farms characteristics.

Processors' motivation to engage in production contracts include the control of input supply, improved response to consumer demand, and expansion and diversification of operations.

Further incentives to closer coordination come from the increasing sophistication of consumer needs and attention to consumers by the retailer, and the industrialization of input suppliers.

In addition, contract adoption is stimulated by stricter market forces and by the need of the food chain to increase its responsiveness to consumer needs, hence to be better able to transmit signals downstream and to react appropriately.

Other forces derive from the strong trend towards market liberalisation in the world agricultural economy, which also implies strong competition among the main producers worldwide and the need to maintain territorial links between producers and processors to meet the general political attitude towards each one's own industries.

The contracting problem from the point of view of the processor can be cast as a principal-agent model, in which a principal designs the optimal contract to provide incentives for an agent to uptake some specified action, or, in a wider sense, design optimal contracts for a set of actions and decide which one to uptake based on the expected costs of each contract. Worley and McCluskey (2000) develop a generic principal-agent model to address this issue.

CONTRACTS FOR WHEAT PRODUCTION IN ITALY

Vertical integration is seen as a major need of Italian food production chains and a major policy and sector priority in order to promote the country's competitiveness. Actions are also taken in this direction, using two main options: a) "production contracts" (contratti di coltivazione), which are contracts between farmers and processors to improve quality management and continuity of supply; and, b) "supply chain contracts" (contratti di filiera), that are contracts between all players in the chain. The latter are also connected to incentives to chain integration in the framework of the Rural development program's first axis payments of the Common Agricultural Policy (CAP).

In spite of this claim and the existing attempts to develop contract relationships, the share of wheat produced under production contracts is still estimated to be very low. In fact, it is very difficult to gain access to any reliable data on the actual amount of production under contract. The main problems concern the lack of systematic statistics on the use of contracts and the confidentiality of contract clauses and design. In 2010, the area sown to durum wheat in Italy reached 1.34 million hectares, which corresponded to a production of 3,5 million tons. According to the only available sources (Zanni, 2010), 75% of production is sold through traditional spot contracts and 25% through forward contracts, which promote grain quality. Only 5% of forward contracts are closed or semi-closed.

The understanding of the motivations for such a situation has been made more difficult in recent years due to the volatility of wheat and cereal prices , which has given way to very complex strategies by both farmers and processors, depending on expectations regarding future prices. Price volatility is also expected to continue in the future. In principle, this should provide incentives to both processors and farmers to undertake contracts, in order to reduce risks, respectively, through securing product supply and by securing a minimum price. However, this depends on the type of contract actually used.

A PRELIMINARY DELPHI ANALYSIS

Methods

Considering the lack of previous literature, the limited market information available (*e.g.* specific statistics), and the complexity of the issue, potentially involving several stakeholders and chain levels, the choice has been to approach this study through participatory methods. Specifically, a Delphi method has been used. Delphi methods are widely used to collect distributed information from informed actors (experts) concerning complex issues (viWTA, 2005; EVALSED). This choice was also supported by the substantial lack of any scientific literature on this issue in Italy, which contributes to highlight the difficulties in studying the issue of contracting in Italy.

In the Delphi study, the problem was organised into a set of five interrelated questions:

1. Is chain integration (and related contracts) a useful tool to support Italian durum wheat production?
2. What are the main advantages and disadvantages of the introduction of durum wheat chain contracts from the point of view of the different actors along the chain?
3. What are the main reasons for the limited diffusion of wheat production contracts at present?
4. What are the most suitable types of contracts for the Italian durum wheat chain?
5. What is the expected rate of adoption of production contracts for durum wheat in Italy?

Question 2 has been further divided into 5 sub-questions, four of which are each related to a particular component of the chain (*i.e.* farmers, stockists, millers, and pasta manufacturers) and one of which is related to the chain as a whole.

The Delphi exercise was carried out in two rounds. During the first round a questionnaire was circulated among the experts with each question being designed for an open answer. Results from the first round were used to develop a closed list of answers attached to each question. During the second round experts were asked to provide numerical judgments about the importance/credibility of each answer option to each question. Numerical judgments were provided using a 6 point scale, in an interval from zero to five.

The expert panel was composed of 10 people, including farmers (4 representatives), industry staff (processors and input providers) (3 representatives) and researchers in agronomy, food technology and economics (3 representatives).

Results

Are Chain Interactions and Production Contracts a Useful Tool?

The answer to this question is unanimously positive across the Delphi participants and for both chain contracts and production contracts (Table **1**). Both are expected to contribute the reduction of the problems inherent in the spot market that, in a situation characterised by high price volatility, expose all chain actors to significant risks. However, between the two contract typologies, the most important role is attributed to supply chain contracts (with an average score of 4,4 against 3,3), as they are considered to be more suitable to support vertical chain integration and, as a result, to support the survival of the cereal and pasta sector in Italy.

Table 1: Contract relevance

To what extent do you agree with the following statement? (from 0 to 5)	**Average**	**Min**	**Max**
The diffusion of "production contracts" (contracts between farmers and processors) is relevant to improve quality management and continuity of supply.	3,3	0	5
It is very important for "supply chain contracts" between all players of the sector to be more frequently used, because the survival of durum wheat in Italy is linked to the diffusion of vertical integration culture.	4,4	2	5

What are the Main Advantages and Disadvantages of Contracts?

From the perspective of farmers, the most important benefit of contracts is the reduction of uncertainty (Table **2**). This is due to the establishment of clearer rules by way of the contract, which in turn decreases the risks that usually affect the farmers, who are generally perceived as the weakest component of the chain. However, a number of other advantages are detected. There is the opininon that production contracts would increase the degree of professionality (technical and economical) of farmers, which would contribute to the improvement of the quality and yields of agricultural products (in additon to those directly due to the rules established in the contract), with positive effects on the income derived from cultivation. However, some disadvanategs did emerge. In particular, the compliance with exogenously defined technical standards (fixed by the contract) increases costs and decreases the flexibility of commercialisation for the farmer, including the possibility of speculation in the case of particularly favourable market conditions.

Table 2: Advantages and disadvantages for farmers

How relevant are the following advantages/disadvantages for farmers? (from 0 to 5)	**Average**	**Min**	**Max**
ADVANTAGES			
Higher income due to less uncertain prices	3,2	1	5
Higher income due to the higher product quality	3,4	1	5
Higher income due to higher yeld	2,7	1	4
Increased income security (less fluctuation risk)	4,4	3	5
Improvement of agricultural techniques and skills, due to technical advice	4,2	2	5
Higher stability of the "rules of the game"	4,6	4	5
DISADVANTAGES			
Less freedom of speculation	1,6	1	2
Higher production costs	2,3	0	5

Reduction of uncertainty is the more significant advantage also for the stockists (Table **3**). In this case, the rewards concern mainly organizational aspects (availability of a critical mass of raw material, lots homogeneity, easier financial planning), resulting into economic benefits. Although it is necessary to deal with heavy investment and less freedom of speculation, the dominant opinion is that the benefits are worth the costs.

Table 3: Advantages and disadvantages for stockists

How relevant are the following advantages/disadvantages for stockists? (from 0 to 5)	**Average**	**Min**	**Max**
ADVANTAGES			
Lower costs through better supply planning	3,2	2	4
Increased revenue due to higher homogeneity and quality of the lots	3,4	2	5

Table 3: cont….

Better selection and retention (costumer loyalty) of suppliers	3,4	1	5
Lower financial risks connected to market fluctuations	3,9	2	5
DISADVANTAGES			
Less freedom of speculation	2,9	1	5
Need for heavy investment in new facilities	3,0	2	5

From the millers' point of view, benefits in stipulating vertical integration contracts are mainly achieved in increasing supply stability and grain quality (Table **4**). This derives from the improvements identified in the previous stages of the chain. One disadvantage is the reduction of opportunities for gains when raw material prices are low.

Table 4: Advantages and disadvantages for millers

How relevant are the following advantages/disadvantages for millers? (from 0 to 5)	**Average**	**Min**	**Max**
ADVANTAGES			
Higher security of supply continuity	4,3	3	5
Higher grain quality	4,4	3	5
Higher price stability	4,0	3	5
DISADVANTAGES			
Less opportunities to profit from low raw material prices	3,4	2	5
Increased demand for transparency in transactions	3,3	2	5

The benefits for pasta manufacturers are mainly in the area of traceability and continuity of raw material supply (Table **5**). In this regard, an important aspect is the possibility of making national grain availability more consistent, in particular in light of a possible development of "made in Italy pasta". An advantage can be found in terms of cost savings, resulting from lower transport costs. These benefits are considered significantly higher than the possible disadvantages.

Table 5: Advantages and disadvantages for pasta manufacturers

How relevant are the following advantages/disadvantages for pasta manufacturers? (from 0 to 5)	**Average**	**Min**	**Max**
ADVANTAGES			
Higher security of supply continuity	4,4	3	5
Lower transport costs	3,3	2	4
Higher quality of raw materials	4,0	2	5
Increased critical mass of national grains, to support "made in Italy" products marketing	4,3	3	5
Higher traceability of supply	4,6	4	5
Higher stability of prices of raw material	4,0	3	5
DISADVANTAGES			
Less opportunities to profit from low raw material prices	3,1	2	5
Heavy competition from firms that do not apply "supply chain contracts", under low durum wheat prices	3,4	2	5

In general, the feedback regarding the profit that the chain can obtain from the widespread adoption of these contracts is very positive and substantially free of hesitation (Table **6**). Experts consider the integration contracts as a primary method to better face globalisation and to ensure the survival of the pasta industry.

Table 6: Advantages and disadvantages for the supply chain in general

How relevant are the following advantages/disadvantages for the supply chain in general? (from 0 to 5)	Average	Min	Max
ADVANTAGES			
Greater chances of industry survival in the long run	4,3	3	5
Higher opportunities to face market globalisation successfully	4,2	3	5
DISADVANTAGES	none	none	none

The answers to the above points, contrasted with the low diffusion of contracts, emphasises the importance of exploring the reasons why the diffusion of these contracts is so limited in durum wheat, despite the assumed advantages (Table **7**).

According to the views that emerged in the Delphi group, the most serious obstacle to the adoption of contracts is cultural in nature. In such a context, the individualism of many groups participating in the supply chain is particularly relevant. Two of the most striking examples are the preference the stockers show for pursuing speculative strategies even to the prejudice of efficiency and the low confidence that farmers demonstrate with regard to horizontal and vertical integration initiatives, even without any clear information about their contents. When they are not merely the result of issues related to culture and information, such attitudes appear to be more related to structural conditions (fragmentation, small size, lack of professionalism *etc.*) and institutional variables (lack of regulation), rather than pure economic constraints (such as production costs for farmers or investments for stockers). A likely determinant of resistance is to be found in the lack of trust generated by negative experiences in the recent past, such as some cases of breach of contracts by processors. The issue of building confidence and reputation is hence central to pursue a larger diffusion of production contracts.

Table 7: Causes of the low distribution of these contracts in Italy

How relevant are the following variables? (from 0 to 5)	Average	Min	Max
Lack of professionalism of many operators (farmers and stockers)	3,7	2	4
Individualism and lack of trust between farmers (tied to public support rather than market-oriented).	3,8	0	5
Preference of stockers for speculation, rather than for efficiency.	4,2	1	5
Short-sightedness of many pasta manufacturers	3,7	3	5
Structural fragmentation of agricultural and processing facilities	4,0	3	5
Production costs too high to meet technical standards	3,0	2	5
Low incentives to promote product quality	3,7	2	5
Shortage of existing storage facilities	3,4	2	5
Lack of transparent rules for all players	4,0	2	5
A general disinterest in the issue	2,8	0	5

The next question addresses the issue of what contract type is most suitable for the development of the durum wheat chain in Italy (Table **8**). As an alternative to traditional "spot" contracts, the most promising contract, according to the panel, is the “mixed type”. This forward contract is one of the newcomers among the various formats recently tested in Italy. The farmer is committed to use certain cultivars, to comply with a specific technical standard, and to sell the entire harvest to the stocking centre. The price is fixed prior to sowing, for a certain amount (for example, 70%), in a “close mode” (on the basis of production costs, plus a negotiated margin and the storage costs). For the residual component (30%), the price is defined at the sale in an "open mode", on the basis of the stock exchange quotations. A premium price is added, depending on the protein content.

In second place in the ranking is the “close mode” forward contract, where the price is prefixed at 100%, with a premium linked to grain quality.

A particular variant of this type is the "semi-closed MIN-MAX”, which provides a price range between a minimum and a maximum. If the quotation at the time of delivery is below the minimum, the buyer will be committed to pay the agreed minimum. If the quote at the time of delivery is above the maximum, the vendor will be committed to accept the agreed maximum price.

Finally, the "full open mode" forward contract is considered unsuitable for the chain development, as it penalizes the farmer too much, in particular when the prices are low.

Regardless of the specific type of contract, the provision of a premium price for quality is considered very important, and a major determinant of chain enhancement, but it is agreed that it can only work if the incentives are relevant in monetary terms and appreciated by the farmers.

Table 8: Level of adequacy of durum wheat contracts in Italy

How suitable are the following contract formats? (from 0 to 5)	**Average**	**Min**	**Max**
“Mixed price contract” (half “closed”, with price fixed before sowing, and half “open”, with price linked to stock quotations), with selected cultivar and based on quality payment.	4,7	4	5
“Closed price contract” (with price fixed before sowing), with selected cultivar and payment based on quality.	3,3	3	4
“Open price contract” (with price linked to stock quotations) with selected cultivar and based on quality payment.	2,7	0	4
Independently from the type, the best contracts are those promoting the quality of the product	3,1	0	5

Finally, experts were asked to make a prediction regarding the rate of adoption of contracts by chain operators in Italy (Table **9**). On this point, the assessments are spread over a wide range of possibilities, from the most optimistic to the more cautious. The dominant opinion is that contracts will continue to grow, but slowly and heterogeneously across geographical areas. In particular, they are expected to grow more rapidly in Northern Italy, where agricultural chains are more organised and farmers are more used to establish durable relations and to sign agreements with customers and suppliers, rather than in the South, where social capital is historically much less strong. It is also emphasised that there is a need for public support for the dissemination of the use of contracts.

Table 9: Future development of durum wheat contracts

Do you think that the durum wheat contracts will develop in the future in Italy? (from 0 to 5)	**Average**	**Min**	**Max**
Yes, rapidly in all regions of Italy	2,3	0	4
Yes, but only in certain regions of Italy (centre-north)	3,7	2	5
Yes, but only if supported by political intervention	3,8	0	5
Yes, but very slowly and with difficulties	3,4	1	5
A little more than today	2,3	0	4
They will not develop	0,9	0	3

DISCUSSION AND POLICY IMPLICATIONS

The outcome of this Delphi exercise confirms the perceived need of improving the use of contracts in the Italian wheat sector. It also confirms the difficulties in addressing such an issue.

While the needs seem to find a consensual understanding, the same does not apply to solutions to this problem. In addition, as the sphere of choice largely concerns private elements, it is not straightforward to identify appropriate policies to guide the system towards a solution.

A preliminary list of suggestions from the opinions expressed as qualitative statements and commentaries attached to the answers to the Delphi exercise is the following:

- there is a need for policies to provide economic incentives to the various actors in the chain to adopt contracts; this would also be necessary to avoid that contracts are used in some areas, and ignored in others, such as in the South;
- a major component of such policies would be to promote coordination action such as providing a critical mass of farmers willing to engage in contracts, as it is often not profitable for the industry to engage in contracting with individual farmers;
- the role of intermediary organisations, such as producers' organisations (PO), is seen as essential; panellists also expressed the strong feeling that these organisations are not functioning properly at the moment;
- there needs to be a greater (policy) commitment to ensure adequate remuneration to farmers for quality production;
- the need to provide stocking facilities of suitable size should also be addressed through public intervention;
- higher inter-professional coordination would also be necessary, beyond individual contracting;
- it is suspected that, while many talk about contracts, there is no political confidence in their actual usefulness and opportunities. Accordingly, policy action remains limited.

These qualitative insights can be classified according to the three main functions of contracts identified by Bogetoft and Olesen (2004) (Table **10**).

Table 10: Policy needs and functions of contracts

Functions	Key needs/prescriptions
Coordination	Provide an institutional framework for higher dialogue among actors Support integration of the most fragmented component of the chain (farmers) Ensure coordination throughout the process and not only in the initial phase
Motivation	Need for sufficient economic incentives for farmers Need for initial investments to gain trust by the different players and build a critical mass
Reduction of transaction costs	Pooling farmers to reduce costs for search and negotiation

Given the current situation of contracting in the Italian durum wheat chain, all contracting objectives and components deserve attention. Even if the public regulator is often expected to intervene on all of these aspects, it seems most plausible that policy actions would focus on promoting coordination, in order to reduce transaction costs for the parties involved. While public policy could also have a role in terms of providing appropriate incentives, this would most likely require a stronger role for the private players, in order to guarantee the economic sustainability of the entire chain.

FINAL REMARKS

This study has demonstrated the potential relevance of the use of contracting in the durum wheat chain in Italy and some of main orientations for future (policy) actions in this field. It has also highlighted the contradictions between the expected benefits and the paucity of effort being deployed to develop the use of contracts. It also focused on the multiplicity of issues to be addressed in search of potential improvements to the way contracting is approached in such a strategic product chain for Italian agriculture.

The study, based on a two-round Delphi exercise, was explorative in nature and methods. A primary expected outcome is hence to derive implications for further research in this field. As the results show, there is a strong need for research and several issues in particular should be addressed. The potential priorities envisaged can be identified on two main levels.

At the very micro level, a major research need lies in a better understanding of the specific factors, either contract design parameters or exogenous variables, affecting farmers' decision to adopt contracts . In addition, the study of different risk attitudes by farmers would be necessary to design appropriate contracts, particularly in light of increased price volatility as a persistent component of market scenarios in the next future. However, as the preferences of farmers can be affected by multiple issues, a systematic and theoretically-based modelling of incentives provided by contracts would be also welcome. This would, in particular, allow to integrate "hard" information, such as cost levels and profitability differentiation across farmers, with purely preference-driven attitudes.

On the meso and macro level, the focus seems to be on governance structure and coordination mechanisms. Here, the study of potential innovative institutional arrangements would be of great interest, in connection with feasible options for the Italian legal context. Factors affecting trust and a means to guarantee enforcement would also be of significant relevance in the light of the stated causes of low level of contractualisation of the chain discussed above.

In terms of methods, these different research needs call for a variety of approaches, ranging from principal-agent modelling, to institutional economics and transaction cost concepts. A major challenge would be to address these issues in a consistent way on different levels and with different instruments, in order to provide supporting evidence for practically relevant proposals towards an improvement of the economic viability of the durum wheat chain.

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CHAPTER 3

Effects of the European Union Farm Credit Programs on Efficiency and Productivity of the Greek Agricultural Sector: A Stochastic DEA Application

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Abstract: This study examines technical efficiency and productivity growth of Greek farms participating in the 1994 European Union Farm Credit Programs (1994-EU-FCP), *i.e.* regulation 2328/91. In this paper, two farm-level economic data sets are used, *i.e.* the crop and the livestock data set, where each one consists of two different groups of farms: one group contains farms participating in the 1994-EU-FCP while the other one contains non-participating farms. The data sets are observed over the 1993 and 1997 years. The paper uses the approach developed by Simar and Wilson (1998a, b) to bootstrapping both DEA efficiency measures and Malmquist productivity indices. Furthermore, the present paper uses the Malmquist index decomposition proposed by Simar and Wilson (1998b) and Zofio and Lovell (1997) to investigate the sources of productivity change. The technical efficiency score results indicate that, in terms of the crop oriented farms, the program failed to increase the efficiency of the participated farms even though the most efficient farms entered the 1994-EU-FCP. In contrast, in terms of the livestock oriented farms, the program managed to increase the efficiency of the participated farms though less efficient farms entered the program. The total factor productivity growth results, in terms of crop-oriented farms, show statistically significant decline of productivity for the group of program farms but a statistically significant increase for the group of non-program farms. The total factor productivity growth results, in terms of livestock oriented farms, show a statistically significant increase of productivity for the group of program farms but no change for the group of non-program farms.

Keywords: Bootstrap, data envelopment analysis, productivity, farm credit program.

1. INTRODUCTION

Farm Credit Programs (FCP) are policy measures which intend to provide farmers with agricultural credit at subsidized rates. Such programs' main aim is to increase farmers' productivity by improving their access to capital markets and, therefore, provide them with the opportunity to invest on more modern and productive technologies. On the one hand concerning the viewpoint of the society at large, the introduction of FCPs is expected to increase producers' surplus through the reduction of farmers' production cost and the increase of agricultural production. On the other hand, the cost of FCPs is borne by taxpayers. The excess of the FCPs cost over the expected increase in producers' surplus is identified as the welfare or deadweight economic loss resulting from the implementation of FCPs. Thus, the higher the effectiveness of the FCPs, the lower the welfare economic loss would be resulted from the introduction of such programs. There is, however, considerable lack of consensus regarding the effectiveness of such credit programs (Adams, 1971). Specifically, the 'poor but efficient' hypothesis of Schultz (1964) states that traditional farmers can be considered efficient even though they are constrained by technological barriers which cannot be overcome by the simple provision of new capital inputs supplied by credit programs alone.

In addition, Steitieh (1971), studying Southern Brazilian agriculture, indicated that although credit programs give traditional farmers the opportunity to invest on more modernized capital inputs, there is no assurance that these inputs will be used in an efficient manner so as to achieve the possibility of full output

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gains. In particular, Steitieh (p.96) reported that 'increased investment in inputs (capital formation), such as mechanized equipment and fertilizer alone is not the answer to increasing crop production. Better management, information, and utilization of resources are as important and should be equally emphasized if any benefit is to be expected from increasing expenditures on these inputs'. Furthermore, Taylor *et al.* (1986), examining the effectiveness of subsidized credit programs in Southern Brazil, suggested that such programs have no effect on technical efficiency and a slight negative effect on allocative efficiency. Striewe *et al.* (1996) compared the competitiveness of a group of German farms participating in the FCP with a group of non-participating farms and they found that the FCP did not significantly increase the competitiveness of participating farms compared to the non-participating farms. Brummer and Loy (2000) analyzed technical efficiency of a group of Northern Germany dairy farms which participated in the European-FCP over the period 1987 to 1994. They observed that on average the program had led to a slight decrease of the technical efficiency of participating farms.

FCPs have been implemented in Greece since 1983 and are funded by national (75 per cent) and EU (25 per cent) budgets. The aims and main guidelines of FCPs are set out according to the EU level, while the programs are implemented at the national level. In general, farmers who wish to participate in the program should submit a business development plan, *i.e.* improvement plan, which provides detailed information about planned investment activities as well as expected total revenues. Based on the submitted business plans, subsidized loans are principally provided for investments on machinery, buildings, plantation, animals *etc.* The selection of farms is based on at least one of the following criteria: past and expected future farm income, production structure of the farm, size and planned growth of the farm, as well as past and expected future productivity of the farm. The aforementioned criteria are based on certain techno-economic indicators constructed by the Greek Department of Agriculture.

For the period 1983-1998, a number of 77,510 business development plans were submitted, out of which 69,937, *i.e.* about 90%, were approved. The average percentage of subsidy provided by the FCP to the approved business plans, is about 42% of the value of investments. The average value of investments of the approved business development plans is about 23477.6 euros compared to 24651.5 euros of the submitted plans and to 37270.7 euros of the rejected plans. This indicates that the average value of investments proposed by the rejected business development plans is greater than the average value of the submitted ones. The reason is that the rejected development plans come from farms with large economic size which, however, do not fulfill all the criteria for their acceptance into the FCP.

The purpose of this paper is to investigate efficiency and productivity growth of Greek farms participating in the 1994-EU-FCP, *i.e.* Regulation 2328/91. In this paper, two farm level economic data sets are examined, that is, the crop and the livestock data sets. The crop data set corresponds to a panel of farms with plant cultivation as their main production activity while the livestock data set corresponds to a panel of farms with animal breeding as their main production activity. The crop as well as the livestock data sets consist of two different groups of farms: the first group contains farms participating in the 1994-EU-FCP while the second contains non-participating farms, *i.e.* the *control group*. Note that each one of the two data sets, *i.e.* crop and livestock, has been obtained from two annual surveys, *i.e.* the 1993 and 1997 annual surveys. The 1993 annual survey describes the economic condition of the farms the year before the enactment of the 1994-EU-FCP, while the 1997 annual survey shows their condition three years after the enactment of the program. It is assumed that for farms participating in the program all planned investments have been completed during this three year period, *i.e.* 1994-1996, as is also specified by the regulation of the program.1 Thus, this paper presents technical efficiency and productivity measures for two broad farm categories, *i.e.* crop oriented farms and livestock oriented farms. In addition, comparisons can be performed among the groups of farms participating and non-participating in the 1994-EU-FCP as well as within the group of participating farms before and after participating in the program.

In the balk of the empirical literature, the investigation of productivity growth is achieved by applying a non-parametric method developed by Fare *et al.* (1989; 1992), which computes total factor productivity

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[1] Investments of crop-oriented program farms are mainly allocated among tractors (30%), irrigation (25%) and building (10%), while of livestock-oriented program farms investments are allocated mainly among buildings (34%), irrigation (15%) and tractors (15%).

growth using a Malmquist index of productivity change. Within this framework, productivity growth may occur due to a combination of industry-wide technological change, that is, shift in production surface, and technical efficiency change at the level of the operating unit, that is, movements towards or away from the production surface. Then the Malmquist index can be decomposed to capture these two components, *i.e.*, *technical change* and *technical efficiency change*. Furthermore, Fare *et al.* (1994) showed that the efficiency component could be decomposed into a *pure efficiency change* and a *scale efficiency change* components. However, Simar and Wilson (1998b) and Zofio and Lovell (1997) indicated that the decomposition proposed by Fare *et al.* (1992; 1994) is consistent only under the assumption of constant returns to scale technology and thus they proposed an alternative decomposition of the Malmquist index in the context of non-constant returns to scale. Furthermore, they decomposed the technical change component into a pure change in technology and a change in the scale of the technology components.

The present paper uses the Data Envelopment Analysis (DEA) to calculate efficiency measures and also applies the Malmquist index decomposition proposed by Simar and Wilson (1998b) and Zofio and Lovell (1997) to investigate total factor productivity growth for the sample farms. Even though the literature refers to DEA as being deterministic, efficiency is measured relative to an *estimate* of the true, but unobserved, frontier. Note that the corresponding efficiency measures are sensitive to the sampling variation of the obtained frontier, since the statistical estimators of the frontier are obtained from finite samples. Simar and Wilson (1998a) develop a bootstrap procedure which can be used to construct confidence intervals for nonparametric distance functions used to measure technical efficiency. Furthermore, a series of papers by Simar and Wilson (1998b), Gilbert and Wilson (1998), Wheelock and Wilson (1999) and Simar and Wilson (1999) extend the bootstrapping procedure of Simar and Wilson (1998a) to the case of Malmquist indices constructed from nonparametric distance functions using observations from different time periods and thus they estimate confidence intervals for Malmquist indices. The present study applies the aforementioned bootstrapping procedures for the estimation of confidence intervals for both technical efficiency scores and total factor productivity measures for the sample farms of the study.

This paper follows up the previous work of Rezitis *et al.* (2003, 2005) that evaluates the effects of factors influencing technical efficiency of Greek farms participating in the 1994-EU-FCP. The paper by Rezitis *et al.* (2003) obtains technical efficiency measures within the framework of a stochastic frontier approach (Battese and Coelli, 1995) while the paper by Rezitis *et al.* (2005) obtains technical efficiency scores and total factor productivity measures for a sample of crop farms using the DEA methodology and the Malmquist productivity index respectively. The present paper expands the previous studies in several aspects. Firstly, it expands the data set by incorporating farms which are not participating in the 1994-EU-FCP and thus a comparison can be performed between participating and non-participating farms. Secondly, it shows results for both crop and livestock oriented farms whereas the paper by Rezitis *et al.* (2003) does not present results at that level of disaggregation while the paper by Rezitis *et al.* (2005) presents results only for crop oriented farms. Thirdly, it investigates productivity change by using an alternative Malmquist index decomposition to the one used by Rezitis *et al.* (2005), *i.e.* the decomposition proposed by Simar and Wilson (1998b) and Zofio and Lovell (1997), and thus it does not impose the assumption of constant returns to scale technology. Forthly, it estimates confidence intervals for both technical efficiency scores and total factor productivity measures by using specific bootstrapping procedures. The paper is organized as follows: Section 2 present an overview of the various FCPs implemented by the European Union (EU) and Section 3 presents that methodology. Section 4 describes the data, Section 5 discusses the empirical results and Section 6 provides the conclusions.

2. OVERVIEW OF EU-FCPS

The FCPs have been implemented by EU, in the form of 'development (improvement) plans', since 1972 and have been available to all EU members since then *via* a set of Directives and Regulations. More specifically, in 1972 the Mansholt Memorandum was given concrete form by the approval of three 'socio-structural' directives: Directive 159/72 'on the modernization of agricultural holdings'[2], Directive 160/72

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[2] Directive 159/72 provides support for farm investment, keeping farm accounts and the setting up of producer groups.

'on encouragement to cease farming' and Directive 161/72 'on vocational training'[3]. These directives were replaced in the mid 1980s by Regulation 797/85 'on improving the efficiency of agricultural structures' and later by Regulation 2328/91 also 'on improving the efficiency of agricultural structures'[4]. Note that Regulation 2328/91, which is examined in the present paper, was subsequently replaced in 1997 by Regulation 950/97 'on improving the efficiency of agricultural structures'[5] and this, in turn, was incorporated in 1999 under the Rural Development Programs (Regulation 1257/99)[6,7].

Council Directive 159/72 introduced FCPs in all EU members by grating aid for investments with certain conditions, objectives and financial terms. In particular, the conditions for aid are that the farmer should practice farming as his main occupation; possess adequate occupational skills and competence; keep accounts; and draw up a 'development plan' satisfying certain conditions with the most important that the development plan must show that, upon its completion, the farm undergoing modernization will be capable of attaining as a minimum a level of earned income, *i.e.* comparable earned income, comparable to that received for non-agricultural work in the region in question. The main objectives for aid is that the development plan should achieve a significant improvement in agricultural incomes and working and production conditions while the aid should be granted in the form of interest rate subsidies of investments necessary for carrying out the development plan or in the form of capital grants or deferred payments. Note that the interest rate subsidy shall apply to the whole of the loan, except for any part of the loan exceeding 40000 units of account per man-work unit and also the interest rate subsidy could exceed 5% if such action is warranted by the situation of the capital market in the Member State. The European Union finances 25% of the eligible expenditures to the Member State.

In the 1980s, the European Commission became increasingly concerned about the important role agriculture plays in relation to the environment as well as with regard to the maintenance of cultural landscapes and the restructuring and diversification of farms. Thus, the main objectives of Regulations following Directive 159/72 and especially of Regulation 2328/91 are to help restore the balance between production and market capacity; to help improve the efficiency of farms by developing and reorganizing their structures and by promoting supplementary activities; to contribute to the safeguarding of the environment; and to contribute to the improvement of hygiene conditions of livestock. The conditions for aid are the same with those provided by Directive 159/72 with the provision that the reference income, *i.e.* comparable earned income, does not exceed 120% of that received for non-agricultural work in the region in question. The form and the amount of aid as well as the Community's financial contributions remained the same with those of Directive 159/72, while the value of aid expressed as a percentage of the amount of the investment can reach up to the 50% of the total investment of ECU 60743 per man-work unit or ECU 121486 per farm. Afterwards and up to the Regulation 1257/99 the conditions for aid for investments became stricter and thus in order to be eligible farms must demonstrate economic viability, to respect

[3] Directive 161/72 provides support for people working in the agricultural sector and support for the development of services providing socio-economic advise to farmers on whether to continue farming or to move out of the agricultural sector.

[4] Regulation 2328/91 provides support for farm investment, young farmers, introduction of accounts, producer groups, farm management and relief services, less-favored and mountainous areas, agri-environmental measures, forestry measures and vocational training projects.

[5] Regulation 950/97 provides similar support measures as Regulation 2328/91.

[6] Regulation 1257/99 provides support for investment in farm business, improving processing and marketing of agricultural products, young farmers, early retirement, training, less-favored areas and areas with environmental restrictions, agri-environment, and various measures for the general development of rural areas (*e.g.* agricultural water resource management, encouragement for tourist and craft activities, renovation and development of villages and protection and conservation of the rural heritage).

[7] In general, the overall objectives of the aforementioned Directives and Regulations (*i.e.* 159/72, 797/85, 2328/91, 950/97 and 1257/99) were "to help restore the balance between production and market capacity; to help improve the efficiency of farms by developing and reorganizing their structures and by promoting supplementary activities; to maintain a viable agricultural community; and to contribute to the preservation of the environment and the countryside" while the main measures provided by the Regulations were "investments in agricultural holdings; measures to support farm incomes and to maintain viable agricultural communities in less-favored and mountainous areas; introduction of farm accounts and the launching of groups; vocational training projects".

minimum standards for environment, hygiene and animal welfare. Furthermore, farmers must possess adequate occupational skills and competence. The amount of support, expressed as a percentage of the volume of eligible investment is limited to a maximum of 50% in the less favorable regions and 40% in the other regions. Finally, the introduction of Council Regulation 1783/2003 amended Regulation 1257/99 and added some additional measures such as support for agricultural production methods designed to improve the quality of agricultural products; support for promotion of those products; and support for the development and application of new technologies.

3. METHODOLOGY

Measures of Efficiency and Productivity

Following the presentation by Wheelock and Wilson (1999), let consider N farms producing q outputs by using p inputs over T time periods. Let $\mathbf{y} \in \mathbb{R}_+^q$ is an output vector and $\mathbf{x} \in \mathbb{R}_+^p$ is an input vector. The production possibilities set at time t is defined as

$$P^t = \{(\mathbf{x},\mathbf{y}) | \mathbf{x} \text{ can produce } \mathbf{y} \text{ at time } t\}, \quad \textbf{(1)}$$

and the output correspondence sets as

$$\Upsilon^t(\mathbf{x})\{\mathbf{y} \in \mathbb{R}_+^q \,|(\mathbf{x},\mathbf{y}) \in P^t\}. \quad \textbf{(2)}$$

Standard assumptions are made about $\Upsilon^t(\mathbf{x})$, and thus P^t, (see Wheelock and Wilson, 1999) such as P^t is convex and $\Upsilon^t(\mathbf{x})$ is convex, bounded, and closed for all $\mathbf{x} \in \mathbb{R}_+^p$; all production requires the use of some inputs; and both outputs and inputs are strongly disposable. The upper boundary of P^t is referred to as the technology at time t, which may change over time due to innovation, regulatory changes, *e.g.* farm credit programs, and to other factors.

Let $(\mathbf{x}_i^t, \mathbf{y}_i^t)$ represent the input and output vectors of farm i at time t. The Shephard (1970) output distance function for farm i at time t+1, relative to the technology at time t, is defined as

$$D^{t+1}(\mathrm{x}_i^t, \mathrm{y}_i^t) \equiv \inf\{\theta > 0 |\, \mathrm{y}_i^t/\theta \in \Upsilon^{t+1}(\mathrm{x}_i^t)\}. \quad \textbf{(3)}$$

The distance function $D^{t+1}(\mathbf{x}_i^t, \mathbf{y}_i^t)$ provides a normalized measure of distance from the ith farm's position in the input/output space at time t to the boundary of the production set at time t+1 in the hyperplane where inputs are constant. In a similar manner $D^t(\mathbf{x}_i^{t+1}, \mathbf{y}_i^{t+1})$ provides the measure of the farm's position at time t+1 to the boundary of the production set at time t and is defined by

$$D^t(\mathrm{x}_i^{t+1}, \mathrm{y}_i^{t+1}) \equiv \inf\{\theta > 0 |\, \mathrm{y}_i^{t+1}/\theta \in \Upsilon^t(\mathrm{x}_i^{t+1})\}. \quad \textbf{(4)}$$

The distance function $D^t(\mathbf{x}_i^t, \mathbf{y}_i^t)$ provides a measure of efficiency relative to contemporaneous technology and is defined by

$$D^t(\mathrm{x}_i^t, \mathrm{y}_i^t) \equiv \inf\{\theta > 0 |\, \mathrm{y}_i^t/\theta \in \Upsilon^t(\mathrm{x}_i^t)\}. \quad \textbf{(5)}$$

Note that $D^t(\mathrm{x}_i^t, \mathrm{y}_i^t) \leq 1$, with $D^t(\mathrm{x}_i^t, \mathrm{y}_i^t)=1$ indicating that the ith farm is technically efficient, *i.e.* located on the boundary of the production set. On the other hand $D^{t+1}(\mathrm{x}_i^t, \mathrm{y}_i^t)$ and $D^t(\mathrm{x}_i^{t+1}, \mathrm{y}_i^{t+1})$ (<, =, >)1. The estimation of the distance functions (3), (4) and (5) requires estimation of the output correspondence set (2). There are two possible estimators of $\Upsilon^t(\mathrm{x})$, such as

$$\hat{\Upsilon}_c^t(x) = \left\{ y \in \mathbb{R}_+^q \mid y \le Y^t\eta, \quad x \ge X^t\eta, \quad \eta \in \mathbb{R}_+^N \right\} \tag{6}$$

and

$$\hat{\Upsilon}_v^t(x) = \left\{ y \in \mathbb{R}_+^q \mid y \le Y^t\eta, \quad x \ge X^t\eta, \quad \vec{1}\eta = 1, \quad \eta \in \mathbb{R}_+^N \right\} \tag{7}$$

where $Y^t = [y_{1t} \dots y_{Nt}]$ and $X^t = [x_{1t} \dots x_{Nt}]$, with y_{1t} and x_{1t} are (q×1) and (p×1) vectors of observable outputs and inputs, respectively; $\vec{1}$ is a (1×N) vectors of ones; and η is a (N×1) vector of intensity variables. The estimator in (6) indicates constant returns to scale, while the one in (7) allows variable returns to scale. Estimators of the distance functions defined in (3), (4) and (5) are obtained by substituting either (6) or (7) for the output correspondence set in the aforementioned distance functions. Thus, the following estimators are obtained for the distance function in (3) which may be solved as linear programs:

$$\left[\hat{D}_c^{t+1}\left(x_i^t, y_i^t\right) \right]^{-1} = \max\left\{ \lambda_i \mid X^{t+1}\eta_i \le x_i^t, \quad Y^{t+1}\eta \ge \lambda y_i^t, \quad \eta_i \in \mathbb{R}_+^N \right\} \tag{8}$$

and

$$\left[\hat{D}_v^{t+1}\left(x_i^t, y_i^t\right) \right]^{-1} = \max\left\{ \lambda_i \mid X^{t+1}\eta_i \le x_i^t, \quad Y^{t+1}\eta \ge \lambda y_i^t, \quad \vec{1}\eta = 1, \quad \eta_i \in \mathbb{R}_+^N \right\}. \tag{9}$$

Note that (8) incorporates constant returns to scale while (9) allows for the assumption of variable returns to scale. The estimators of the distance function in (4) are obtained from (8) and (9) by interchanging the time indices, *i.e.* substituting t+1 for t and t for t+1, respectively. The estimators of the distance function in (5) are obtained by

$$\left[\hat{D}_c^{t}\left(x_i^t, y_i^t\right) \right]^{-1} = \max\left\{ \lambda_i \mid X^{t}\eta_i \le x_i^t, \quad Y^{t}\eta \ge \lambda y_i^t, \quad \eta_i \in \mathbb{R}_+^N \right\} \tag{10}$$

and

$$\left[\hat{D}_v^{t}\left(x_i^t, y_i^t\right) \right]^{-1} = \max\left\{ \lambda_i \mid X^{t}\eta_i \le x_i^t, \quad Y^{t}\eta \ge \lambda y_i^t, \quad \vec{1}\eta = 1, \quad \eta_i \in \mathbb{R}_+^N \right\}. \tag{11}$$

Note that the estimator of (10) provides a measure of overall technical efficiency while that of (11) a measure of pure technical efficiency. Furthermore the ratio of overall to pure technical efficiency provides a measure of scale efficiency. Finally, similar estimators to those of (10) and (11) but with reference to time t+1 are given by

$$\left[\hat{D}_c^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right) \right]^{-1} = \max\left\{ \lambda_i \mid X^{t+1}\eta_i \le x_i^{t+1}, \quad Y^{t+1}\eta \ge \lambda y_i^{t+1}, \quad \eta_i \in \mathbb{R}_+^N \right\} \tag{12}$$

and

$$\left[\hat{D}_v^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right) \right]^{-1} = \max\left\{ \lambda_i \mid X^{t+1}\eta_i \le x_i^{t+1}, \quad Y^{t+1}\eta \ge \lambda y_i^{t+1}, \quad \vec{1}\eta = 1, \quad \eta_i \in \mathbb{R}_+^N \right\} \tag{13}$$

Fare *et al.* (1989; 1992) showed that the Malmquist total factor productivity index is represented as

$$\hat{M}(t,t+1)=\left[\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\times\frac{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right]^{1/2}$$
$$=\left(\frac{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)\times\left(\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}\times\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)^{1/2} \quad \textbf{(14)}$$

and can be decomposed into two components: the first ratio on the right-hand side (RHS) of (14), *i.e. the efficiency change* (Δ*Eff*) component, which measures how much closer to the production frontier the farm is in period *t*+1 compared to the period *t* and it is referred to as the catching up effect; and the remaining part on the RHS of (14), *i.e. the technical change* (Δ*Tech*) component, which captures the change in the production technology as a shift in the production frontier. Productivity advances occur if $\hat{M}(t,t+1)>1$ while improvements in efficiency and technological advances occur if Δ*Eff*>1 and Δ*Tech*>1, respectively. Fare *et al.* (1994) showed that the Δ*Eff* component can be written as the product of two components: *the pure efficiency change* (Δ*PureEff*) component and *the scale efficiency change* (Δ*Scale*) component, *i.e.* Δ*PureEff*×Δ*Scale*=Δ*Eff*, and thus (14) can be rewritten as

$$\hat{M}(t,t+1)=\left(\frac{\hat{D}_v^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_v^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)\times\left(\frac{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})\big/\hat{D}_v^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})\big/\hat{D}_v^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)$$
$$\times\left(\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}\times\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)^{1/2} \quad \textbf{(15)}$$

where the first term in parentheses on the RHS of (15) is the Δ*PureEff* component, the second term in parentheses is the Δ*Scale* component and the third term in parentheses is unchanged from (14) and is the Δ*Tech* component. Both the numerator and denominator of the Δ*PureEff* component measure the contemporaneous efficiency of the farm at times *t*+1 and *t*, respectively. Measures of Δ*PureEff* (>=<) 1 indicate an increase, no change and a decrease in technical efficiency, respectively. Both the numerator and denominator in the Δ*Scale* component contain ratios of distance functions and each of these ratios represents a measure of the scale efficiency. The ratio in the numerator (denominator) measures the distance between the boundaries of $\hat{\Upsilon}_c^{t+1}$ and $\hat{\Upsilon}_v^{t+1}$ ($\hat{\Upsilon}_c^{t}$ and $\hat{\Upsilon}_v^{t}$) relative to the farm's position at time *t*+1 (*t*). Measures of Δ*Scale* (>=<) 1 indicate an increase, no change and a decrease in scale efficiency, respectively. Δ*Scale* describes the change in returns to scale faced by the farm between *t* and *t*+1. Changes represented by Δ*Scale* may be due to (i) changes in the shape of the technology, (ii) changes in the location of the farm in input/output space between *t* and *t*+1 or (iii) some combination of (i) and (ii). (Weelock and Wilson, 1999).

Simar and Wilson (1998b) and Weelock and Wilson (1999) indicated that the only way the Δ*Tech* component in (15) could denote a change in technology is if the underlying true technology is one of constant returns to scale. If, however, it is not one of the constant returns to scale, then there is a problem with the constant return to scale estimate of the technology because it is statistically inconsistent, *i.e.* even if the sample size becomes infinitely large, the constant returns to scale estimator of the technology would not converge to the true technology. Kneip, Park, and Simar (1998) showed that under certain assumptions the variable returns to scale estimator is always consistent. Thus, it would be appropriate to use the variable returns to scale estimate in order to estimate changes in technology. Simar and Wilson (1998b) and Zofio and Lovell (1997) decomposed the Δ*Tech* component of the Malmquist index by rewriting (15) as

$$\hat{M}\left(t,t+1\right)=\left(\frac{\hat{D}_v^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_v^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)\times\left(\frac{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})\Big/\hat{D}_v^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})\Big/\hat{D}_v^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)$$
$$\times\left(\frac{\hat{D}_v^{t}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_v^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}\times\frac{\hat{D}_v^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}{\hat{D}_v^{t+1}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)^{1/2}$$
$$\times\left(\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})\Big/\hat{D}_v^{t}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})\Big/\hat{D}_v^{t+1}(\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1})}\times\frac{\hat{D}_c^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})\Big/\hat{D}_v^{t}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}{\hat{D}_c^{t+1}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})\Big/\hat{D}_v^{t+1}(\mathbf{x}_i^{t},\mathbf{y}_i^{t})}\right)^{1/2} \quad \textbf{(16)}$$

The first two components in parentheses on the RHS of (16) are the same as in (15). The product of the last two components on the RHS of (16) constitutes the Δ*Tech* term on the RHS of (15), *i.e.* Δ*PureTech*×Δ*ScaleTech*= Δ*Tech*. The fist of these represents *the pure change in technology* (Δ*PureTech*), while the second describes *the change in the scale of the technology* (Δ*ScaleTech*). The Δ*PureTech* component is the geometric mean of two ratios. The first (second) of these measures the shift in the variable returns to scale frontier relative to the farm's position at time t+1 (t). Measures of Δ*PureTech*>1 represents an upward shift in the variable returns to scale estimate of the technology, *i.e.* an increase in pure technology. The Δ*ScaleTech* component is also a geometric mean of two terms. The ratio in the numerator (denominator) of the first term measures the distance between the boundaries of $\hat{\Upsilon}_c^{t}$ and $\hat{\Upsilon}_v^{t}$ ($\hat{\Upsilon}_c^{t+1}$ and $\hat{\Upsilon}_v^{t+1}$) relative to the farm's position at $\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1}$. Thus, the first term of Δ*ScaleTech* measures the change in the scale, or shape, of the technology between times t and t+1 relative to the farm's location at time t+1. Accordingly, the second term in Δ*ScaleTech* measures the change in the shape of the technology between times t and t+1 relative to the farm's location at time t. According to Simar and Wilson (1998b), Δ*ScaleTech* describes the *change in the scale of the technology* of the production unit while Δ*Scale* reflects *changes in the scale efficiency* of the production unit. Furthermore, measures of Δ*ScaleTech*<1 represents a flattening of the technology, while Δ*ScaleTech*>1 represents increasing curvature, or change away from constant returns to scale. According to Zofio and Lovell (1997), however, the Δ*ScaleTech* term describes the scale bias of technical change. Measures of Δ*ScaleTech*=1 indicate that technical change is neutral with respect to scale, *i.e.* it has not altered technically optimal scale. If Δ*ScaleTech*≠1 is biased with respect to scale, *i.e.* Δ*ScaleTech*(<>)1 according as $\mathbf{x}_i^{t+1},\mathbf{y}_i^{t+1}$ is more or less scale efficient relative to the contemporaneous technology $\hat{\Upsilon}^{t+1}$ than relative to the previous technology $\hat{\Upsilon}^{t}$.

Bootstrapping Efficiency Scores and Productivity Indices

The bootstrap technique is a computer-based simulation method used to obtain the sampling properties of random variables, see Efron (1979), Efron and Tibshirani (1993) and Davison and Hinkley (1997) for a presentation of the method. Simar (1992) introduced the bootstrapping method in frontier models; while Simar and Wilson (1998a) further developed this approach for nonparametric envelopment estimators. Bootstrapping, in the DEA framework, is based on the idea of approximating the sampling distribution of the DEA estimators by repeatedly simulating the data generating process (DGP), usually through resampling of the observed data and thus producing repeated estimates. Hence, the sampling distribution of the estimators is approximated by the empirical distribution of the simulated estimates and it can be used to construct confidence intervals for the estimated parameters. Following Simar and Wilson (1998a) the bootstrap technique for the output-oriented technical efficiency measures in (10) and (11) can be described with the following algorithm:

i) Compute the DEA efficiency scores $\hat{\theta}_i$ for each farm where i=1, 2, …,n.
ii) Select the bth (b=1, 2,…,B) independent bootstrap sample $\left\{\theta_{1,b}^{*},\theta_{2,b}^{*},...,\theta_{n,b}^{*}\right\}$, which consists of n data values drawn with replacement from the estimated values θ_i s.

iii) Construct the smoothed bootstrap sample $\left\{\theta_{1,b}^{**},\theta_{2,b}^{**},...,\theta_{n,b}^{**}\right\}$ as follows:

$$\theta_{i,b}^{**}=\begin{Bmatrix}\theta_i^{*}+h\varepsilon_i & if \quad \theta_i^{*}+h\varepsilon_i\le 1; \quad for \quad i=1,2,...,n\\ 2-(\theta_i^{*}+h\varepsilon_i) & otherwise\end{Bmatrix} \qquad \textbf{(17)}$$

where, h is the optimal width which minimizes the approximate mean integrated square error of $\hat{\theta}_i$'s distribution, given by $h = 0.9An^{-1/5}$, where A=min(standard deviation of θ, interquartile range of $\theta/1.34$).

iv) Construct the *b*th pseudo-data set as $\left\{\left(x_i, y_i^{*} = y_i\,\hat{\theta}_i \big/ \theta_i^{**}\right); i = 1, 2, ..., n\right\}$.

v) Use the pseudo-data set to create new $\hat{\theta}_i^{*}$ s.

vi) Repeat steps (ii)-(iv) *B* times to obtain $\left\{\hat{\theta}_{i,b}^{*}; b = 1, 2, ..., B\right\}$ for each farm *i*, *i*=1,2,…,n.

vii) Calculate the average of the bootstrap estimates of θ_i's, the bias and the confidence intervals as they are described below.

The average of the bootstrap estimates of θ_i is calculated as the arithmetic mean

$$\hat{\theta}_i^{*}(\bullet) = \frac{1}{B}\sum_{b=1}^{B}\hat{\theta}_{i,b}^{*} \qquad \textbf{(18)}$$

A measure of the estimated bias of the bootstrap estimator based on *B* replications is

$$\widehat{bias}_i\left(\hat{\theta}_i\right) = \hat{\theta}_i^{*}(\bullet) - \hat{\theta}_i \qquad \textbf{(19)}$$

Therefore, a bias-corrected estimator of θ_i is

$$\tilde{\theta}_i = \hat{\theta}_i - \widehat{bias}_i\left(\hat{\theta}_i\right) = 2\hat{\theta}_i - \hat{\theta}_i^{*}(\bullet) \qquad \textbf{(20)}$$

Following Simar and Wilson (2000) the correction in (20) should not be used unless

$$\hat{\sigma}^2 < \frac{1}{3}\left[\widehat{bias}_i\left(\hat{\theta}_i\right)\right]^2 \qquad \textbf{(21)}$$

where $\hat{\sigma}^2$ represents the sample variance of the bootstrap values. Note, that in the present analysis the relation in (21) is satisfied.

Once the bias-corrected estimates are calculated, the percentile method can be used to construct the (1-2a)% confidence intervals for θ as

$$\left(\tilde{\theta}_i^{(a)}, \tilde{\theta}_i^{(1-a)}\right) \qquad \textbf{(22)}$$

where $\tilde{\theta}_i^{(a)}$ indicates the $100\cdot\alpha$ th percentile of the empirical density function of $\tilde{\theta}_{i,b}$, *b*=1,…,*B*.

The approach for bootstrapping productivity indices is based on the fact that the Malmquist index in (16) is a function of distance estimators such as (8)-(13). Thus the aforementioned methodology for bootstrapping distance function estimators such as (10) and (11) is employed to bootstrap the distance function estimators used in the construction of the Malmquist productivity index (16). In particular, the process of bootstrapping the Malmquist productivity index can be summarized as follows:

i) Compute the Malmquist productivity index (16), $\hat{M}(t,t+1)$, and its components, *i.e.* $\Delta PureEff$, $\Delta Scale$, $\Delta PureTech$, and $\Delta ScaleTech$, for each farm by solving linear programming models such as (8)-(13) in order to obtain the appropriate distance function estimators used in the construction of (16).

ii) Compute a pseudo-data set as $\left\{\left(x_{it}^{*}, y_{it}^{*}\right); i=1,2,...,n; t=1,2\right\}$ to generate the appropriate bootstrap reference technology using a bivariate kernel estimation approach presented by Simar and Wilson (1999). Note that in the present case a panel data set is used and thus a kernel method is employed to preserve any temporal correlation present in the data.

iii) Calculate the bootstrap estimate of the Malmquist productivity index (16), $\hat{M}_{ib}^{*}(t,t+1)$, and its components, *i.e.* $\Delta \hat{PureEff}_{ib}^{*}$, $\Delta \hat{Scale}_{ib}^{*}$, $\Delta \hat{PureTech}_{ib}^{*}$, and $\Delta \hat{ScaleTech}_{ib}^{*}$, by using the pseudo-data set obtained in step (ii).

iv) Repeat steps (ii)-(iii) B times to obtain $\left\{\hat{M}_{ib}^{*}(t,t+1); b=1,2,...,B\right\}$ for each farm i, i=1,2,…,n. The same applies for the aforementioned components of the index.

v) Working in a similar manner as in the case of technical efficiency, these bootstrap estimates can be used to calculate the average of bootstrap estimates of the Malmquist productivity index (and its components), the bias and the confidence intervals. Note, that in the present analysis the relation (21) is satisfied for the productivity index and its components. Thus the bias-corrected estimators of the productivity index, *i.e.* $\tilde{M}_i(t,t+1)$, and its components, *i.e.* $\Delta \tilde{PureEff}_i$, $\Delta \tilde{Scale}_i$, $\Delta \tilde{PureTech}_i$, and $\Delta \tilde{ScaleTech}_i$, are calculated using a relation similar to the one given in (20).

4. DATA

In this paper two farm-level economic data sets are used, *i.e.* the crop and the livestock data sets. The crop data set corresponds to a panel of 483-farms, *i.e.* 179-farms participating in the 1974-EU-FCP program and 304-farms not participating in the program (the *control group*), with plant cultivation as their main production activity. On the other hand, the livestock data set corresponds to a panel of 162-farms, *i.e.* 48-farms participating in the program and 114-farms not participating in the program (the *control group*), with animal breeding as their main production activity. Each one of the two data sets was created from data obtained from two annual surveys, *i.e.* the 1993 and 1997 annual surveys. The 1993 annual survey provides data that describe the economic condition of farms the year before the enactment of the 1994-EU-FCP, while the 1997 annual survey provides data that show their condition three years after the enactment of the program. It is considered that for the farms participated in the program all planned investments have been completed during this three year period, *i.e.* 1994-1996, as it was also expected by the program.

The 483 crop oriented farms are multi-product enterprises and they are classified into 8 crop categories according to their main production activity, *i.e. grain*; *cotton*; *horticulture* and *flowers*; *olive crops*; *viticulture*; *tobacco and other tilling cultivation*; *other permanent cultivation*; and *multi-cultivation*. On the other hand the 162 livestock oriented farms are classified into 3 livestock categories, *i.e. sheep breeding*; *cattle breeding*; and *ruminants*. Empirical results are presented for each one of the 8 crop production activities as well as for each one of the 3 livestock production activities. It is worth noting that the highest number of approved business development plans for the 1994-EU-FCP comes from farms with *other permanent-cultivation* (28%) as their main production activity, followed by farms with *horticulture and flowers* (12%)*, and sheep-breeding* (12%). Through the 1994-EU-FCP, the highest investments were performed in farms with *grains* as their main production activity, following farms with *cattle-breeding*, *horticulture and flowers*, and *other permanent cultivation*. The lowest investments were performed in farms with *tobacco* as their main production activity following farms with *olive crops, ruminants, and cotton*.

Table **1** presents the mean and standard deviation of variables used in the construction of DEA models for the calculation of efficiency and productivity measures for crop and livestock oriented farms respectively. The dependent variable in the construction of DEA models for both crop and livestock oriented farms is the value, in euros, of gross farm output (*Y*), which includes the gross value of all final farm products and the "value added" to livestock over the year net of direct payments. Four inputs are considered in construction of DEA models for both crop and livestock oriented farms. The first input considered is the value, in euros, of capital (X_1), which includes the value of agricultural machinery and equipment, agricultural buildings, permanent cultivation and livestock. The second input considered is labor (X_2), which is measured as the number of hours of human labor used on individual farms during the year, and includes operator, family, and hired labor used in the farm. The third input is land area operated (X_3), measured in stremmas. Note that one stremma is equal to 1000 m^2 (about ¼ of an acre). The final input used is the value, in euros, of intermediate inputs (X_4), which includes expenses on fertilizer, lime, other chemicals, feeds, fodder, hay, veterinary care and other miscellaneous livestock expenses per farm. Note, however, that variables in value terms are expressed in 1993 constant prices.

Table 1: Mean and Standard Deviation of Variables Used in the Estimation

	1993	**1997**	**%Change 1993-97**	**1993**	**1997**	**%Change 1993-97**
Crop Farms	*Program Farms*			*Non-Program Farms*		
Y Mean (St. Dev.)	14530.1 (11784.5)	17564.3 (15336.8)	20.9%	10977.1 (7338.6)	11274.7 (13109.9)	2.7%
X_1 Mean (St. Dev.)	26368.6 (25031.4)	38827.2 (28369.2)	47.2%	21939.4 (22286.6)	18026.2 (21075.5)	-17.8%
X_2 Mean (St. Dev.)	2902.4 (2293)	3689.2 (2316.8)	27.1%	4129.5 (1479)	4217.5 (1908.8)	2.1%
X_3 Mean (St. Dev.)	108.4 (103.5)	135.3 (131.2)	24.8%	93.6 (88.9)	89.6 (79.1)	-4.3%
X_4 Mean (St. Dev.)	5861.2 (4893.7)	7748.1 (6748.6)	32.2%	3468.2 (2456.8)	3879.2 (5461.1)	11.9%
Livestock Farms	*Program Farms*			*Non-Program Farms*		
Y Mean (St. Dev.)	16224.3 (15227.3)	29518.4 (31628.1)	81.9%	18384.6 (12964.2)	16851.8 (11544.8)	-8.3%
X_1 Mean (St. Dev.)	29668.9 (31364.4)	56110.5 (45372.2)	89.1%	22152.3 (15181)	18508.6 (13671.4)	-16.4%
X_2 Mean (St. Dev.)	3320.3 (2265.9)	4667.7 (2293.1)	40.6%	4168.1 (1423.3)	4505.5 (1366.1)	8.1%

Table 1: cont….

X_3 Mean (St. Dev.)	97.2 (113.7)	116 (109.4)	19.3%	43.5 (35.8)	44.1 (42.42)	1.4%
X_4 Mean (St. Dev.)	7746.7 (8153.7)	12841.7 (16772.2)	65.8%	7194 (7300.6)	6877.7 (6634.6)	-4.4%

Note: Y represents gross farm output and is the value, in euros, of all final farm products and the 'value added' to livestock over the year; X_1 represents capital and is the value, in euros, of agricultural machinery, equipment and buildings, permanent cultivation and livestock, during the year; X_2 represents labor and is the number of hours of operator, family and hired farm labor, during the year; X_3 represents area operated, in stremmas, during the year; X_4 represents intermediate inputs and is the value, in euros, of expenses on fertilizer, lime, other chemicals, feeds, fodder, hay, veterinary care and other miscellaneous livestock expenses during the year.

The means of Table **1** indicate that farms changed their input mix during the period 1993-1997. Among both crop and livestock *program farms*, there were increases on average (in percentage terms) among output (Y) and inputs (X_1, X_2, X_3, and X_4). Note, however, that among the crop *program farms* the increase of inputs was greater than that of output, while, among the livestock program farms the increase of inputs (except that of X_1) was smaller than that of output. A common feature among both crop and livestock *non-program farms* was a significant decrease of capital (X_1), which possibly occurred because these farms did not participate in the 1994-EU-FCP. Furthermore, the crop *non-program farms* show a decrease in land (X_3) while the livestock *non-program farms* a decline in intermediate inputs (X_4). The aforementioned changes had as a result a small increase of the output of crop *non-program farms* and a decrease of the output of livestock *non-program farms.*

5. EMPIRICAL RESULTS

Technical Efficiency

Tables **2-5** show results for the bootstrap of efficiency scores for crop (Tables **2** and **4**) and livestock (Tables **3** and **5**) farms for the years 1993 (Table **2** and **3**) and 1997 (Tables **4** and **5**). Resampling has been carried out for B=1000, *i.e.* 1000 pseudo-samples have been used. Each table provides results for *overall, pure* and *scale* efficiency indices. Note that estimates for each one of the aforementioned efficiency indices are provided on the original DEA efficiency scores ($\hat{\theta}_i$), the bootstrap bias-corrected estimates ($\tilde{\theta}_i$), and the 95% confidence intervals for the bias-corrected efficiency estimates centered on $\tilde{\theta}_i$. Estimates are given for each production and breeding activity for crop and livestock farms, regarding the samples of *program farms* (*i.e.* farms participating in the 1994-EU-FCP), *non-program farms* (*i.e.* farms non-participating in the 1994-EU-FCP; *control group*), as well as for *all farms* (*i.e.* program and non-program farms). In general the results reveal the sensitivity of the efficiency measures with respect to sampling variation. In other words the bias-corrected estimates ($\tilde{\theta}_i$) reveal that differences in measured efficiency are of a different magnitude than those when original efficiency scores ($\hat{\theta}_i$) are considered.

Table 2: Bootstrap of efficiency scores of crop oriented farms, 1993

i	$\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$ (2.5% - 97.5% Centered on)	$\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$ (2.5% - 97.5% Centered on)	$\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$ (2.5% - 97.5% Centered on)
	Overall Technical Efficiency	*Pure Technical Efficiency*	*Scale Efficiency*
Program Farms			
1	0.578 0.617 0.504 0.732	0.677 0.776 0.674 0.883	0.858 0.776 0.717 0.813
2	0.447 0.372 0.291 0.463	0.537 0.488 0.405 0.578	0.821 0.737 0.685 0.778
3	0.729 0.855 0.732 0.991	0.811 0.953 0.827 1.079	0.894 0.884 0.816 0.941

Table 2: cont….

4	0.455 0.429 0.327 0.533	0.482 0.423 0.312 0.537	0.938 0.979 0.924 1.031
5	0.401 0.303 0.198 0.413	0.449 0.372 0.260 0.480	0.909 0.867 0.831 0.891
6	0.507 0.521 0.397 0.657	0.620 0.711 0.572 0.849	0.838 0.737 0.700 0.774
7	0.544 0.572 0.451 0.697	0.646 0.717 0.592 0.847	0.878 0.849 0.807 0.892
8	0.507 0.504 0.445 0.564	0.587 0.622 0.560 0.684	0.865 0.798 0.769 0.823
9	0.509 0.500 0.468 0.535	0.588 0.610 0.577 0.646	0.871 0.817 0.791 0.841
Non-Program Farms			
1	0.399 0.292 0.225 0.364	0.468 0.409 0.339 0.481	0.862 0.763 0.730 0.787
2	0.371 0.244 0.189 0.304	0.446 0.377 0.319 0.435	0.857 0.744 0.715 0.760
3	0.522 0.457 0.346 0.564	0.581 0.528 0.421 0.627	0.894 0.851 0.808 0.883
4	0.399 0.282 0.203 0.366	0.445 0.342 0.260 0.425	0.904 0.866 0.823 0.897
5	0.439 0.359 0.264 0.451	0.471 0.396 0.300 0.488	0.937 0.918 0.888 0.940
6	0.291 0.068 -0.035 0.171	0.364 0.186 0.079 0.288	0.817 0.685 0.641 0.714
7	0.395 0.293 0.170 0.424	0.419 0.322 0.194 0.456	0.950 0.943 0.909 0.968
8	0.419 0.336 0.266 0.410	0.482 0.439 0.370 0.513	0.876 0.795 0.769 0.814
9	0.401 0.288 0.258 0.321	0.459 0.380 0.348 0.413	0.881 0.807 0.784 0.822
All Farms			
1	0.460 0.404 0.345 0.461	0.540 0.535 0.477 0.595	0.860 0.768 0.735 0.790
2	0.396 0.286 0.236 0.333	0.476 0.413 0.366 0.461	0.845 0.742 0.717 0.761
3	0.596 0.600 0.523 0.685	0.663 0.680 0.603 0.764	0.894 0.863 0.825 0.897
4	0.415 0.326 0.262 0.387	0.456 0.366 0.298 0.429	0.914 0.900 0.863 0.931
5	0.424 0.338 0.260 0.413	0.462 0.387 0.306 0.463	0.926 0.898 0.873 0.918
6	0.349 0.190 0.104 0.279	0.433 0.327 0.238 0.415	0.822 0.699 0.664 0.724
7	0.456 0.408 0.317 0.499	0.512 0.484 0.392 0.579	0.922 0.904 0.876 0.929
8	0.462 0.417 0.371 0.462	0.533 0.527 0.480 0.575	0.871 0.796 0.774 0.815
9	0.441 0.367 0.343 0.392	0.507 0.465 0.440 0.492	0.877 0.810 0.790 0.827

Note: Program Farms indicates the sample of farms participating in the 1994-EU-FCP; *Non-Program Farms* indicates the sample of farms not participating in the 1994-EU-FCP; *All Farms* indicates farms participating in both aforementioned samples. The numbers in the first column of the table classify crop farms into categories according to their main production activity. In particular numbers: '1' indicates the *grain* production activity; '2' *cotton*; '3' *horticulture* and *flowers*; '4' *olive crops*; '5' *viticulture*; '6' *tobacco and other tilling cultivation*; '7' *other permanent cultivation*; '8' *multi-cultivation*; and '9' defines a group which contains all aforementioned production activities. Also, $\hat{\theta}_i$ indicates DEA efficiency scores and $\tilde{\theta}$ indicates the bias-corrected estimator of efficiency scores according to equation (20).

Table 3: Bootstrap of efficiency scores of livestock oriented farms, 1993

ι	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$
	Overall Technical Efficiency	*Pure Technical Efficiency*	*Scale Efficiency*
Program Farms			
1	0.426 0.170 0.081 0.260	0.497 0.268 0.181 0.352	0.890 0.839 0.803 0.868
2	0.591 0.498 0.378 0.618	0.662 0.575 0.456 0.689	0.905 0.893 0.830 0.941
3	0.518 0.318 0.195 0.431	0.619 0.447 0.339 0.545	0.877 0.837 0.774 0.895
4	0.496 0.299 0.241 0.355	0.575 0.400 0.347 0.453	0.891 0.853 0.816 0.884

Table 3: cont….

Non-Program Farms			
1	0.691 0.685 0.582 0.783	0.714 0.703 0.595 0.799	0.962 0.966 0.933 0.992
2	0.644 0.600 0.477 0.733	0.683 0.644 0.521 0.769	0.948 0.946 0.899 0.979
3	0.654 0.611 0.560 0.662	0.685 0.650 0.598 0.702	0.955 0.943 0.926 0.957
4	0.659 0.621 0.575 0.665	0.689 0.657 0.611 0.699	0.956 0.947 0.929 0.962
All Farms			
1	0.542 0.394 0.332 0.463	0.593 0.458 0.395 0.526	0.922 0.894 0.869 0.918
2	0.616 0.547 0.466 0.629	0.672 0.608 0.530 0.691	0.926 0.918 0.868 0.953
3	0.636 0.572 0.523 0.619	0.677 0.623 0.574 0.669	0.945 0.930 0.909 0.946
4	0.610 0.526 0.490 0.560	0.656 0.581 0.547 0.616	0.936 0.919 0.899 0.936

Note: Program Farms indicates the sample of farms participating in the 1994-EU-FCP; *Non-Program Farms* indicates the sample of farms not participating in the 1994-EU-FCP; *All Farms* indicates farms participating in both aforementioned samples. The numbers in the first column of the table classify livestock farms into categories according to their main breeding activity. In particular numbers: '1' indicates *sheep breeding*; '2' *cattle breeding*; '3' *ruminants*; and '4' defines a group which contains all aforementioned breeding activities. Also, $\hat{\theta}_i$ indicates DEA efficiency scores and $\tilde{\theta}_i$ indicates the bias-corrected estimator of efficiency scores according to equation (20).

Table 4: Bootstrap of efficiency scores of crop oriented farms, 1997

i	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$
	Overall Technical Efficiency	*Pure Technical Efficiency*	*Scale Efficiency*
Program Farms			
1	0.483 0.495 0.400 0.603	0.504 0.516 0.417 0.625	0.957 0.959 0.901 0.986
2	0.298 0.137 0.049 0.223	0.373 0.203 0.120 0.289	0.836 0.803 0.741 0.868
3	0.631 0.744 0.619 0.873	0.724 0.839 0.718 0.960	0.884 0.890 0.821 0.951
4	0.407 0.391 0.290 0.506	0.518 0.508 0.396 0.627	0.831 0.826 0.753 0.904
5	0.339 0.243 0.142 0.346	0.394 0.295 0.194 0.400	0.887 0.858 0.820 0.897
6	0.484 0.530 0.408 0.683	0.557 0.614 0.482 0.765	0.893 0.874 0.807 0.940
7	0.304 0.175 0.055 0.294	0.379 0.280 0.153 0.408	0.844 0.777 0.738 0.816
8	0.373 0.316 0.259 0.375	0.416 0.370 0.308 0.430	0.902 0.872 0.837 0.897
9	0.395 0.343 0.311 0.377	0.457 0.410 0.377 0.445	0.883 0.859 0.827 0.886
Non-Program Farms			
1	0.346 0.249 0.177 0.322	0.356 0.250 0.177 0.320	0.970 0.978 0.946 0.996
2	0.295 0.145 0.094 0.205	0.305 0.145 0.089 0.206	0.961 0.963 0.940 0.982
3	0.597 0.638 0.534 0.748	0.638 0.659 0.564 0.759	0.934 0.954 0.901 1.003
4	0.412 0.405 0.328 0.491	0.444 0.432 0.347 0.520	0.929 0.936 0.883 0.974
5	0.368 0.283 0.186 0.387	0.416 0.332 0.235 0.433	0.912 0.902 0.858 0.940
6	0.245 0.046 -0.051 0.141	0.262 0.048 -0.051 0.151	0.940 0.941 0.910 0.970
7	0.314 0.182 0.063 0.320	0.359 0.234 0.104 0.373	0.884 0.840 0.790 0.882
8	0.420 0.397 0.326 0.474	0.446 0.414 0.340 0.496	0.945 0.950 0.923 0.974
9	0.370 0.288 0.256 0.320	0.395 0.305 0.273 0.339	0.940 0.942 0.922 0.959

Table 4: cont….

All Farms			
1	0.393 0.333 0.274 0.392	0.407 0.341 0.282 0.400	0.966 0.972 0.936 0.990
2	0.296 0.143 0.097 0.191	0.327 0.164 0.120 0.212	0.920 0.911 0.886 0.938
3	0.609 0.676 0.597 0.760	0.669 0.723 0.646 0.803	0.916 0.931 0.886 0.971
4	0.410 0.401 0.335 0.471	0.466 0.455 0.388 0.528	0.899 0.903 0.856 0.947
5	0.357 0.294 0.228 0.364	0.408 0.338 0.271 0.411	0.902 0.909 0.861 0.953
6	0.309 0.176 0.088 0.259	0.341 0.200 0.113 0.285	0.927 0.923 0.889 0.942
7	0.439 0.254 0.127 0.384	0.520 0.358 0.222 0.491	0.868 0.822 0.818 0.834
8	0.398 0.359 0.311 0.409	0.432 0.393 0.345 0.443	0.924 0.912 0.889 0.932
9	0.379 0.308 0.283 0.333	0.418 0.344 0.319 0.369	0.919 0.911 0.891 0.928

Note: Program Farms indicates the sample of farms participating in the 1994-EU-FCP; *Non-Program Farms* indicates the sample of farms not participating in the 1994-EU-FCP; *All Farms* indicates farms participating in both aforementioned samples. The numbers in the first column of the table classify crop farms into categories according to their main production activity. In particular numbers: '1' indicates the *grain* production activity; '2' *cotton*; '3' *horticulture* and *flowers*; '4' *olive crops*; '5' *viticulture*; '6' *tobacco and other tilling cultivation*; '7' *other permanent cultivation*; '8' *multi-cultivation*; and '9' defines a group which contains all aforementioned production activities. Also, $\hat{\theta}_i$ indicates DEA efficiency scores and $\tilde{\theta}_i$ indicates the bias-corrected estimator of efficiency scores according to equation (20).

Table 5: Bootstrap of efficiency scores of livestock oriented farms, 1997

i	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$	2.5% - 97.5% Centered on $\hat{\theta}_i$ $\tilde{\theta}_i$ $\tilde{\theta}_i$
	Overall Technical Efficiency	*Pure Technical Efficiency*	*Scale Efficiency*
Program Farms			
1	0.479 0.287 0.200 0.378	0.568 0.407 0.323 0.494	0.868 0.810 0.769 0.846
2	0.657 0.603 0.481 0.721	0.711 0.663 0.544 0.775	0.927 0.920 0.860 0.963
3	0.427 0.187 0.067 0.314	0.577 0.371 0.256 0.480	0.805 0.746 0.666 0.819
4	0.513 0.346 0.285 0.404	0.609 0.467 0.408 0.523	0.867 0.822 0.782 0.857
Non-Program Farms			
1	0.652 0.618 0.516 0.716	0.684 0.629 0.529 0.724	0.952 0.970 0.923 1.012
2	0.683 0.680 0.554 0.803	0.699 0.679 0.559 0.797	0.975 0.993 0.942 1.024
3	0.598 0.530 0.480 0.581	0.657 0.601 0.552 0.650	0.922 0.904 0.877 0.927
4	0.615 0.559 0.514 0.603	0.665 0.614 0.573 0.656	0.932 0.923 0.899 0.944
All Farms			
1	0.554 0.431 0.364 0.497	0.618 0.504 0.437 0.567	0.905 0.880 0.847 0.910
2	0.670 0.640 0.550 0.723	0.706 0.671 0.586 0.752	0.950 0.955 0.912 0.988
3	0.575 0.486 0.441 0.529	0.646 0.572 0.525 0.614	0.907 0.884 0.856 0.905
4	0.585 0.496 0.459 0.533	0.649 0.570 0.534 0.607	0.913 0.893 0.869 0.914

Note: Program Farms indicates the sample of farms participating in the 1994-EU-FCP; *Non-Program Farms* indicates the sample of farms not participating in the 1994-EU-FCP; *All Farms* indicates farms participating in both aforementioned samples. The numbers in the first column of the table classify livestock farms into categories according to their main breeding activity. In particular numbers: '1' indicates *sheep breeding*; '2' *cattle breeding*; '3' *ruminants*; and '4' defines a group which contains all aforementioned breeding activities. Also, $\hat{\theta}_i$ indicates DEA efficiency scores and $\tilde{\theta}_i$ indicates the bias-corrected estimator of efficiency scores according to equation (20).

Tables **2** and **4** show results for crop farms for 1993 and 1997, respectively. The results are given for each main production activity for the samples of *program farms*, *non-program farms*, and *all farms*. The eight production activities which are given by numbers 1-8, in the first column of the tables are: #1 *grain*, #2 *cotton*, #3 *horticulture* and *flowers*, #4 *olive crops*, #5 *viticulture*, #6 *tobacco and other tilling cultivation*, #7 *other permanent cultivation,* and #8 *multi-cultivation*. Note that #9 groups all eight production activities into a single group showing the efficiency level of each sample of farms, *i.e. program farms*, *non-program farms*, and *all farms*. For the year 1993 (Table **2**), the bias-corrected estimates ($\tilde{\theta}_i$) indicate that *overall* and *pure* efficiency measures for *program farms* as a group, *i.e.* #9, are greater than those of *non-program farms* (#9) while *scale efficiency* measures are about the same for both *program* and *non-program* group of farms (#9). These results are also supported by the respective confidence intervals which are not overlapping for both *overall* and *pure* technical efficiency scores but are overlapping to a notable extend for *scale* efficiency measures. It is worth stating that *overall* and *pure* bias-corrected estimates ($\tilde{\theta}_i$) of each one of the production activities (except for #5) are greater for *program* farms than those for *non-program* farms while this is not the case for *scale efficiency* estimates. These results are also supported by the corresponding confidence intervals which are not overlapping for both *overall* and *pure* technical efficiency scores for each one of the production activities (except for #5), but this is not true for *scale* efficiency measures.

Three years after the enactment of the 1994-EU-FCP, *i.e.* in 1997 (Table **4**), the results for *program* farms as a group, *i.e.* #9, indicate a decrease in *overall* and *pure* efficiency and an increase in *scale* efficiency. Among the production activities showing a decrease in *overall* efficiency are #1, #2, #3, #7 and #8; those experiencing a decline in *pure* efficiency are #1, #2, #7 and #8; and those showing an increase in *scale* efficiency are #1, #2, #6 and #8. The results for *non-program* farms as a group, *i.e.* #9, indicate no change in *overall* efficiency, a decrease in *pure* efficiency and an increase in *scale* efficiency. Among the production activities indicating a decline in *overall* efficiency are #2, #5 and #7 while those showing an increase are #3, and #4; those experiencing a decrease in *pure* efficiency are #1, #2 and #6; and the majority of the production activities show an increase in *scale* efficiency. The aforementioned results are also supported by the corresponding confidence intervals.

A comparison of the results between *program* and *non-program* farms for the year 1997 (Table **4**) indicates that even-thought both *overall* and *pure* efficiency estimates have declined for the group of *program* farms (#9), compared to the 1993 year estimates, still both of these estimates are higher than those of the group of *non-program* farms (#9). This is also supported by the respective confidence intervals. However, there is a number of production activities, *i.e.* #2, #4, #5 and #7, which shows similar performance in terms of *overall* and *pure* efficiency as the corresponding bias-corrected estimates ($\tilde{\theta}_i$) and confidence intervals indicate. In terms of scale efficiency, the group of *program* farms (#9) show lower estimates than the group of *non-program* farms (#9), and this is also supported for each one of the production activity estimates with the corresponding confidence intervals showing small overlapping.

Tables **3** and **5** show results for livestock farms for 1993 and 1997, respectively. The results are given for each main breeding activity for the samples of *program farms*, *non-program farms*, and *all farms*. The three breeding activities which are given by numbers 1-3, in the first column of the tables are: #1 *sheep breeding,* #2 *cattle breeding,* and #3 *ruminants*. Note that #4 groups all three breeding activities into a single group showing the efficiency level of each sample of farms, *i.e. program farms*, *non-program farms*, and *all farms*. For the year 1993 (Table **3**), the bias-corrected estimates ($\tilde{\theta}_i$) indicate that *overall*, *pure* and *scale* efficiency measures for *program farms* as a group, *i.e.* #4, as well as for each breeding activity, *i.e.* #1, #2 and #3, are smaller than those of *non-program farms* as a group (#4) and for the corresponding breeding activities, *i.e.* #1, #2, and #3. These results are also supported by the respective confidence intervals which are not overlapping (except for #2) for *overall*, *pure* and *scale* efficiency scores.

Three years after the enactment of the 1994-EU-FCP, *i.e.* in 1997 (Table **5**), the results indicate an increase in *overall* and *pure* efficiency of the *program* farms as a group (#4) and for each breeding activity, except

#3. With regard to the *scale* efficiency the results show a fall in efficiency for the *program* farms as a group (#4) and for each one of the breeding activities, except #2. The results also indicate a decline in *overall* and *pure* efficiency for *non-program* farms as a group (#4) and for each breeding activity of this group of farms *i.e.* #1-#3. With regard to the *scale* efficiency of *non-program* farms the results indicate a decrease in efficiency of these farms as a group (#4) but an increase of breeding activities #1 and #2 and a decline in #3. Note that the aforementioned results are conditional on the degree of overlapping of the corresponding confidence intervals. A comparison of the results between *program* and *non-program* farms for the year 1997 (Table **5**) underlines that even-thought both *overall* and *pure* efficiency estimates have increased for *program* farms as a group (#4) and for each one of the breeding activities (except 3), compared to the 1993 year estimates, still both of these estimates are smaller than those of *non-program* farms. Furthermore, *scale* efficiency measures for *program* farms as a group (#4) and for each one of the breeding activities (#1-#3) are smaller than the corresponding measures of *non-program* farms. These results are also supported by the respective confidence intervals which are not overlapping (except for #2) for *overall*, *pure* and *scale* efficiency scores.

From the empirical results discussed in the present subsection several general points can be drawn for both groups of crop and livestock farms. Firstly, the group of *program* crop-farms shows higher efficiency (*overall* and *pure*) than the group of *non-program* crop-farms before the enactment of the program, while the opposite occurs for the group of livestock farms. Secondly, three years after the enactment of the program, the group of *non-program* crop-farms shows no change in *overall efficiency* and a decline in *pure efficiency*, while the group of livestock farms shows a decline in both *overall* and *pure* efficiency. Thirdly, three years after the enactment of the program, the group of *program* crop-farms shows a decline in efficiency (*overall* and *pure*) while the opposite occurs for the group of livestock farms. Thus, the results indicate that, in terms of the crop oriented farms, the program failed to increase the efficiency of the participated farms even though the most efficient farms entered the 1994-EU-FCP. In contrast, in terms of the livestock oriented farms, the program managed to increase the efficiency of the participated farms though the less efficient farms entered the program.

In general, the finding of the present study, in terms of the crop-oriented farms, is in similar lines with that of Rezitis *et al.* (2005), which indicates that the program failed to increase the average *overall* efficiency of crop-oriented farms. However, the results of the present study cannot be compared with those of Rezitis *et al.* (2003) since the latter does not present results at this level of disaggregation, *i.e.* crop and livestock oriented farms, like the former. Note that the general conclusion of the study by Rezitis *et al.* (2003) is that the program failed to increase the efficiency of the group of all farms, *i.e.* crop and livestock farms considered together. Finally, the finding of the present study, with regard to the crop oriented farms, is in agreement with other studies such as Schultz (1964), Steitieh (1971), Taylor *et al.* (1986), Striewe *et al.* (1996), and Brummer and Loy (2000), which argue that while credit programs do give farmers the opportunity to invest in more modernized capital inputs, they do not provide assurance that these inputs will be used in such an efficient manner so that farmers can realize the full extent of possible output gains.

Productivity Change

Comparison of farms' efficiency between the two years, *i.e.* 1993 and 1997, partly reveals changes in the performance of the farms. This is because changes in distance functions from 1993 to 1997 could be due either to movements of farms within the input/output space or to technological change, *i.e.* to movement of the boundary of the production set between the two years. Thus, examining solely efficiency estimates could give incomplete information about the performance of farms between 1993 and 1997. A complete view of the performance of farms could be obtained by estimating productivity indices of the form given by (16).

Tables **6** and **7** report bootstrap estimates of productivity change, *i.e.* $\tilde{M}_i(t,t+1)$, and its components, *i.e.* $\Delta \tilde{Eff}_i$, $\Delta \tilde{PureEff}_i$, $\Delta \tilde{Scale}_i$, $\Delta \tilde{Tech}_i$, $\Delta \tilde{PureTech}_i$, $\Delta \tilde{ScaleTech}_i$, as derived in equation (16), for crop and livestock farms respectively. Application of the bootstrap methodology allows assessment of the "null hypothesis" of no *efficiency change*, no *pure efficiency change*, no *scale efficiency change*, no *technical change*, no *pure* *change in technology*, no *change in the scale of the technology* and no *productivity change*, which indicates that the corresponding measures are not statistically different from unity. Resampling has been carried out for *B*=1000, *i.e.* 1000 pseudo-samples have been used. Results for 90% and 95% confidence intervals are provided. If the 95% confidence interval contains unity then the corresponding measure is not significantly different from one at the 5% significance level. In contrast, when the confidence interval does not contain unity, it can be concluded that the corresponding measure is significantly different from unity. An analogous interpretation is applicable for the 90% confidence interval, and the conclusion should be made at the 10% significance level.

Table **6** reports estimates of changes of total factor productivity and its components of crop farms for each main production activity for the samples of *program farms*, *non-program farms*, and *all farms*. The eight production activities which are given by numbers 1-8, in the first column of the table, are the same as those of Tables **2** and **4** described previously. Note that #9 groups all eight production activities into a single group showing estimates of changes of total factor productivity and its components of each sample of farms, *i.e. program farms*, *non-program farms*, and *all farms*. The results indicate a statistically significant decline of total factor productivity, *i.e.* $M_i(t,t+1)$, for the group of *program farms* (#9) but a statistically significant increase for the group of *non-program farms* (#9). This outcome is supported by the changes of the means of the variables presented in Table **1**. In particular, for crop *program* farms the increase of each one of the inputs, between 1993 and 1997, was greater than the increase of the output, while, for *non-program* farms the opposite occurred, except for intermediate input (X_4).

Table 6: Total factor productivity index and its components for crop oriented farms

i	$\Delta \tilde{Eff}_i$ $\Delta \tilde{PureEff}_i$ $\Delta \tilde{Scale}_i$	$\Delta \tilde{Tech}_i$ $\Delta \tilde{PureTech}_i$ $\Delta \tilde{ScaleTech}_i$	$\tilde{M}_i(t,t+1)$
Program Farms			
1	0.655** 0.505** 1.228**	1.036 1.411** 0.647	0.691**
2	0.457** 0.405** 1.058	1.125 1.765** 0.510**	0.533**
3	0.909 0.888 1.022	1.081 1.502** 0.674*	0.986
4	0.899 1.055 0.846**	1.144** 1.792** 0.564**	1.015
5	0.740** 0.733** 0.996	1.234** 2.795** 0.188**	0.916
6	0.943 0.804 1.158**	1.107** 1.401** 0.695	1.044
7	0.012** 0.041** 0.926**	1.220** 2.699** 0.160**	0.027**
8	0.661** 0.592** 1.100**	1.136** 1.866** 0.487**	0.753**
9	0.627** 0.583** 1.053**	1.135** 1.874** 0.485**	0.713**
Non-Program Farms			
1	0.927 0.717** 1.263**	1.146** 1.7892** 0.549**	1.059
2	0.711** 0.514** 1.278**	1.120** 1.638** 0.617**	0.805**
3	1.074 0.759 1.401**	1.770** 4.615** 0.140*	1.871**
4	1.266** 1.186** 1.081**	0.964 1.498** 0.540**	1.248**
5	0.927 0.713** 1.299**	1.161 2.506** 0.151**	1.090
6	0.835 0.594** 1.326**	1.003 1.602** 0.561**	0.840
7	0.712* 0.802 0.890**	1.364** 2.022** 0.541**	0.986
8	1.058 0.892 1.189**	1.138** 1.726** 0.583**	1.207**
9	0.953 0.812** 1.164**	1.121** 1.696** 0.585**	1.067**
All Farms			
1	0.831** 0.643** 1.251**	1.107** 1.653** 0.585**	0.922
2	0.625** 0.480** 1.204**	1.123** 1.683** 0.586**	0.714**

Table 6: cont….

3	1.026 0.811 1.261**	1.489** 3.179** 0.240**	1.517**
4	1.155** 1.152** 1.007	1.015 1.584** 0.552**	1.183**
5	0.865 0.728** 1.177**	1.190** 2.623** 0.174**	1.033
6	0.867 0.650** 1.279**	1.030 1.551** 0.599**	0.894
7	0.193** 0.252** 0.867**	1.453** 3.086** 0.153**	0.318**
8	0.854** 0.739** 1.146**	1.138** 1.795** 0.538**	0.974
9	0.824** 0.723** 1.122**	1.126** 1.762** 0.549**	0.928**

Note: Program Farms indicates the sample of farms participating in the 1994-EU-FCP; *Non-Program Farms* indicates the sample of farms not participating in the 1994-EU-FCP; *All Farms* indicates farms participating in both aforementioned samples. The numbers in the first column of the table classify crop farms into categories according to their main production activity. In particular numbers: '1' indicates the *grain* production activity; '2' *cotton*; '3' *horticulture* and *flowers*; '4' *olive crops*; '5' *viticulture*; '6' *tobacco and other tilling cultivation*; '7' *other permanent cultivation*; '8' *multi-cultivation*; and '9' defines a group which contains all aforementioned production activities. Also, $\Delta\widetilde{Eff}_i$, $\Delta\widetilde{PureEff}_i$, $\Delta\widetilde{Scale}_i$, $\Delta\widetilde{Tech}_i$, $\Delta\widetilde{PureTech}_i$, $\Delta\widetilde{ScaleTech}_i$ and $\widetilde{M}_i(t,t+1)$ indicate the bias-corrected estimators of *efficiency change*, *pure efficiency change, scale efficiency change, technical change, pure change in technology, change in the scale of technology,* and *total factor productivity index*, respectively. Finally, single asterisks (*) denote significant differences from unity at 0.10; double asterisks (**) denote significant differences from unity at 0.05.

The total factor productivity deterioration of the group of *program farms* (#9) is attributed exclusively to the significant decrease of efficiency change, *i.e.* $\Delta\widetilde{Eff}_i$, which outweighs the technical progress, *i.e.* $\Delta\widetilde{Tech}_i$. In contrast, the total factor productivity improvement of the group of *non-program farms* (#9) is attributed exclusively to the technical progress, *i.e.* $\Delta\widetilde{Tech}_i$, because the *efficiency change* component, *i.e.* $\Delta\widetilde{Eff}_i$, is not significantly different from unity, *i.e.* it does not indicate any statistically significant change. It is worth stating that the two components, *i.e. pure efficiency change* ($\Delta\widetilde{PureEff}_i$) and *scale efficiency change* ($\Delta\widetilde{Scale}_i$), of the *efficiency change* term ($\Delta\widetilde{Eff}_i$) show similar effects for both *program* and *non-program* group of farms. In particular, the $\Delta\widetilde{PureEff}_i$ component shows a significant deterioration of *pure* efficiency while the $\Delta\widetilde{Scale}_i$ component indicates a significant increase in *scale* efficiency. Nevertheless, in the group of *program farms*, the deterioration in *pure* efficiency ($\Delta\widetilde{PureEff}_i$) outweighs the improvement in *scale* efficiency ($\Delta\widetilde{Scale}_i$) and thus the net effect is a significant deterioration in *efficiency* change ($\Delta\widetilde{Eff}_i$). This is in contrast, in the group of *non-program* farms, where, the deterioration in *pure* efficiency ($\Delta\widetilde{PureEff}_i$) is offset by the improvement in *scale* efficiency ($\Delta\widetilde{Scale}_i$) and thus the net effect is not any significant *efficiency* change ($\Delta\widetilde{Eff}_i$). With regard to the two components of the technical change term ($\Delta\widetilde{Tech}_i$), *i.e. pure change in technology* ($\Delta\widetilde{PureTech}_i$) and change in the *scale of technology* ($\Delta\widetilde{ScaleTech}_i$), the results show similar effects in both *program* and *non-program* group of farms with the final outcome resulted in technical progress. In particular, the $\Delta\widetilde{PureTech}_i$ component is statistically significant greater than one and thus indicates an upwards shift in the variable return to scale technology, *i.e.* an increase in pure technology. Furthermore, the $\Delta\widetilde{ScaleTech}_i$ is statistically significant less than one indicating, according to Simar and Wilson (1998b), flattening of the technology and changes towards constant returns to scale, or, according to Zofio and Lovell (1997), the production becomes more scale efficient relative to the contemporaneous technology than relative to the previous technology.

The aforementioned results are also supported by the empirical findings at the main crop production activity level. In particular, the results show that none of the crop production activities for *program* farms experienced any significant increase in total factor productivity, *i.e.* $\tilde{M}_i(t,t+1)$, four experienced a significant decline (#1, #2, #7 and #8) and the rest did not show any significant change in $\tilde{M}_i(t,t+1)$, while for *non-program* farms three activities (#3, #4 and #8) experienced a significant increase in $\tilde{M}_i(t,t+1)$, one experienced a decrease (#2) and the rest showed no change. It is worth stating that the majority of the crop production activities for both *program* and *non-program* farms showed, in terms of the *technical change* component, *i.e.* $\Delta\tilde{Tech}_i$, significant technical progress but the same did not happen in terms of the *efficiency change* component, *i.e.* $\Delta\tilde{Eff}_i$. In particular the majority of crop production activities for *program* farms (#1, #2, #5, #7 and #8) showed significant inefficiencies and the rest of them did not show any statistically significant change of efficiency, while the majority of crop activities for *non-program* farms (#1, #3, #5, #6, and #8) did not show any significant change in technical efficiency, two (#2 and #7) showed a significant decrease and only one (#4) showed a statistically significant increase. Finally, the findings of the present study, with regard to the productivity growth of crop oriented farms, agree in part with the results of Rezitis *et al.* (2005). In particular, the results of the study by Rezitis *et al.* (2005) indicate that the decrease of total factor productivity growth is attributed to the efficiency deterioration and to technical regress while the results of the present study support that the decrease of total factor productivity growth is attributed exclusively to the decrease of efficiency change which outweighs the technical progress found in the present study.

Table **7** reports estimates of changes of total factor productivity and its components of livestock farms for each main production activity for the samples of *program farms*, *non-program farms*, and *all farms*. The three production activities which are given by numbers 1-3, in the first column of the table, are the same as those of Tables **3** and **5** described previously. Note that #4 groups all three production activities into a single group showing estimates of changes of total factor productivity and its components of each sample of farms, *i.e. program farms*, *non-program farms*, and *all farms*. The results indicate a statistically significant increase of total factor productivity, *i.e.* $\tilde{M}_i(t,t+1)$, for the group of *program farms* (#4) but no change for the group of *non-program farms* (#4). The outcome of the increase of productivity of livestock *program* farms is supported by the changes of the means of the variables presented in Table **1**. In particular, for livestock *program* farms, the increase of each one of the inputs, between 1993 and 1997, was smaller, except for the capital input (X_1), than the increase of the output.

Table 7: Total factor productivity index and its components for livestock oriented farms

i	$\Delta\tilde{Eff}_i$ $\Delta\tilde{PureEff}_i$ $\Delta\tilde{Scale}_i$	$\Delta\tilde{Tech}_i$ $\Delta\tilde{PureTech}_i$ $\Delta\tilde{ScaleTech}_i$	$\tilde{M}_i(t,t+1)$
Program Farms			
1	1.362** 1.365** 0.996	1.038 1.629** 0.523**	1.404**
2	1.175 1.148 1.025	1.117** 1.466** 0.617	1.322**
3	0.704** 0.834 0.849*	0.972 1.593** 0.324*	0.691**
4	1.115* 1.154** 0.963	1.040 1.581** 0.502*	1.161**
Non-Program Farms			
1	0.862 0.855 1.005	1.112** 1.472** 0.702	1.057
2	1.135 1.076 1.060*	1.091** 1.417* 0.696	1.240**
3	0.867** 0.917 0.947**	1.021 1.436** 0.652*	0.887*
4	0.894** 0.925 0.967*	1.042 1.441** 0.665*	0.933
All Farms			
1	1.132** 1.131** 1.001	1.070** 1.564** 0.603**	1.206**

Table 7: cont….

2	1.160* 1.117 1.042	1.105** 1.448** 0.662	1.287**
3	0.845** 0.906* 0.934**	1.015 1.465** 0.616**	0.860**
4	0.957 0.991 0.966*	1.041 1.487** 0.621**	0.999

Note: Program Farms indicates the sample of farms participating in the 1994-EU-FCP; *Non-Program Farms* indicates the sample of farms not participating in the 1994-EU-FCP; *All Farms* indicates farms participating in both aforementioned samples. The numbers in the first column of the table classify livestock farms into categories according to their main breeding activity. In particular numbers: '1' indicates *sheep breeding*; '2' *cattle breeding*; '3' *ruminants*; and '4' defines a group which contains all aforementioned breeding activities. Also, $\Delta \tilde{Eff}_i$, $\Delta \tilde{PureEff}_i$, $\Delta \tilde{Scale}_i$, $\Delta \tilde{Tech}_i$, $\Delta \tilde{PureTech}_i$, $\Delta \tilde{ScaleTech}_i$ and $\tilde{M}_i(t,t+1)$ indicate the bias-corrected estimators of *efficiency change*, *pure efficiency change, scale efficiency change, technical change, pure change in technology, change in the scale of technology,* and *total factor productivity index*, respectively. Finally, single asterisks (*) denote significant differences from unity at 0.10; double asterisks (**) denote significant differences from unity at 0.05.

The total factor productivity increase of the group of *program farms* (#4) is attributed exclusively to the significant increase of *efficiency*, *i.e.* $\Delta \tilde{Eff}_i$, considering that the *technical change* component, *i.e.* $\Delta \tilde{Tech}_i$, does not indicate any statistically significant change. In contrast, the unchanged total factor productivity, *i.e.* $\tilde{M}_i(t,t+1)$, of the group of *non-program farms* (#4) is attributed exclusively to the unchanged *technical change* component, *i.e.* $\Delta \tilde{Tech}_i$, considering that the *efficiency change* component, *i.e.* $\Delta \tilde{Eff}_i$, decreases. It is worth stating that the two components, *i.e. pure efficiency change* ($\Delta \tilde{PureEff}_i$) and *scale efficiency change* ($\Delta \tilde{Scale}_i$), of the *efficiency change* term ($\Delta \tilde{Eff}_i$) show different effects for each group of farms, *i.e. program* and *non-program* farms. In particular the $\Delta \tilde{PureEff}_i$ component shows a significant improvement of *pure efficiency* for the group of *program farms* and no change for the group of *non-program* farms while the $\Delta \tilde{Scale}_i$ component indicates no change in *scale* efficiency for the group of *program* farms but deterioration for the group of *non-program* farms. Thus, the improvement in *efficiency* ($\Delta \tilde{Eff}_i$) of the group of *program farms* is due to the improvement in *pure* efficiency ($\Delta \tilde{PureEff}_i$), while the deterioration in *efficiency* ($\Delta \tilde{Eff}_i$) of the group of *non-program farms* is due to the deterioration in *scale* efficiency ($\Delta \tilde{Scale}_i$). With regard to the two components of the *technical change* term ($\Delta \tilde{Tech}_i$), *i.e. pure change in technology* ($\Delta \tilde{PureTech}_i$) and *change in the scale of technology* ($\Delta \tilde{ScaleTech}_i$), the results show similar effects in both *program* and *non-program* group of farms with the final outcome indicating no technical change. In particular, the $\Delta \tilde{PureTech}_i$ component is statistically significant greater than one at the 5% significance level, and thus indicates an upwards shift in the variable return to scale technology, *i.e.* an increase in pure technology. The $\Delta \tilde{ScaleTech}_i$ component, however, is not statistically significant different than one at the 5% significance level, indicating that there is not any significant change in the scale of technology (Simar and Wilson, 1998b; Zofio and Lovell, 1997). Thus, the unchanged *technical change* component ($\Delta \tilde{Tech}_i$) of both group farms is due to the unchanged *scale of technology* component ($\Delta \tilde{ScaleTech}_i$) which outweighs the *pure change in technology* component ($\Delta \tilde{PureTech}_i$).

The aforementioned results are also supported by the empirical findings at the main livestock production activity level. In particular, the results show that two of the livestock production activities (#1 and #2) for *program* farms experienced significant increase in total factor productivity, *i.e.* $\tilde{M}_i(t,t+1)$, and only one experienced a significant decline (#3), while for *non-program* farms one activity (#2) experienced a significant increase in $\tilde{M}_i(t,t+1)$, one experienced a decrease (#3) and one did not show any significant change (#1). Among the group of program farms, livestock activities #1 and #2 experienced an increase in total factor productivity, while #3 experienced deterioration. The increase in productivity for #1 was due to the efficiency improvement whereas the increase for #2 was due to technical progress. The activity #3 experienced a decline in productivity due to efficiency deterioration. Among the group of *non-program* farms, livestock activity #2 experienced an increase in total factor productivity due to technical progress, while #3 experienced productivity deterioration due to efficiency deterioration. Finally, livestock activity #1 does not show any productivity change and the performance of this activity is the one which causes the main differences between the group of *program* and *non-program* livestock farms.

6. CONCLUSIONS

This study examines technical efficiency and productivity growth of Greek farms participating in the 1994-EU-FCP, *i.e.* regulation 2328/91. In this paper, two farm-level economic data sets are used, *i.e.* the crop and the livestock data set, where each one consists of two different groups of farms: one group contains farms participating in the 1994-EU-FCP while the other one contains non-participating farms. The data sets are observed over the 1993 and 1997 years. The 1993 data set describes the economic condition of farms the year before the enactment of the 1994-EU-FCP, while the 1997 data set shows their condition three years after the enactment of the program. This paper uses the approach developed by Simar and Wilson (1998a, b) to bootstrapping both DEA efficiency measures and Malmquist productivity indices. In addition, the present paper uses the Malmquist index decomposition proposed by Simar and Wilson (1998b) and Zofio and Lovell (1997) to investigate the sources of productivity change.

The technical efficiency score results, in terms of the crop oriented farms, indicate that the program failed to increase the efficiency of the participated farms even though the most efficient farms entered the 1994-EU-FCP. In contrast, in terms of the livestock oriented farms the program achieved to increase the efficiency of the participated farms though the less efficient farms entered the program. The total factor productivity growth results, in terms of crop-oriented farms, show statistically significant decline of total factor productivity of the group of *program* farms but a statistically significant increase for the group of *non-program* farms.

The total factor productivity deterioration of the group of *program* farms is attributed exclusively to the significant deterioration of efficiency, which outweighs the technical progress. This indicates that farmers participated in the 1994-EU-FCP are unable to use the new technology efficiently. This could be attributed to the fact that most of the crop-oriented program farms are located in the most disadvantageous regions of the country, *i.e.* mountainous areas, and thus the adoptions of new technology, *e.g.* tractors, was not accommodated by the expansion of land size causing inefficient use of the new technology. In contrast, the total factor productivity improvement of the group of *non-program* farms is attributed exclusively to technical progress because the efficiency change component does not indicate any statistically significant change. The total factor productivity growth results, in terms of livestock oriented farms, show a statistically significant increase of total factor productivity for the group of *program* farms but no change for the group of *non-program* farms. The total factor productivity increase of the group of *program* farms is attributed exclusively to the significant increase of efficiency considering that the technical change component does not indicate any statistically significant change. In contrast, the unchanged total factor productivity of the group of *non-program* farms is attributed exclusively to the unchanged technical change component, considering the decrease of the efficiency component.

The findings of the present paper with regard to the crop-oriented farms might also be attributed to the way the FCP was implemented at the national level, *i.e.* Greece. As it was mentioned in the introduction of the present paper, the selection of farms participated in the FCP was based on certain techno-economic indicators which are constructed by the Greek Department of Agriculture. These techno-economic indicators are created at the regional level, corresponding to each one of the 13 regions of Greece, and not at the local level, *e.g.* county level, because of the lack of appropriate scientifically founded data.

Consequently, the administrative process for selecting the crop oriented participating farms should be altered and it should not be based on general regional techno-economic indicators but rather on more specific local indicators. This is more important for crop oriented farms rather than for livestock oriented farms because crop oriented farms are more dependent on the local farming conditions, *e.g.* physical environment, soil quality, climate, local farming practices *etc.*, than the livestock oriented farms. Finally, the effects on the economies of scale to the farm from the potential adoption of an improvement plan should be introduced as an additional criterion for selecting the submitted improvement plans, beyond the currently existing selection criteria, *e.g.* total value of investment.

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CHAPTER 4

Institutional Innovations in the Common Agricultural Policy: A Theoretical Approach based on Legitimacy

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Abstract: The Common Agricultural Policy (CAP) of the European Union (EU) has been highly political and social controversy, within the EU as well as at international level. However, the reforms on the institutional structure have not been frequently analysed. This paper, based on the Institutional Innovation Theory, examines the role of different exogenous and endogenous factors which have been boosted or slowed down, the five CAP reforms. According to these factors we analyse three key issues in the EU general political system, two topics in the EU domestic-economic system and the external pressures. Later, these factors are considered on a theoretical approach applying investment theory and expected utility maximization by means of the net present value model and dependency relations. The main results show that role played by the EU institutional structure is fundamental as a limited factor, and the external pressures and citizen's acceptance of this policy are an important boost factor.

Keywords: Institutional innovation, common agricultural policy, political structures, allocation of public funds, social changes.

INTRODUCTION

The development of the European Union (EU) Common Agricultural Policy (CAP) is determined by the relations of social, economic and institutional factors over time, in addition to their feedback. As a result, this policy has become a highly complex institutional structure which has substantial economic effects both within and outside the EU(Runge and von Witzke 1987).

The CAP is composed of a set of guidelineswhich have defined the formal rules of the system (Williamson 2002). These rules, which have induced important changes in the agricultural sector since the 1950s, have been planned and designed from five fundamental reforms (Reform of 1988; Reform of 1992; Agenda 2000; Intermediate Review of 2003; and Health Check of 2008). By means of the CAP Reforms, the political-decision makers have tried to solve the problems caused by this Policy implementation and adapt it to the rapid economic and social changes. Nevertheless, the CAP continues to be a very controversial policy transformed into a weakness open to criticisms. The critics and scepticism in the EU are due to its difficulty responding and balancing priorities from citizens and agricultural sector, together with its high budget. Outside the EU, trade distortions, which have been introduced in international agricultural markets, are the main issue of conflict.

Currently, new transformations of the CAP are being discussed and the agricultural sector has a negative view about the European agriculture future because of an expected reduction in the budget and the unstable regulatory framework. The economic literature has analysed the CAP characteristics, objectives, measures, budgets, efficiency or effects (Rosenblatt *et al.* 1988, Josling and Moyer 1991, Ackrill 2000, Fuller and Beghin 2007). However, we undertake a review of the economic, social and political factors which have been keys for inducing the changes introduced into the CAP. Then we propose a theoretical model which sets out a way to estimate the probability of obtaining an increase in legitimacy, *i.e.* the interest in implementing CAP reforms from a social viewpoint. The study was developed in two steps. Firstly, the

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Institutional Innovation Theory from the standpoint of demand allows us to get a holistic path to examine the most mentioned factors in the literature: some issues in the EU general political system, two topics in the EU domestic-economic system –*i.e.* resource and fund misallocation together with social changes– and the external pressures. Secondly, the theoretical model was designed based on economic policy principles and introducing pecuniary and non-pecuniary functions of agriculture, applying investment theory and expected utility maximization.

Below, in Section 3 and 4, we describe the main factors which have limited or induced to the institutional changes in the CAP from standpoint of demand. Next, the theoretical model is developed. Finally, the chapter is closed with a review of the main conclusions and a brief discussion of the most relevant issues.

The political framework of the EU and the Common Agricultural Policy

The Induced Innovation Theory was first proposed by Hayami and Ruttan in the 1970s (Hayami and Ruttan 1971). It is based on both the definition of institution as guidelines for societies or organizations that facilitates coordination among persons and helps them to form the expectations to behave rationally in their relations and the definition of institutional innovation as changes in: 1) the behaviour of organizations; 2) the relations among organizations and their setting; and 3) the guidelines that establish conducts and relations in the context of organizations (Ruttan and Hayami 1984). In addition, one assumption is that institutions are endogenous factors in the economic process. This theory studies the supply and demand factors which induce institutional innovations to the processes of agricultural development.

We assume that the CAP has caused fundamental institutional innovations for EU countries since the rules imposed by this policy have determined the economic agents' behaviours and actions (official organizations, farmers, consumers and tax payers). Furthermore, the CAP is endogenous to economic development process in the EU. Thus, the transformations into the CAP have been provoked by supply and demand factors. From a demand standpoint, three factors have been identified as the main boosted or limited ones in inducing CAP changes across the EU political framework.

The first one is connected with the political, social and economic frames which surround the CAP born. The creation of the EU was focus on linking economically European territories in order to avoid future armed conflicts. The CAP is considered the first common policy of the Community. Politicians expected that agricultural Policy would generate the ties for planning other policies. These particularities have constituted a limit for institutional innovations since modifications, which encompass issues such as flexibility, subsidiarity and even renationalization, are still considered a threatened for the EU supranational character.

Moreover, the CAP has become a highly complex policy not only from the legal standpoint but also in relation to the decision-making process. The different innovations implemented by each reform have brought about multitude of regulations. This high complexity has converted this policy into an unwieldy question for farmers and citizens, and the transaction costs have increased. The necessity of simplification and transparency has been a key issue to induce innovations. In 2008 some changes have been made in this line –*i.e.* the implementation of the single CMO (Common Market Organization) and of some citizens' participation mechanisms, but they are not enough. In the next reform both to make easier the bureaucratic frame and to involve higher percentage of citizens in the CAP processes will be aims again.

From the perspective of the EU decision-making process, since 1965 the agricultural decisions were adopted by unanimity in the EU Council[1]. Recently, the decision-making structure in the agricultural

[1] Since 1 January 2007, a qualified majority was considered to have been reached when a majority of the Member States gives their approval and a minimum of 255 votes (73.9% of the total) back the proposal. Furthermore, each Member State can request that the votes in favour represent at least 62% of the EU population. In the case of unanimity, each Member State can exercise a veto if it opposes the agreement of the legislative text.

framework has turn into qualified majority vote in the EU Council. Consequently, it will be easier to adjust agricultural Policy to the changes produced in the general environment, favouring the institutional innovations on it.

Related to the EU financing system, the general perception of injustice due to the EU fund transfers between countries has also been identified as an inducted factor of transformations in the CAP (Runge and von Witzke 1990). The countries seek to minimize their payments and maximize their receipts, while there is no direct relationship between the requests of the countries and their financial responsibility[2].The net contributors countries have pressured to maintain a strict budgetary discipline as well as to reduce the budget that would not exceed 1% of the community Gross National Income (GNI). Some reduction in general budget will imply a decrease in the agricultural funds since it is one of the most important and controversial heading. In fact, the agricultural budget has been decreased in relative terms since Agenda 2000 (in 2009 the agricultural budget was 34% of the European total one, in 2013 it will be 30%, approximately); in spite of agricultural protection in absolute terms had not appreciably diminished. According to the data of the OECD, since 1990 the Producer Support Estimate[3] of the EU remained above 30%, depending on the difference between national and international farm prices (OECD 2005).

On the other hand, the model of political management in the EU is not focussed on the subject of the policies –*i.e.* the government (hierarchical or pyramidal models)– but rather on the structure, the activities and the behaviour of the object, the citizenry. However, the EU does not have a democratic decision-making process on the European scale, suffering the so-called democratic deficit (Schmitter 2003). This characteristic complicates the legitimization of political interventions, especially when the actions do not have the same consequences for all citizens. The democratic deficit has recently become worse. The 2008 financial crisis has raised some protests in Greece, Belgium, the United Kingdom and France. Furthermore, Euro-sceptic groups have attracted attention and they have even formed a political party (Libertas) since the Irish refusal to ratify the EU's Constitution in 2008. Thus, "to respond to the political regulatory expectations of national populations" has become a pillar where the legitimacy of the EU should be upheld (European Commission 2001). In this regard, the necessity of political legitimacy has become a determining factor of institutional innovation in the CAP. Nevertheless, the agricultural lobbies, which have been quite organized than consumers and taxpayers, have pursued the status quo of the CAP. Also, from the sociological standpoint, farmers tend to mobilize so as not to lose their status quo, more than citizens do to achieve lower prices. Consequently, the collective action crystallized in agricultural movements has become a limit to institutional innovation.

Resource and fund allocation, social changes and external pressures: their roles in the institutional changes of the CAP.

Historically, the EU decision makers designed the CAP from a clearly Neoclassical economics approach: focused on technology and accumulation of capital to improve the economic development. However, poor policy foresight caused many undesirable effects which persist nowadays in a recursive way.

The resources and funds misallocation have turn into repetitive elements that enhance the CAP's innovations in measures[4]. The high levels of protection implemented by the CAP and the improvement on technology, the so-called modernization and mechanization of agriculture, enabled a leap in productivity

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[2]The European Council and the Parliament are responsible for approving the general UE budget, while the European Commission oversees its execution. Despite this arrangement, it is estimated that the member states are responsible for executing 85% of the budget.

[3] The Producer Support Estimate (PSE) is calculated by the support received by producers through institutional prices and direct aid, defined as the annual gross transfer from consumers and tax payers to producers, derived from agrarian policies. Therefore, it measures the transfers as a percentage of gross agricultural income.

[4] The CAP objectives and general principles have not been modified up to now (only in the Agenda 2000, food quality and safety, rural development, and environmental protection were included as new objectives of EU agriculture).

throughout the 1970s. The self-sufficiency levels were exceeded and surpluses were generated. This overproduction increased the budget significantly as well as the inefficiency in resources and funds reallocation. In addition, some measures –*i.e.* quotas or institutional prices– were ineffective in terms of competitiveness of farms and environmental protection. Until 1992, the main instruments of market regulation such as institutional prices or quotas were maintained. From the 1990s, institutional prices were decreasing and direct aid were gradually establishing. After 2008 Reforms (the CAP Health Check), the European Commission has definitively implemented the decoupled direct payments to farms, advancing in the simplification and giving more relevance to measures direct to rural development and environmental protection. Nowadays decoupled direct aid are the main measures of market regulation (69% of CAP's budget in 2009) (European Commission 2009). These aids are calculated according to the economic support received by the farmers in a period of time. They can obtain the direct aids without producing. As a result, the land can be wasted and the equity on funds reallocation is not guarantee since the largest farms in the most productive regions, and often belonging to large companies, receive the most money[5]. Such facts have prompted and exacerbated the public's perception that protection is a privilege and it is not a justified contribution to an economic activity that satisfies social needs.

With respect to farmer income, when the economic conditions for the agriculture turned into negative and there were a substantial difference between the income for farmers and that for other economic activities, the governments tend to protect their farming sector (Swinner, Banerjee and Gorter 2001, Harvey 2004). This is especially true when the interests are large, and when the political costs diminish and the benefits grow in order to maximize political returns. Moreover, a political system does not usually promote changes that harm the well-being of a given social group. The more organized a group is and the higher the threat to its well-being, the more resistance to drastic political reform will be (Harvey, 2004). From 1980 on, the protection levels of agriculture continued to rise, despite the decreased disparity between rural and urban income. In the European Union, agricultural income[6], as well as the rural non-agricultural one, has augmented; so that the rural-urban gap has been narrowed, although agricultural income continues to be less than the EU average. Also, in 2007 the rural income was around 25% less than the urban one for EU-25 (European Commission 2007).

Farm income is reflected in the reforms of 2000, 2003 and 2008 as a cultural aim, due to the importance of preserving the European agrarian model of family farms; despite the structural adjustments the number of farms continued to be advocated (Marsh and Tarditi 2003). Therefore, the incoherences between equity and some measures have induced changes in this agrarian Policy.

Moreover, the social viewpoint on agriculture has significantly changed. Previously, farming was viewed as cultural heritage and an environmental conservation guarantee. In the last few decades the view of agriculture has degraded to a source of pollution and farmers to businessmen looking for profits. At the same time, the swift changes prompted by economic development and the levels of well-being have fostered what sociologists call post-materialistic values[7], particularly in the new generations that have been educated in a middle-high standard of living. The post-materialist dimension emphasizes quality of life, equality, solidarity, and a greater willingness to participate in decisions concerning work, community, politics, *etc.* These principles have stimulated different interests and demands in such matters as food quality, environment protection or rural development. Also, the citizens have become active and legitimate agents to express opinions and to demand their preferences to the European agriculture.

Firstly, the structure of consumption has been modified towards quality products due to health consciousness, greater interest in physical appearance and the consumption of natural products. Furthermore, after the different

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[5] For more information, see: http://ec.europa.eu/agriculture/funding/index_es.htm

[6] Agricultural income refers to the money generated directly or indirectly by farming activities, excluding the income from non-agricultural activities, salaries, social benefits, or land ownership. The European Commission [16] predicts a rise in agricultural income of 18% between 2006 and 2013 in real terms per work unit.

[7] The term "post-materialistic" emerged from Inglehart in 1971 in his work "The Silent Revolution in Europe: Intergenerational Change in Post-Industrial Societies".

food crises that have stricken Europe (mad-cow disease, foot-and-mouth disease, bird flu, etc.) implying the loss of confidence by consumers, the CAP has made a priority of quality, safety and health in food, giving growing importance to systems of quality control, traceability, denominations of origin, etc.

The relations between agriculture and the environment have become a matter of general interest due to the environmental awareness as well as the progressive demand for leisure and recreational activities. Since the Reform of 1992, the CAP has tried to respond to the growing demand for environmental protection. Thus, collective social action has served to promote changes in the CAP in favour of the environment, a trend that continues.

Parallel to the new environmental request, new social demands have arisen regarding rural areas for both their conservation as historical heritage and leisure places. For this reason, in the CAP new measures have been incorporated and a specific policy, the Rural-Development Policy, was created.

Nevertheless, the CAP has generated social dissatisfied with the agricultural activity because of high prices, food crisis, pollution, unemployment, inequity, *etc.* (European Commission 2010). The economic literature have outlined that the Common Agricultural Policy does not respond adequately to the changes in social priorities, preferences and values related to agriculture (Potter and Burney 2002, Hall, McVittie & Moran 2004, Hyytiä and Kola 2005, Cooper, Baldock and Farmer 2007). Thus, social changes have been a notable factor of institutional innovation in the CAP, and nowadays they still continue boosting transformations on it. At international level a new commercial and political framework has emerged. The increased in food demands, the major importance acquired by developing countries and the tendency to the liberalization of world trade have had an influence on institutional innovations into the CAP. To place the CAP reforms, it is necessary to indicate that the Uruguay Round of the GATT began in 1986[8] and, in the year 2000 the Doha Development Agenda or Doha Round started. Agriculture was included in both negotiations. The Reform of 1992 and those of 2000, 2003 and 2008 have tended to eliminate progressively those measures that distorted international trade (the so-called blue and amber boxes) according to the WTO agreements. In this way many of the institutional innovations undertaken were adjusted to get an agreement in multilateral negotiations. For example, in 1992 direct aids were introduced by means of the compensatory payments. Their implementation made easier for the EU and United States to get an agreement in the Uruguay Round. These payments were incorporated to the blue box, and the measures inside the blue box could be applied at the same level that the existing in 1992. Other example was the creation of the rural and environmental measures which were designed according to the features of WTO's green box. But the CAP still presents some incompatibilities with the proposal of the Doha Round. Therefore, it is expected that the future reforms will tend to eliminate border measures, export subsidies and those measures that distort the trade.

THEORETICAL FRAMEWORK AND MODEL SPECIFICATION

The Legitimacy: A Theoretical Approach

The CAP analysis from the Neoclassical approach implies a limited view to explain the complexity of this policy since it is necessary a study of both the political system and the individual decisions units –*i.e.* political decision-makers, farmers, consumers and taxpayers– to explain it (Zezza 1991, Brooks 1998 and Nedergaard 2006). In this regard, we adopt a neoclassical approach with some approximations of Public Choice theory.

From the agricultural general side, we define the EU as one multi-level governance system which tries to maximize the utility from their political power (Nedergaard 2006). We consider three basic axioms in an optimization problem: 1) the objective in a long-term is the exercise of political power along time; 2) the EU has preferences about social order, so that an order relation across the different alternatives can be established, *i.e.* a preference relation. All preference relations define a convex set which is delimited by a

[8] General Agreement on Tariffs and Trade (GATT), created in 1947, was the regulatory instrument of world trade, providing a legal structure to rule international trade relations among member states.

concave function in the sense of Debreu; 3) a utility function, in the sense of Debreu, exists and it is called power function [$P_i(\bullet)$] (Debreu 1973). Simplify, we can suppose that the political power is derived from the capacity of legitimating the political interventions to the interest groups. The interest groups can be classified as society [L_t^S], economic sectors and lobbies [L_t^L], Member States [L_t^I] and international framework [[L_t^E] (*e.g.* international organizations, countries, foreign societies, *etc.*). Given the EU institutional rules and financial constraints[9], we can define:

$$P_i(t) = f(L_t^S, L_t^L, L_t^I, L_t^E) \quad \textbf{(1)}$$

We are focussing on the study of the social legitimacy variable [L_t^S]. Concretely in analysing how to estimate the resulting or expected social legitimacy from an institutional innovations in the CAP. Social legitimacy is defined as the level of support which is expressing by the European citizens in the moment *t* [$L_{UE}^S(t)$]. Thus, it is logical to suppose that this support depends on the citizens' political satisfaction with the results derived from the institutional changes carried out in the different policies. If we have the situation perceived by citizens (S_p) and the ideal situation for them (S_i), we can estimate the Euclidean distant between both situations as follow:

$$D_s(t) = D(S_i, S_p) = \sqrt{\sum (S_i - S_p)^2} \quad \textbf{(2)}$$

If we denote the degree of political satisfaction as a decreasing function of the distant between both situations, $Gps = g[D_s(t)] = g(S_i, S_p), g'[D(t)] < 0$, we can relate the political situation and the citizens'opinions. Therefore, the support by the citizens is a function of the political satisfaction's degree regarding to the political situation in *t*, $PS = f(Gps)$.

The previous function can be dichotomy adopting the value 1 if the citizens support the institutional change or 0 if not. But this function can be ordinal also when the citizenry express their level of support.

If we consider a dynamic model, the political situations are the results from previous policies and previous political situations (*t-1*). In this regard, we can state that political situation in the future will be the outcome from the decisions adopting now. As the social support depends on the distant between the ideal and perceived political situations, the possibility of support will increase as much as the gap will decrease. If we project the previous finding to the future, given a policy in the moment *t*, such policy will only have effects in the moment *t+1*. Consequently, the support will be given by the expectation for the resulting political situation.

MODEL SPECIFICATION

The model assumes that: 1) the CAP can decrease or increase the legitimization of the EU; 2) the legitimization depends on the citizens' political satisfaction degree with the expected results from the policy changes; 3) this political satisfaction is derived from the citizens' perception of the expected utility from pecuniary and non-pecuniary costs and incomes providing by the intervention; 4) the political satisfaction is influenced by citizens' nationality (*n*) because of the high regional component for some functions providing by agriculture, especially from non-commercial outputs; and 5) according to Ruttan and Hayami institutional innovations will be offered if the expected return of the innovation exceeds the cost of mobilizing the resources (Ruttan & Hayami 1984).

In our case, we suppose that the CAP reforms are implemented if the probability of obtaining an increase in legitimacy is higher than the resulting from the status quo, *i.e.* for the society the incomes are over the costs [$P = \Pr\{CAPL_{UE} > CAPL'_{UE}\} = \Pr\{CAPL_{UE} - CAPL'_{UE} > 0\}$, { $\Pr(\Delta PS_{UE}^n) > 0$,

[9] The Common Agricultural Policy has a constraint budget which is negotiated by the financial EU Council.

$\Pr\{U(I_t, \phi_t, \omega_t, \varpi_t) - U(I'_t, \phi'_t, \omega'_t, \varpi'_t) > 0\}$ where I_t represents the pecuniary incomes obtained by citizens, φ_t is the non-pecuniary ones; ω_t shows the monetary costs and ϖ_t includes the non-monetary ones]. The status quo is shaped by CAP objectives, measures and budget which has just received a political support by the citizens in the previous moment (*t-1*).

The expected utility (as the probability of obtaining an increase in social legitimacy) can be expressed, for a time period (*t*), with a simple equation with the assumption that $\omega_t > \omega'_t$ and $\varpi_t > \varpi'_t$:

$$\Delta PS_{UE} = \sum_{k=1}^{n} \int_0^t e^{\rho t} U\{[I(t) + \varphi(t)] - [\varphi'(t)]\} - [\omega(t) + \varpi(t)] - [\omega'(t) + \varpi'(t)]dt + B_t \quad \textbf{(3)}$$

where ρ is a subjective discount rate [ρ ∈(0, 1)]. It represents the risk or uncertainty because of the citizens' ignorance about the real returns derived from the institutional innovations of the CAP; *t* is the time horizon which is given for the period between reforms; *n* shows the number of Member States; and B_t incorporates a geometric Brownian motion (random shocks) on a given probability space.

Regarding the pecuniary income variable (I_t), it refers the aggregated expected price differential on average estimated by countries for the same group of agricultural commodities (*e.g.* cereals, vegetables, fruits) which supposed a basic consumption for EU citizens[10]. The non-pecuniary incomes (φ_t) include the expected returns due to the quality of the products and the non-commercial functions performed by agriculture. Related to quality, if the consumers are willingness to pay higher prices because they perceive higher quality on products, the price differential between reforms could be considered an improvement on the well-being. Moreover, when the prices are equal and the quality is higher an improvement in utility is generated (the consumer surplus increases). On the other hand, certain features of agricultural supply provoked market failures and some positive and negative externalities are generated. The outcomes of non-commercial functions respond to this concept of positive externality since the society is not implied in the production process and the prices of the goods do not incorporate the improvement in the social well-being generated by them; so that, the farmers do not considered the social demand for non-commercial functions in their production planning.

The φ_t is given by the following expression:

$$\varphi(t) = \sum_{k=1}^{n} VA_t + VS_t \quad \textbf{(4)}$$

where VA_t and VS_t are the monetary value of environmental and social functions provided by agriculture. The monetary quantification for these functions faces two main problems. Firstly, no market exits for these goods so an economic value cannot be directly obtained from the market. However, over the years some methods, based on environmental economics, have been developed using revealed preferences (Hedonic prices and Travel cost method) or stated ones (Contingent Valuation method and Choice Experiments). These methods allow measuring the social willingness to pay for non-commercial goods, but their success depends on the experiment design and they continue to be very discussing.

The second problem is related to establish the functions assigned by the society to agriculture. The environmental or social demands have an important regional component. We can find an enormous variety of them, *e.g.* as environmental functions: to preserve the flora and fauna, to control erosion and soil loss, to maintain water quality and improve water management, to preserve and protect the landscape, *etc.*; as social or territorial functions: to maintain and create jobs, to maintain and restore the rural population, to protect cultural heritage and customs, *etc.* Obviously, people are very influenced by their close reality. The demands will include the main environmental and social concerns that affect their living. In this manner, the literature has pointed out the necessity to go down from the general to the particular situations

[10] The EU and Member States have available secondary data about the evolution of agricultural prices. The problem arises because some data are referring to origin prices not destination prices.

(Drummond & Nardsen 1999). Furthermore, the indexes to quantify their provision are limited; although the EU is making an effort to contribute with harmonized indexes in order to make easier the monitoring.

Finally, when we are analyzing non-commercial functions, we have to take into account that the CAP is not the only policy which affects them. An increase in the supply of non-commercial goods from agriculture can be boosted by the Rural Development Policy (RDP). If we considered the lower knowledge of citizens about the CAP, we can suppose that they incorporate any improvement in the supply of non-commercial outputs to the political situation of the CAP (European Commission 2010). Also, the analysis could consider estimating the legitimacy for both policies as a whole since it is very complex to divide their effects and influence in the agricultural activity because of joint production.

Related to the monetary costs for citizens, ω_t, it can be estimated as:

$$\omega(t) = \sum_{k=1}^{n} CD_t + CM_t + CI_t + CO_t \quad \textbf{(5)}$$

where CD_t represents the taxes paid by the citizens which finance the CAP; CM_t shows the dead-weight-loss costs, *i.e.* those costs generated by the allocative inefficiency caused by the tariff and pricing policies. OECD estimated that around a quarter of CAP's market price support is lost through economic inefficiencies (deadweight losses); CI_t is the costs linked with the bureaucratic frame of the CAP (OECD 2003). It does not include UE costs because 5% inside the CAP´s budget, approximately, is designated to pay bureaucratic and monitoring costs (CD_t), but it incorporates the part of taxes used for the upholding of national and regional institution in administrative working for the CAP; CO_t is the opportunity costs derived from the taxes assigned to the CAP which could be another political or administrative applications.

The ϖ_t, or non-monetary costs, incorporates the so-called negative externalities from agriculture. In the production process of agricultural goods some undesirable effects are provoked, e.g. soil and water pollution because of agricultural residues, erosion, loss of biodiversity, etc. When the farmer is penalized for the negative consequences generated by this economic activity, a percentage of the decrease in the social well-being is compensated. Thus, the CAP is specifying the social and farmers' property rights over soil, water and air by means of defining the levels of pollution which are not being sanctioned. If we consider that the European society wants a clean soil, water and air, we can suppose that they do not want any level of pollution from agriculture. So that the monetary quantification of the negative externalities can be estimated, e. g., using pecuniary sanctions from EU, which can be extend and estimated across any level of pollution.

DISCUSSIONS AND CONCLUSIONS

The decisions related to the Common Agricultural Policy (CAP) are widely influenced both by the institutional structure of the EU and of the policy itself, as well as the individual decision agents. The institutional innovation supply of the CAP has tried to respond to the demands from society, international organizations and to the financial interests of the Member States. The efforts have been leading to minimize the impact on the budget status quo; to reorganize agricultural activity towards efficient fund allocations; to tend to implement measures that do not distort trade in the international markets; and to satisfy a post-materialist society. The cost of introducing these innovations has been elevated in terms of decision making processes, expenses, bureaucratic complexity, social distrust and even discord from farmers. Thus, the factors which influence on the CAP are numerous and they display many inter-relationships among them.

Different theories and models have tried to explain the CAP as a whole or some concrete aspects inside this policy, but the role of the society in the changes is not widely dealt by the literature. Nevertheless, one of the CAP objectives is to improve the citizens' well-being by responding to social demands. Theoretical and empirical tools have to be developed to determine when institutional changes have the probability to get this aim.

Based on economic and political considerations the proposed theoretical model tries to give an approximation in order to analyse if past or future changes implemented by the CAP are adequate from legitimacy viewpoint. The model is defined by a utility function and it incorporates the effects of the commercial and non-commercial outputs from agricultural activity. However, to assign a monetary value to the non-commercial goods is a very complex question and the lack of data is a handicap in the estimation of the model. In addition, the model is not tested empirically; although we can obtain basic predictions from social standpoint: the CAP innovations have to be led to decrease prices or taxes, to simplify the bureaucratic framework, to get higher efficiency in resources, or to raise quality products or non-commercial functions.

If we consider the prices depend on external circumstances (international prices or even the climate conditions) and taxes are not concretely fixed by this policy, in the next reforms the most important issues for the CAP are the simplification, the efficiency which includes equity, the quality food and the supply of environmental and social goods from the agriculture.

The period of financial programming ends in 2013. New negotiations should be held in the European Council in order to reach an agreement concerning the budget allocation and the new CAP. However, it is still necessary to overcome the political sluggishness and resistance to change which tends to maintain the financial status quo and to defend national interests.

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CHAPTER 5

Agricultural Externalities and Environmental Regulation: The Case of Manure Management and Spreading Land Allocation

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Abstract: The aim of this paper is firstly to show how the measures introduced by the European regulation on manure management are incorporated into the theoretical analysis framework for studying the issue of nonpoint externality and especially, agricultural runoff. The model is extended because only some of the polluting emissions at the origin of diffuse pollution are regulated by the Nitrates Directive. More specifically, the model represents the standard that limits the spreading of organic manure to 170 kg/ha as a production right assigned to each farm. Secondly, this paper proposes an empirical model in which the theoretical assumption that productive abilities are fully exploited is relaxed. In order to describe the disparity that exists between individual situations, an empirical model represents the production technology by means of a directional distance function. Finally, the aggregation properties of the directional distance function are used to simulate the practice of looking for off-farm lands as a means of complying with the standard. We look at how land can be allocated among producers in such a way as to combine the disposal of manure in accordance with the limit of the Nitrates Directive with an improvement in the productive and environmental efficiency of all farms. Using a sample of French pig farms, results indicate only a low potential for a reduction in nitrogen pollution based on the reduction in productive inefficiencies and the allocation of spreading lands among farmers in a same area.

Keywords: Environmental efficiency, permits trading system, directional distance function, data envelopment analysis, pig production.

INTRODUCTION

In Europe, nitrogen pollution resulting from agricultural activities is a major threat to the quality of ground, surface and marine waters. Intensive livestock production is an important source of pollution, due to the insufficient area of land available to farmers for spreading manure. This is particularly relevant for pig production. The direct impact on the environment of pig production is really severe in some areas. Along with the expansion of production, there have also been significant structural changes in the pig sector. Pig farming has become more intensive and more regionally concentrated, with fewer farms producing a larger number of pigs often with very little land, and of a more specialized nature with feed obtained from off-farm sources. The disposal of pig manure tends to be driven more by the need to lower disposal costs than by the optimization of the nutrient needs of crops and grassland, at a detrimental cost to the environment. Because pig manure is a low-density nutrient fertilizer source and is more costly to transport over long distances than inorganic fertilizers are, areas of intensive pig production usually have a surplus of manure. This has led to an increase in residual pig manure in the environment in these areas, which can have an adverse effect on water quality and imposes environmental pollution costs on society as a whole.

Policy measures to deal with this problem are predominantly regulatory and are becoming increasingly severe and complex. Aid has been provided to offset the increased costs imposed by regulations, particularly to reduce the level of capital expenditure required to bring production facilities up to the regulatory standard. Regulations seek to influence producer behaviour in a direction that induces environmental benefits for society as a whole (OECD, 2003). In pig production, the main policy instrument introduced in Europe to combat pollution linked to nitrogen from agricultural sources is directive 91/676/CEE, known as the Nitrates Directive. The application of this directive in France got under way in 1994.

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The actions to be undertaken were organized into a framework of two programs. These programs called *Programmes de Maîtrise des Pollutions d'Origine Agricole* (programs to control pollution of agricultural origin) or PMPOA were developed by the Ministries for Agriculture and the Environment in consultation with agricultural organizations. The first program of action against nitrates (1994-2000) was aimed at rectifying the most polluting practices, targeting farms in decreasing order of size, while the second (2001-2003) was intended to bring about changes in these practices so as to protect and even restore water quality. The main measures resulting from these programs were the implementation of more environmentally friendly agricultural practices with regard to soil management, the limitation of the spreading of livestock manure to 170kg of nitrogen per hectare per year and statutory storage durations for livestock effluent.

From the economic perspective, this environmental regulation amounts to granting each producer an individual production right, which is an expression of the 170kg of organic nitrogen per hectare spreading standard. Imposing this type of restriction on agricultural land is equivalent to annexing part of the producer's property rights and assumes that, in the original situation, the property rights were fully allocated to the farmers. Through government intervention in the use of private land, it implies a reallocation of a certain proportion of the set of property rights from producers to society. It thus implies that determining the most efficient scale of production is no longer an exclusively private decision and that it is now constrained by regulation. This restriction is viewed in this article as a restriction of the producer's property rights to influence his manure management through a subset of production possibilities compatible with the environmental regulation.

When these programs were drawn up in France, the various courses of action producers were to take to dispose of their livestock effluent were set out in order of priority, to guide them in their decision-making processes. Spreading, using the land's purging capacity to full advantage, is the first course of action required. Then, in descending order of priority come the reduction of effluent at its source through changes in the animal's diet and improved control over the use of inorganic fertilizers, the treatment of manure, and as a final resort, a reduction in the total number of livestock on the farm. At the current time, only the first two courses of action have actually been put into practice. The third, which deals with the treatment of manure and its export to areas far away from the production centres, is being introduced. Thus, the most widespread practice currently used to deal with livestock effluent is spreading. Given the target of 170kg of nitrogen of animal origin per hectare set by the Nitrates Directive, a large number of farmers located in intensive production areas find themselves in a position where they do not have enough areas of available spreading land to dispose of all their effluent, and so have to resort to borrowing land. The practice of lending land allows producers to continue their production activities and, at the same time, to comply with current regulations on spreading. It is a low-cost solution since it does not involve any significant changes to the original production structure.

The aim of this paper is firstly to show how the measures introduced by the European regulation on manure management are incorporated into the theoretical analysis framework proposed by Griffin and Bromley (1982) for studying the issue of nonpoint externality and, in particular, agricultural runoff. The model is extended in the sense that only some of the polluting emissions at the origin of diffuse pollution are regulated by the Nitrates Directive. Secondly, this paper proposes an empirical model in which Griffin and Bromley's assumption that productive abilities are fully exploited (1982) is relaxed. In order to describe the disparity that exists between individual situations, the empirical model represents the production technology by means of a directional distance function (Chung *et al.* 1997; Chambers *et al.* 1996, 1998). As noticed by Chavas and Cox (1999), this function allows for the rescaling of inputs and outputs in a more flexible way than in Shephard's distance function. Furthermore, the directional distance function easily represents the jointness of production between the intended output and polluting emissions (Färe and Grosskopf, 2004). This function is used to assess the increase in productive efficiency that each farm can achieve when it seeks to increase its production - and thereby its income – while at the same time decreasing its production of nitrogen surplus, which is a source of environmental pollution, by improving its management and technical abilities. Finally, we simulate the management of the individual spreading constraint applicable to each farm, and look at how land can be allocated among producers in such a way as to combine the disposal of manure in accordance with the limit of the Nitrates Directive together with an improvement in the productive and environmental efficiency of all farms, using a sample of French pig farms.

Previous papers in the literature have already studied manure management in the pig sector by using the non parametric approach called Data Envelopment Analysis (DEA) for measuring productive and environmental performance of pig farms. Piot-Lepetit and Vermersch (1998) implicitly introduced the environmental regulation on organic manure in a DEA framework. By using a radial distance function, they estimated a price for organic manure disposal. A directional distance function is used by Piot-Lepetit and Le Moing (2007a) for measuring productivity of pig farms and decomposing it between two components, namely, efficiency and technical progress and by Piot-Lepetit (2010b) for providing efficiency measurements by farming system and at the sector level as a whole. In these papers, the environmental regulation is also implicitly modelled. The first introduction of an explicit design of the standard on organic manure within a DEA framework can be found in Piot-Lepetit and Le Moing (2007b). This development has been recently extended by Piot-Lepetit (2010a) for analyzing policy issues linked to the management of organic manure in the pig sector based on command and control and economic measures. However, none of them papers clearly describes the standard on the spreading of organic manure as a productive right allocated to each producer.

The current chapter adds to this literature by proposing a way to link the theoretical model on non point externality proposed by Griffin and Bromley (1982) with the specific case of manure management under the regulation of the Nitrates Directive. Furthermore, this chapter shows how the use of a directional distance function and a DEA approach allows for weakening the assumption of efficiency on which the theoretical model is based.

Nonpoint Externality Theoretical Model

To analyze the economic problem posed by nitrate pollution and the regulatory choices introduced by the European Commission, we place ourselves in the theoretical framework proposed by for studying the nonpoint externality and, more specifically, agricultural runoff.

Considering a single-period model, we assume that a limit on emissions has been politically decided. The objective of the environmental regulation is to achieve this limit at minimal cost in a given geographical area. We assume that there are J firms (j=1,…,J) in the region. Let y_j be the output vector of firm j with y_{jm} being the mth element of that vector and x_j the input vector with x_{jn} being the nth element of that vector. We assume that there are M marketable goods that can be sold on markets at the price $p \in R_+^M$ and N marketable factors that can be purchased on markets at the price $w \in R_+^N$. At the same time, these farms produce pollutant emissions that are denoted b_j for farm j with b_{js} being the sth element of that vector. As we are concerned with nonpoint externality, the emission levels can be linked directly to output or input quantities. Assume that there exists a function h_j such that $f_j[y_j, x_j, h_j(y_j, x_j)] = 0$ for all j. Thus, nonpoint externality production can be expressed as a continuously differentiable function of inputs and outputs used in the production process. Following Griffin and Bromley, we assume that the nonpoint production function $h_j(y_j, x_j)$ does not differ among farms. This allows us to drop the underscript on this function without implying that all farms have the same soil types or slopes since these variables are arguments of the h function.

Maximizing profits subject to this technological constraint for each farm can be written as follows:

$$\max_{y_j, x_j} \; py_j - w_j x_j \;\; s.t. \;\; f_j[y_j, x_j, h_j(y_j, x_j)] = 0 \quad \text{for all } j \tag{1}$$

Equation in (1) yields the following Lagrangian:

$$L_j = py_j - w_j x_j - \delta_j f_j[y_j, x_j, h(y_j, x_j)] \tag{2}$$

where δ_j is the Lagrangian multiplier for farm j. The following optimality conditions are then derived:

$$\begin{aligned} &p_m - \delta_j (f_{jm} + f_{jb} h_m) = 0 \qquad \text{for all } m, j \\ &w_n - \delta_j (f_{jn} + f_{jb} h_n) = 0 \qquad \text{for all } n, j \end{aligned} \tag{3}$$

In our case, the nonpoint function $b_j = h(y_j, x_j)$ represents the farm's production of nitrogen surplus. This surplus is determined for each farm on the basis not only of its production of organic nitrogen from livestock farming and the use of chemical fertilizers for crops, but also on the characteristics of the land and choice of crops grown, which have an effect on the potential discharge of nutrients into the environment. To change the manure spreading behaviour of producers, the Nitrates Directive imposes an individual standard set at 170kg of organic nitrogen per hectare. We consider that this individual limit is a production right allocated by society to each producer and which depends directly on the area of land the farm has available for manure spreading and on the European standard. It has an effect on each individual farm's level of production. Assume that the production of organic manure is denoted $e_j = e(y_j)$ for all *j*. The restriction imposed by society on this by-product of animals can be expressed in the following way $e(y_j) \leq \overline{e}_j$, where $\overline{e}_j$ is the value of the production right allocated to each farm by society. With this constraint, maximizing profits for each farm yields to the following model:

$$\max_{y_j, x_j} \; py_j - w_j x_j \;\; s.t. \;\; f_j[y_j, x_j, h_j(y_j, x_j)] = 0 \quad \text{for all } j \;\; e(y_j) \leq \overline{e}_j \quad \text{for all } j \tag{4}$$

The corresponding Lagrangian can be written as:

$$L_j = py_j - w_j - \delta_j f_j[y_j, x_j, h(y_j, x_j)] - \eta_j[\overline{e}_j - e(y_j)] \tag{5}$$

where δ_j and η_j are the Lagrangian multipliers for farm *j*. The derived optimality conditions are then:

$$\begin{aligned} & p_m - \delta_j(f_{jm} + f_{jb}h_m) - \eta_j e_{jm} = 0 && \text{for all } m, j \\ & w_n - \delta_j(f_{jn} + f_{jb}h_n) = 0 && \text{for all } n, j \end{aligned} \tag{6}$$

For certain producers, this production right $\overline{e}_j$ may be very limiting. If they wish to go on producing, they are forced to look for off-farm spreading land, *i.e.* to obtain production rights not used by other producers. This situation can be represented by the following model:

$$\max_{y_j, x_j} \sum_{j=1}^{J} py_j - \sum_{j=1}^{J} w_j x_j \;\; s.t. \;\; \sum_{j=1}^{J} f_j[y_j, x_j, h_j(y_j, x_j)] = 0 \;\; \sum_{j=1}^{J} e(y_j) \leq \overline{E} \tag{7}$$

The corresponding Lagrangian can be written as:

$$L = \sum_{j=1}^{J} py_j - \sum_{j=1}^{J} wy_j - \sum_{j=1}^{J} \alpha_j f_j[y_j, x_j, h(y_j, x_j)] - \mu[\sum_{j=1}^{J} e(y_j) - \overline{E}] \tag{8}$$

where $\overline{E} = \sum_{j=1}^{J} \overline{e}_j$ and α_j (*j=1,…J*) and μ are Lagrangian multipliers. The new optimality conditions are:

$$\begin{aligned} & p_m - \alpha_j(f_{jm} + f_{jb}h_m) - \mu e_m = 0 && \text{for all } m, j \\ & w_n - \alpha_j(f_{jm} + f_{jb}h_n) = 0 && \text{for all } n, j \end{aligned} \tag{9}$$

This model enables producers to continue their activity and maximize profit, while at the same time taking into account the environmental impact of their production choices and complying with the spreading constraint imposed by the Nitrates Directive. Such compliance is achieved through exchanges of production rights between producers while keeping within the overall constraint imposed on the geographical area under consideration.

Nonpoint Externality Empirical Model

In the theoretical model, the production technology is described by a function of production based on the assumption that all producers are efficient, in other words, that they exploit their productive abilities to the full.

The use of the directional distance function analysis framework (Chung *et al.*, 1997; Chambers *et al.*, 1996, 1998) allows a representation of the multi-product, multi-factor technology and takes into account the joint production of undesirable goods while at the same time weakening the assumption that producers fully exploit their productive abilities. Only those observations that are on the production possibility frontier are considered to be efficient. Farms that lie inside the set of production possibilities show a productive or environmental inefficiency. We then use this framework analysis to represent the individual behaviour model (1) and measure changes in practices in terms of each farm's productive and environmental efficiency subsequent to the introduction of a restrictive regulation on the disposal of jointly-produced goods at the origin of diffuse pollution. We then use the aggregation properties of directional distance functions (Färe and Grosskopf, 2004) to simulate the allocation of production rights as described by the model (7).

By using the same notations as in the previous section, the production technology can be expressed as an output set defined on all feasible input-output vectors as:

$$P(x_j) = \left\{(y_j, b_j) : x_j \text{ can produce } (y_j, b_j)\right\} \quad x_j \in R_+^N \qquad \textbf{(10)}$$

The output set $P(x_j)$ is assumed to produce both desirable and undesirable outputs from the input allocation x_j. It is assumed that it cannot produce one without the other. Non-marketable and undesirable outputs are produced jointly with the desirable marketable goods. In order to address the fact that bad outputs are costly to reduce, we impose weak disposability on bad outputs, *i.e.* a reduction in undesirable outputs can be achieved by reducing good outputs given fixed input levels. This assumption models the idea that disposing of the bad outputs is not a free activity, but that it requires foregoing some of the good outputs or increasing some of the inputs. In addition to imposing weak disposability, we also assume that the desirable outputs are freely disposable, *i.e.* it is possible to dispose of goods without additional production costs (Färe *et al.*, 1994). Using this set of assumptions, the production technology can be represented with the help of a directional distance function.

Let $g = (g_y, g_b)$ be an output directional vector with $g \in R^M \times R^S$.

$$\vec{D}_o(y,b;g) = \max\left\{\beta : ((y,b) + \beta.g \in P(x)\right\} \qquad \textbf{(11)}$$

where β is the measure of productive and environmental efficiency. By construction, $\vec{D}_o(y,b;g) \geq 0$ if and only if $(y,b) \in P(x)$. When $\vec{D}_o(y,b;g) = 0$, the farm is on the boundary of the production set. Otherwise, the output directional distance takes *(y,b)* in the *g* direction and places it on the production frontier. $\vec{D}_o(y,b;g) > 0$ means that the farm is located inside the production possibilities set. It reflects inefficiency in that the farm is not on the best practice frontier. Following Chung *et al.*, 1997, we assume that the *g* vector is defined as $(y, -b)$. Thus, the output directional distance function seeks the simultaneous maximum expansion in good outputs and reduction in bad outputs. The output directional distance function is a generalization of the Shephard output distance function that allows some outputs to be expanded while others are contracted. This property is particularly attractive in our case as we study polluting outputs.

To characterize the first model, we consider a single time period and we assume that there are *j=1,.., J* observations of inputs and outputs. We model the reference technology by using a DEA (Data Envelopment Analysis) approach.

To measure the farm *j'* specific output distance function, we calculate for each *j'=1,..,J* the following linear programming problem:

$$\vec{D}_o^{j'}(y_{j'}, b_{j'}; g) = \max\ \beta_{j'} \qquad \textbf{(12)}$$

s.t.

$$\sum_{j=1}^{J} z_j y_{jm} \geq (1+\beta_{j'}) y_{j'm} \quad m=1,...,M$$
$$\sum_{j=1}^{J} z_j b_{js} = (1-\beta_{j'}) b_{j's} \quad s=1,...,S$$
$$\sum_{j=1}^{J} z_j x_{jn} \leq x_{j'n} \quad n=1,...,N \tag{13}$$
$$\sum_{j=1}^{J} z_j = 1$$
$$z_j \geq 0 \quad j=1,...,J$$

The z's are intensity variables which serve to construct the reference technology as convex combinations of the observed data. The equality in the constraint on undesirable outputs in the above equation is based on the assumption that bad outputs are weakly disposable. The program defines the production frontier using the observed combinations of inputs and outputs *(x,y,b)*. The model is a single period model. The level of polluting emissions b_j is determined according to the practices observed over the period.

The model defined by (12) and (13) allows us to assess the productive and environmental efficiency of each farm together with the modelling of the polluting output that we seek to decrease so as to limit the environmental impact of this production activity. When $\beta_j = 0$, the observation is efficient. It lies on the production possibility frontier. When $\beta_j > 0$, the observation can improve its productive and environmental efficiency in the direction of the vector *g* by increasing its production of desirable goods and decreasing its polluting emissions of β_j. However, the model provides no information about the compatibility of the optimal solution obtained with the environmental regulation in place.

To obtain a representation of the model introducing the production rights $\bar{e}_j$ allocated to each producer defined in (7), we use a property of the directional distance function, namely that "when a common directional vector is chosen for all firms in an industry, the sum of the directional distance functions for the firms equals industry directional function" (Färe and Grosskopf, 2004). In other words, we have:

$$\vec{D}_o^{coll}\left(\sum_{j=1}^{J} y_j, \sum_{j=1}^{J} b_j; g\right) = \sum_{j=1}^{J} \vec{D}_o^{j}(y_j, b_j; g) \tag{14}$$

In the modelling of production rights management, the polluting emissions are always weakly disposable because of the set of regulatory measures that exist to restrict spreading possibilities. These measures concern storage durations and storage capacities, the periods when it is possible to spread manure, and specific restrictions depending on the nature of the soil. If we denote $\bar{e}_j$ as the level of spreading the individual *j* can carry out on his farm, we could define his productive right as follows:

$$\bar{e}_j = 170 * land_j \qquad j=1,...,J \tag{15}$$

where $land_j$ is the area available for spreading and 170kg/ha is the standard resulting from the European regulation on manure management.

Over the region under study, the total level of production rights for these farms is defined by:

$$\bar{E} = \sum_{j=1}^{J} \bar{e}_j \tag{16}$$

The introduction of this last constraint results in the production technology being represented by the directional distance function as the following aggregate output:

$$\vec{D}_o^{coll}(\sum_{j=1}^{J} y_j, \sum_{j=1}^{J} b_j, \overline{E}; g) = \sum_{j=1}^{J} \vec{D}_o^{j}(y_j, b_j, e_j; g)$$
$$= \max\left\{ \sum_{j=1}^{J} \beta_j^{coll} : ((y_j, b_j, e_j) + \beta_j^{coll} g) \in P(x_j), \quad \sum_{j=1}^{J} e_j \leq \overline{E} \right\} \quad \textbf{(17)}$$

The production rights management model is obtained from the set of J observations for the sample, allowing production rights to be allocated in such a way as to maximize the sum of their output directional distance functions or productive and environmental efficiencies.

This “collective” model can be expressed as follows:

$$\vec{D}_o^{coll}(\sum_{j=1}^{J} y_j, \sum_{j=1}^{J} b_j, \overline{E}; g) = \max \sum_{j'=1}^{J} \beta_{j'}^{coll} \quad \textbf{(18)}$$

s.t.

$$\begin{aligned}
&For\ j' = 1\\
&\sum_{j=1}^{J} z_j^1 y_{jm} \geq (1+\beta_1^{coll}) y_{1m} \quad m = 1,\ldots,M\\
&\sum_{j=1}^{J} z_j^1 b_{js} = (1-\beta_1^{coll}) b_{1s} \quad s = 1,\ldots,S\\
&\sum_{j=1}^{J} z_j^1 \overline{e}_j = e^1\\
&\sum_{j=1}^{J} z_j^1 x_{jn} \leq x_{1n} \quad n = 1,\ldots,N\\
&\sum_{j=1}^{J} z_j^1 = 1\\
&z_j^1 \geq 0 \quad j = 1,\ldots,J\\
&\vdots
\end{aligned} \quad \textbf{(19)}$$

$$\begin{aligned}
&For\ j' = J\\
&\sum_{j=1}^{J} z_j^J y_{jm} \geq (1+\beta_J^{coll}) y_{Jm} \quad m = 1,\ldots,M\\
&\sum_{j=1}^{J} z_j^J b_{js} = (1-\beta_J^{coll}) b_{Js} \quad s = 1,\ldots,S\\
&\sum_{j=1}^{J} z_j^J \overline{e}_j = e^J\\
&\sum_{j=1}^{J} z_j^J x_{jn} \leq x_{Jn} \quad n = 1,\ldots,N\\
&\sum_{j=1}^{J} z_j^J = 1\\
&z_j^J \geq 0 \quad j = 1,\ldots,J
\end{aligned} \quad \textbf{(20)}$$

$$\sum_{j=1}^{J} e^j \leq \sum_{j=1}^{J} \overline{e}_j = \overline{E} \quad \textbf{(21)}$$

Where z^j , e^j and β_j^{coll} ($j = 1,...,J$) are the variables of this linear program. Other variables are observed data from the sample data set.

A number of comments are required with regard to the applicability of such modelling. First of all, the model assumes that livestock effluent from farms that do not comply with the standard will be fully accepted by those that do. This is a valid assumption if we consider a set of farms all located within a zone where compliance with the Nitrates Directive is mandatory. Brittany, a region located within a "*zone d'excédent structurel*" (area with a structural surplus of nitrogen), falls into this category. Secondly, the model does not incorporate the cost of transporting the effluent. As a general rule, areas of land that are lent are located close to the farms that require the extra land. The sample therefore has to be restricted to an area in which the geographical proximity of the farms concerned allows such lending to be simulated without the need for transport cost data. Finally, the production right is defined *a priori* without allowing for any changes in the nitrogen balance leading to an increase in this right. This assumption, albeit admittedly restrictive, is not inconsistent with the observed reality, since the amount of nitrogen that may be accepted by each farm is set out in an agreement between the two partners, and is therefore known in advance. Land loan agreements refer to the number of tons of organic nitrogen to be accepted by the farm lending the land, and define the parcels of land on which the manure will be spread, and the approximate date on which it will be offloaded. The requesting farm is responsible for carrying out the spreading. However, the impact of a change in the nitrogen balance on the spreading potential will need to be taken into account if several years are considered, rather than the single year looked at in the modelling presented here.

Data

The modelling has been applied for the sole purpose of illustrating the relevance of the models presented in the previous section. The results do not provide information about observed practices, but endeavour to come somewhere close. Real data about farms that have resorted to lending and borrowing land is actually hard to come by, mainly because information about these practices is not centralized in any way. Loans are often made within the framework of an agreement between two partners. The sample has been compiled on the basis of the most plausible possible criteria using a sample from the French FADN (Farm Accountancy Data Network) database.

We have chosen to look at a region in which livestock production is intensive. Brittany has to deal with nitrogen surpluses that need to be absorbed and uses the practice of lending land to dispose of livestock manure (produced by pig farms in particular). In most cases, land is lent by one farm raising livestock to another farm raising livestock, and, as a general rule, the type of land lent for the purposes of manure spreading is grassland. We have restricted our sample to farms mainly producing pigs, either as a specialist activity or in conjunction with other livestock such as cattle. The compiled sample enables us to illustrate the appropriateness of nonpoint externality empirical models from the previous section. Indeed, some of the farms comply with the standard imposed by the environmental regulation while others do not; a fact that will enable us to simulate the allocation of spreading land among the farms in the sample.

Our analysis is restricted to 1996. The year 1996 was selected firstly because it falls at the beginning of the period when the PMPOA was introduced – the largest farms were targeted by this program during the years 1994-1996. Secondly, the year 1996 came just before the 1997 and 1998 drop in production prices, in other words at a time when certain shock elements caused by the implementation of the regulation can be seen without too much interference from the economic upset of the following years.

Data on the nitrogen surplus and on the production right of each farm are calculated. The level of organic manure is based on the number of animals on the farm. We have applied the coefficients provided by the CORPEN[1], which provide an approximation of the level of organic manure produced by each type of animal. The level of manure surplus is derived from the individual nutrient balance of each farm. This balance is a tool used to provide estimates of flows of nitrogen across the farm boundary. Nutrient balances are defined as the

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[1] The CORPEN is an organization responsible for defining the Codes of Good Agricultural Practice relating to the management of nitrogen and phosphorus. It also provides information on the average level of nitrogen produced by different types of animal and taken up by crops.

difference between input and output flows, where input flows are nitrogen from inorganic fertilizers, nitrogen from organic manure, and nitrogen by deposition from the atmosphere, and where output flows include uptake by harvested crops and livestock sold (Meisinger and Randall, 1991). In view of the lack of any specific data on the area of spreading land, we have used a conventional, non-real approach to calculate each farm's production right. The area of spreading land is estimated on the basis of the farm's Utilised Agricultural Area (UAA). This estimation is approximate and leaves out agronomic constraints. Under these conditions, the theoretical estimated area available for receiving livestock effluent is over-estimated. In spite of this over-estimation, 80 farms in our sample do not have enough spreading land available to deal with all their effluents and therefore need extra land outside their own perimeter. The other 108 farms comply with the constraint.

In the sample, the average nitrogen surplus level (b) is 158.65kg/ha. However, this mean does not reflect the differences that exist between farms. 43% of the farms in the sample do not comply with the constraint imposed by the Nitrates Directive, which requires a level of organic manure spread per hectare (e) of less than 170kg/ha. These farms represent 319kg/ha of organic nitrogen, *i.e.* an average excess of almost 150kg/ha over the regulatory threshold, with an average nitrogen surplus of 250kg/ha. Conversely, farms complying with the spreading constraint have an average theoretical capacity to accept 53kg of effluent per hectare. Thus, when evaluating farms' performances relative to their productive and environmental efficiency, it seems important to integrate the standard derived from the EU regulation and to allow for the lending of spreading land by one producer to another.

We have implemented empirical models by specifying a set of inputs and outputs. The first model given in (12) and (13) corresponds to the conventional analysis framework. It simply considers the presence of an undesirable by-output. It measures the efficiency of farms in a direction which only allows an increase in production if the surplus can be reduced by the same proportion. In this context, the two desirable outputs are total gross output from pig production and from other types of production. The bad output is nitrogen surplus. Six inputs are used to describe farms' production activities (land, labour, pig livestock, other livestock, variable inputs for pig production and other variable inputs). For the second empirical model given in (18)-(21), we also consider the regulation on organic manure from the EU Nitrates Directive *via* the introduction of production rights, and the possibility of lending and borrowing spreading land as a means of complying with those production rights. The same outputs and inputs are used to define the production technology. We merely define an additional variable that represents the production right of each farm, *i.e.* its on-farm spreading land possibilities. Summary statistics for these variables are reported in Table **1**.

Table 1: Summary Statistics for Inputs and Outputs.

	Mean	St. Dev.	Minimum	Maximum
Desirable outputs				
Pig total gross output (€)	192 689.13	169 910.95	136.59	827 605.16
Other products total gross output (€)				
	81 090.53	52 894.54	316.03	272 136.13
Undesirable outputs				
Nitrogen surplus (kg)				
	5 976.32	4 142.90	186.66	20 240.81
Inputs				
Land (ha)				
Labour (Awu)	45.32	19.77	5.61	104.00
Pig livestock (Lu)	186.69	75.91	81.82	418.18
Other livestock (Lu)	20 399.83	16 603.27	30.00	92 232.00
Variable inputs for pigs (€)	4 797.37	9 688.47	0.00	89 614.94
Other variable inputs (€)	112 184.41	97 350.47	64.79	489 811.68
	58 670.63	30 135.46	10 479.96	168 080.99
Environmental regulation				
Productive rights (kg)				
	7 704.76	3 360.36	953.70	17 680.00

Results

Table **2** presents the results obtained from the two nonpoint externality empirical models developed and implemented in this article. The 'individual' model repeats the conventional approach used in economic literature and only considers the presence of polluting emissions (nitrogen surplus), and gives only information on productive and environmental efficiency improvements of sample farms. The 'collective' model however introduces an individual productive right for each farm and a simulation of the allocation of production rights among the farms when measuring their productive and environmental efficiency.

When a farm is considered to be efficient, the value taken by the output directional function is zero, since there is no way of increasing production while at the same time jointly decreasing the production of the polluting output. When the value is greater than zero, then there are possibilities for modifying practices in order to improve the productive and environmental performance of these farms

Table 2: Economic and Environmental Efficiency of Farms.

	#	β^{ind}		**Efficient farms**		β^{coll}		**Efficient farms**	
		Mean	St-Dev	#	%	Mean	St-Dev	#	%
$e_j > 170$	80	0.0409	0.0682	49	61	0.0436	0.0695	46	57
$e_j < 170$	108	0.0312	0.0691	73	67	0.0330	0.0707	72	67
Total	188	0.0354	0.0687	122	65	0.0375	0.0702	118	63

On average across the sample, both models provide very similar measurements, and the same farms are considered to be efficient in both cases. The mean inefficiency measurement provided by the individual model is 3.54% with 65% of efficient farms. The mean measurement obtained from the collective model is 3.75% of inefficiency and 63% of efficient farms. Regardless of the model used, the possibilities for farm development are weak, but do exist. Farms above the 170kg/ha standard are on average less efficient than those below it. These results are in keeping with the recorded fact that controlling spreading alone has not led to a decrease in water pollution by nitrates. The potential for improving individual situations, on a like-for-like production structure basis, based solely on the practice of spreading with or without land loans, is relatively low.

The relevance of the collective model is that it represents behaviour in terms of the allocation of production rights or spreading land among the farms in the sample. The optimal distribution of spreading lands is described in Table **3**. Of the 188 farms in the sample, 57% are in a position to be potential suppliers of spreading land whenever the practices observed for these farms do not result in the complete saturation of the constraint resulting from the European standard. The other farms (43%) are in a demand position, and require spreading land. In the initial situation, none of the farms completely saturates the 170kg/ha organic nitrogen constraint imposed by the environmental regulation. The results obtained using the individual model leave this situation unchanged. However, the results provided by the collective model enable us to obtain the same level of decrease in inefficiency by distributing spreading land among supply and demand farms. After land reallocation, 84% of the farms in the sample saturate their productive right, which means they spread the full amount of organic nitrogen authorized by the regulation on their land.

Table 3: Distribution of Spreading Land.

	Observed situation		**Optimal situation**	
	#	**%**	**#**	**%**
Supply farms (<170)	108	57	30	16
Demand farms (>170)	80	43	0	0
Other (=170)	0		158	84
All farms	188	100	188	100

Table **4** compares the initial situation observed for each farm with the optimal situation obtained by means of the collective model. There are notable differences. Of the 158 farms that saturate the standard in the optimal situation, 53% initially stood as suppliers of spreading land and 47% as demand farms. Only 30 farms (16% of the total sample) still have any land potentially available to receive manure, 6 of which (3% of the total sample) used to be farms with a demand for spreading land in the observed situation. The status of these farms has thus changed during the allocation of land. Not a single farm is left in a demand situation.

Table 4: Changes in Farms between the Initial Situation and the Optimal Situation.

#	**Optimal situation**					
Observed situation	Supply farms		Others		All farms	
	#	%	#	%	#	%
Supply farms	24	80	84	53	108	57
Demand farms	6	20	74	47	80	43
All farms	30	100	158	100	188	100

In terms of the distribution of land for spreading among the farms, Table **5** shows the estimates provided by the collective model and compares them to the situation observed in the sample. In the initial situation, the farms have 8,520 hectares of land available for a spreading requirement of 8,628 hectares. A simple mathematical sum shows us that this sample falls 107 hectares short of complying with the regulation. The supply farms have 5,656 hectares of land at their disposal and the demand farms have 2,864 hectares. Their own requirements are for 3,843 and 4,784 hectares respectively. The supply farms therefore have 1,813 hectares available while the demand farms need about 1,921 hectares of spreading land.

Table 5: Distribution among the Farms of Land available for Spreading (hectares).

(hectares)	**Observed situation**	**Land requirement***		**Optimal situation**	
	Σ	Σ	Diff**	Σ	Diff**
Supply farms	5656.64	3843.12	+1813.52	5429.11	+227.53
Demand farms	2863.92	4784.64	-1920.72	2836.61	+27.31
All farms	8520.56	8627.76	-107.20	8265.72	254.84

* land requirement: number of hectares needed to meet the European directive with regard to the maximum spreading threshold of 170kg/ha of organic nitrogen.
** diff: difference between the amount of land available on the farm and the amount of spreading land required to comply with the Nitrates Directive.

In the optimal collective model situation, the land areas of supply farms used to meet spreading requirements total 5,429 hectares, in other words, 1,586 hectares more are used than in the initial situation. The areas used by demand farms total 2,836 hectares, slightly less than their initial productive rights, which total 2,864 hectares. The 27-hectare positive balance for the latter farms can be explained by the change in the situation of 6 farms, which switched from being in a demand situation to a supply situation at the time of the reallocation. The scarce spreading land resource could therefore be allocated when optimizing the collective model. Over the sample used, some production rights even remain unused, for a total of 254 hectares. This distribution of land among the farms with a view to complying with the regulation is accompanied by an average 3.75% increase in production and decrease in the nitrogen surplus.

The results obtained are based on a simulation using theoretical data. They describe a situation in which there are no limits on exchanges of land between the participants. Nonetheless they do highlight the potential for pig farms to comply with the existing regulation through the practice of lending land, as well as the low impact of this type of action on reducing nitrogen pollution from pig farms.

CONCLUSIONS

This paper adapts the modelling approach proposed by Griffin and Bromley to represent nonpoint externality and, more specifically, agricultural run-off. It extends the said modelling in two ways. Firstly, the manure spreading standard introduced by the European regulation aimed at regulating nitrate pollution from agricultural activities is introduced into the models as a production right. Secondly, the assumption that productive abilities are fully exploited is weakened by using a directional distance function to represent the production technology.

At the empirical level, the models developed using the directional distance function can be used to measure the productive and environmental efficiency of farms, while at the same time taking into account the joint production of polluting emissions. The aggregation properties of the directional distance function allow us to develop a model that simulates exchanges of production rights between farms in the sample under consideration.

This analysis framework is applied to a sample of pig farms located in Brittany in 1996. The results highlight the fact that both analysis frameworks provide a very similar assessment of the efficiency of the farms. The simulation of the practice of lending spreading land demonstrates that it is possible for farms to collectively manage the constraint linked to the Nitrates Directive while at the same time improving their efficiency in a direction that enables them to increase production and decrease their nitrogen surplus that is a source of pollution. The results indicate the low potential for a reduction in nitrogen pollution on the basis of a reduction in the productive and environmental inefficiencies of farms and the practice of manure spreading alone, even when there is a standard to be complied with.

Despite the fact that the simulated results are not compared with any real data, the work carried out here is original in two ways. First of all, it expresses the European organic nitrogen spreading standard in the form of a production right assigned to each farm by the public decision maker. Unlike the approaches developed in Environmental Economics, the production right is not a license to emit pollutants. In the context of pig production, the emission of pollution comes from the nitrogen surplus whereas the standard is applicable to just one component of this surplus, organic nitrogen. Secondly, the developments made in this article enable us to consider not just the productive and marketable functions of land, but also its function in disposing of undesirable outputs, which by definition is a non-marketable function. The collective model is used to simulate the practice of lending spreading land among the farms in the sample. The aim is then to improve the productive and environmental efficiency of each farm, the sole constraint being to comply collectively and individually with the Nitrates Directive spreading standard. Thus defined, the model enables an exchange of production rights, or loans of spreading land by one farm to another, in an area subjected to a broader set of command-and-control measures that restrict producers' production possibilities. This system respects individual production rights and, at the same time, improves the efficiency of the farms under study. The model can then be used within the framework of a set of simulations to study the change in the production of livestock farms in a given area that is limited by the land factor and an environmental regulation.

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CHAPTER 6

Energy Crops Situation in Castile and Leon: Incentives and Barriers to Success

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Abstract: Over the last few years, a number of events have produced deep change in Spanish agriculture. The agreements ensuring from the negotiations within the World Trade Organization (WTO), the new exigencies of the demand for reducing the surpluses of certain food and feed crops (cereals, oil-seeds, sugar beet…) and the Common Agricultural Policy (CAP) expenses, the reform of CAP and the different Common Markets Organizations (CMO's), along with the vocation to produce (greatly influenced by geo-climatic factors), have led to a deep and long-lasting crisis of the sector in many important agricultural regions in Spain, as is the case in Castile and Leon. This crisis implies depopulation and alteration of the population structure and the rural environment, with subsequent environmental, socio-cultural and territorial consequences. Within this framework, energy crops are one of the scarce local productive orientations which could allow Castile and Leon farmers to produce an output demanded by the markets. This paper examines the current situation and the possibilities of development for this sector, using the Rural Rapid Appraisal (RRA) and Strengths, Weaknesses, Opportunities, Threats (SWOT) methods, in order to identify and assess the profitability of the main energy crops as well as the technical, socio-cultural, political and economic barriers for introducing these crops in the local productive farming sector. The study also provides an evaluation of the last energy and CAP measures and an outlook for future market developments and policy recommendations.

Keywords: Energy crops, supply and demand analysis, production costs, CAP.

INTRODUCTION

Reforms of the Common Agricultural Policy (CAP) over the last few years, together with changes in the Common Market Organization (CMO) on sugar, have brought in mechanisms that try to re-adjust production toward market requirements. The "CAP Health Check" constitutes a further step in this attempt to balance supply and demand in agricultural markets. This new proposal is intended to modernize the agricultural sector and respond to demand in markets through a number of measures. These include: (i) the abolition of compulsory set-aside of land, (ii) decoupling payments that are still linked to production in certain Member States, incorporating them within the Single Payment Scheme, (iii) ruling out any intervention in some sectors, and (iv) transferring funds from the direct aid to the rural development (Council of the European Union, 2009a; 2000b; 2000c). Likewise, it is noteworthy how important a role agriculture has as a supplier of raw material in fulfilling the commitment to reduce emissions of carbon dioxide by 20% (below 1990) at the latest by 2020, and, in particular, to ensure that biofuels reach a weighting of 10% within overall petrol and diesel consumption. The part it is intended it should play in the requirement to slow down the decrease in biodiversity by 2010 is also crucial. With regard to the above mentioned subjects, Health Check involve several proposals, among which the following are of note:

- The provision of aid to encourage diversification of agricultural output with a view to the production of energy.
- Encouragement for groups within the Leader Programme to incorporate climate change and renewable energy into their strategies for local development.
- Removal of the regime applicable to energy crops, in view of the considerable current demand for bio-energy.

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More recently, in an attempt to fit the upcoming CAP to the European Union (EU) citizens' requirements (European Commission, 2010b), the European Commission presented a new document "The CAP towards 2020" (European Commission, 2010c) reinforcing the above mentioned aspects and stressing that the future CAP should contain a greener and more equitably distributed first pillar and a second pillar focussing more on climate change and the environment. Thus, further efforts in the field of biomass and renewable energy production will be required to meet the EU energy and climate agenda.

What has been stated so far highlights the strong link between the production of biofuels and the production of energy crops. The first of these activities may contribute to the appearance of new products in agriculture, besides giving a boost to activities consisting of the provision of services, and aiding in the diversification of economic activities in rural areas; the European Council itself has been encouraging Member States to support research aimed at bringing about the appearance of new non-food products as a means of boosting renewable energy (Council of the European Union, 2006). The second will have an impact on the availability of raw materials which may help to achieve the energy commitments adopted.

Similarly, Directive 2003/30/EC (European Parliament and Council of the European Union, 2003) stresses that the best method for increasing the level of participation of biofuels in national and community markets will depend on the availability of raw materials, together with other fiscal and energy policies, and the involvement by the various stakeholders. It goes even further, pointing to a range of different positive effects that might be derived from co-ordinating promotion of the use of biofuels with sustainable cropping practices, as supported by the philosophy of the CAP. Among these effects, the following are of interest (Launder, 2002): the appearance of new opportunities for rural development, maintaining diversity and multi-functionality, and opening up niches for new farm products, within a new model of agriculture increasingly oriented towards international markets.

To sum up, promotion of energy crops may fulfil three medium-term objectives, these being: (i) ensuring the supply of raw material needed by the sector producing biofuels; (ii) creating opportunities for the diversification of income and the growth of a market for farm products intended for energy producing purposes; (iii) developing the production of these crops in such a way as to avoid harmful effects on other alternative uses (destabilization of markets).

The aspects mentioned above are crucially important in the case of a region like Castile and Leon. Although this is the most extensive single region in Spain and, indeed, the entire European Union, it has a population density of only 26 inhabitants per square kilometre, in contrast to the 79 inhabitants per square kilometre that is the average for Spain as a whole. Depopulation, combined with the large number of small population centres, widely dispersed, constitutes one of the most prominent problems for this region, which faces a gradual slow decline in the population of rural towns and villages and a trend of migration to larger urban areas with better job opportunities, services and development. This has led to a considerable aging of the rural population: 30% of the population is aged over 60, according to documents published by the Regional Government of Castile and Leon (Junta de Castilla y León, 2005a and Junta de Castilla y León, 2005b).

Likewise, the rural nature of the region is a factor that can be clearly seen from the fact that the contribution to its total Gross Added Value from the farming sector is of the order of 6%, as compared to the 3.2% Spanish national average. The percentage of workers involved in the farming sector in the region is 8.8%, well above the figure for Spain as a whole, which is 5.5% (Junta de Castilla y León, 2005a; Junta de Castilla y León, 2005b).

Agricultural activity in the region takes place in a geographical and climatic context that channels the possible approaches to farming strongly towards systems of an extensive, rather than an intensive, type, herbaceous crops predominating, with two main trends standing out: cereals and industrial crops (Junta de Castilla y León, 2005a; Junta de Castilla y León, 2005b). Yields from irrigated and from unirrigated land are markedly different, but the products of both face the problems that they are in surplus and lack competitiveness in international markets.

Various factors of a legal, technical, economic, or socio-cultural nature have a direct or indirect effect on the value chain for biofuels. These can affect the production sector (area cultivated, costs and the price of raw material), manufacturing (costs and price of biofuel), distribution and consumers (quantities used and prices paid), as noted by Robles and Vannini (2008). In any case, a final decision to include or exclude energy crops when considering alternatives for production lies with the entrepreneur (the farmer) and if energy crops are to be grown farmers must perceive some advantage in the financial results of growing them.

In relation to this point (economic viability and readiness of farmers to sow such crops), regional studies hitherto undertaken (Rodríguez López *et al.*, 2006; Rodríguez López and Sánchez Macías, 2007) would seem to concentrate exclusively on an assessment of the range of prices that the manufacturing sector is willing to offer and producers to accept. They do not appear to take into consideration variables which may have a considerable impact, such as production costs and the variations in the prices for the inputs used in the production process, or the different kinds of growing systems, among others.

Furthermore, these studies (Rodríguez López and Sánchez Macías, 2007; Rodríguez López *et al.*, 2006), although recent, were carried out under political and socio-economic conditions appreciably different from the present state of affairs. The variations in legal, political and socio-economic circumstances commented upon in this section (the implementation of new measures in the CAP, involving decoupling; the disappearance of compulsory set-aside and of subsidies for energy crops; changes in the prices of raw materials affecting the last few harvests; the debate stirred up by a competition between two markets, food or energy use, for raw material) make it necessary to evaluate the sector within this new context. In any case, these same studies point to a need to encourage research techniques that will allow a reduction in costs, the incorporation of actions of an environmental nature directly related to energy crops, like those tending to avoid any degradation of soils or of the natural surroundings, and a boost for the culture of sustainable farming and energies (Rodríguez López *et al.*, 2006).

To sum up, the rules of the game have changed, opening up new possibilities that will doubtless shape the selection of future alternatives for crops by farmers in this region. They are likely to bring about changes in this selection, with resultant consequences both for the sector itself and for the whole of the regional economy.

OBJECTIVES AND POINTS OF INTEREST

Set in the context of renewable energies, one of the priorities for the sector defined in the Strategic Competitiveness Framework for Castile and Leon, with a particular link to the sector priorities of the “Seventh Framework Program” 2006-2013 (European Parliament and Council of the European Union, 2006) and the “Europe 2020 Strategy” (European Commission, 2010a) whcih replaces the “Lisbon strategy” (2000-10), this proposal concentrates on an analysis of the current situation and problems of the sector supplying raw materials of agricultural origin for the production of biofuels in Castile and Leon. It makes an attempt to identify those factors that threaten, limit or encourage the development of such fuels, with special reference to those of an economic and political nature. It considers their effects and determines which corrective measures might usefully be brought in with the aim of encouraging the development of this sector, with an eye to finding new products permitting continued production activity and improvement of the general situation of the rural economy. Attaining this overall objective requires the achievement of other aims, including:

- Establishment of the economic accounts for the production of the main local energy crops (rape seed and sunflower), using different systems for production (traditional cultivation, minimum tillage and direct sowing).
- An analysis of the socio-economic and environmental viability of such crops.
- A study of the influence of other sorts of factors on the development of this sector (political, cultural, social, technical, and the like).

An approach to these objectives and their implementation is essential if tools allowing future development of strategic actions leading to the consolidation of a new model of agriculture are to become available. Such a model would imply substantial changes in the organization of production in this region, relative to current arrangements.

The beneficiaries involved constitute a broad swath of society. This starts with farmers themselves and their associations and goes on to cover other parties linked to the food chain: manufacturing industry, suppliers of inputs, the government, research organizations down to consumers. The following are the reasons that make this research of interest for these different groups:

Producers (farmers and farmers' associations): At the present time, farming enterprises are faced with the necessity of re-orienting their productive arrangements. This in some cases may entail large investments, so that farmers need to have a precise awareness of the exact economic viability of such products, as also of the effects that other factors (social, political, and so forth) may have on the dynamics of such outputs. Hence, the results of the work being presented here would constitute a useful tool for supporting decision-taking by those working in this area.

Government: The outcome of this research can act as a tool for lying down and fine-tuning the basis for its strategies and current and future policies. This should contribute to ensuring local provision of supplies, free from dependence on outside sources.

Manufacturers: Knowledge of the economic viability of different raw materials can be combined with appropriately framed political measures to encourage the use of those that lead to greater efficiency of production. This may bring about an increase in local sources of supply and a consequent decrease in the costs of raw material.

Support Activities (researchers, suppliers of inputs, consultants and so forth). The results of this investigation will allow an improved functioning of the sector producing raw material. This will encourage its operations and thus of the activities linked to it.

Consumers: Consumers will be indirect beneficiaries. Consideration of the results of this project by the involved parties listed above should lead to a better functioning of the entire supply chain. This would be sure to lead to an increased production of environmental and social goods and services, which are what consumers nowadays demand.

METHODOLOGY

Three basic methods were used to undertake the work being reported upon here. They were: Rapid Rural Appraisal (RRA); Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, and methods employed for calculating economic accounts for agriculture (EAA), as explained by European Parliament and Council of the European Union (2004) and Commission of the European Communities (2008).

SWOT analysis is widely used in business management and is well suited to carry out an analysis of the strategic situation of a business and of the possibilities available to it in relation to the competitive environment in which it finds itself. In such an analysis, four factors are identified: Strengths, Weaknesses, Opportunities and Threats.

RRA is a semi-structured research method half way between quantitative and qualitative research techniques, allowing a reduction in the time and cost required for obtaining data. This technique, extensively used in the area of rural development (FAO, 1997), is employed for gathering information and formulating new hypotheses. It has proved particularly useful in those situations in which there is a lack of knowledge and data, like that under consideration here.

The method generally combines the use of various different research techniques. Thus, application of RRA methodology in the present study has allowed cross-checked and tested information to be obtained through the use of varying techniques. These included direct observation of the situation, the gathering of quantitative data and the use of secondary sources of information, as an initial step prior to in-depth interviews with experts and farmers.

In-depth interviews are widely used in social science research (García Ferrando *et al.*, 2000) as a way to gain access to necessary information that is lacking in secondary sources. In accordance with Mayntz's classification (Mayntz *et al*, 1996), individual in-depth oral interviews were chosen, on the basis of their capacity to extend knowledge of a minimally structured problem, and of the sort of interviewees involved. This was because the kind of interview in question is used with experts in a particular subject, a structured questionnaire being unsuited to fulfilling the aims of this research (Olaz, 1998).

As should happen with any application of RRA, the process of obtaining the information was highly participatory. It brought in panels of different representatives, selected as a function of their prestige, experience and representativeness within each of the following areas:

- Civil servants from the Spanish national government and from the regional administration, involved in developing policies related to the energy crop sector.
- Representatives of the major farmers' organizations, whether trade unions or corporate (co-operative).
- Non-government institutions offering technical support or finance to the sector.
- Researchers and consultants, both national and regional.
- Representatives of the principal industries processing the raw material (primary consumers of the resource)
- Consumers and groups using the end product that the raw material is used to make (biofuels).

The composition of the panel was made up of:

- The Head of Biofuels Department of the Institute for the Diversification and Saving of Energy (IDAE).
- The President of AVEBIOM. AVEBIOM is an association created to contribute to the development of bio-energy and to promote the creation of new firms working in the sector, which supports and provide information to any stakeholder related with bio-energy.
- Different researchers from the University of Leon: three Professors of the University of Leon (PhD Agricultural Engineers and experts in Crop Productions) and two Professors of the University of Leon (PhD Agricultural Engineers and experts in Agricultural Machinery and Farming techniques).
- The responsible for the master of renewable energies at the University of Leon (Spain).
- Two experts belonging to ABENGOA, one of them, expert in the field of energy crop production, while the other one heads the bio-ethanol production plant located in Salamanca. ABENGOA is an industrial and technological firm, working in sustainable development, and, being one of the most important international bio-ethanol production companies.
- A representative of ACOR (a Spanish farmers' cooperative), who's responsible for bio-energy projects and energy crops economic studies.
- Two experts from EREN (Castile and Leon Regional Entity for Energy): The Head of the Department of Renewable Energies and the Biomass Technician.
- The research team heads by the deputy director of the Research and Technological Section of the ITACyL (Castile and Leon Agricultural Technological Institute)
- The manager of the Municipal Transport Holding in Madrid (EMT).
- The manager of E.S. Berciana de Petróleos (A private bio-fuels commercial firm)
- Two representatives of the most important farmers' organizations in Spain: UGAL-UPA and ASAJA.

- Two private agricultural businessmen; these last ones have been recommended as experts growing energy crops by the two above mentioned farmers' organizations.

The data obtained in this way were used to undertake an analysis of the circumstances and economic viability of energy crops, applying the EAA methodology. The crops considered in this section are rape and sunflower seed. The presentation and discussion of the case of cereal crops has been omitted. This is because an overview of the information obtained from the RRA showed, firstly, that they are present on only an extremely small part of the areas given over to energy crops and, secondly, that their profitability in the market for foodstuffs is very slight. This fact is compounded if production of them is for the energy market, where prices are lower than is the case for foodstuffs, the energy alternative not being able to cope with the drop in income arising from this price differential.

In respect of this, two situations were investigated, termed Scenario 1 and Scenario 2. The first corresponds to the parameters for prices for inputs and end products relating up to the 2006 harvest, using the price trends that emerge from market developments up to that point. The second corresponds to the situation during more recent harvests (2007 and 2008), when prices both for inputs and for the crops themselves underwent a considerable increase (crop prices more so). In both scenarios, it was assumed that the unit involved was a typical farm of 75 hectares in extent[1], with two differing systems of production (unirrigated and irrigated) being considered, in combination with three possible systems for cultivation: conventional cultivation and alternative approaches suited to sustainable agriculture that respects the environment, these being minimum tillage and direct sowing.

EAA calculate three balancing items: net value added, net operating surplus (net mixed income) and net entrepreneurial income. Regarding this last one (entrepreneurial income), some considerations must be taken into account in order to adapt the results to the case of sole proprietorships. Thus, we have considered land as own, for being this system the most popular in Castile and Leon, -and in Spain, too-, (INE, 2007). As well, we have considered no paid and no received interest, either, replacing this term by the opportunity cost of the own land and the resting investments (machinery, construction, etc). Table **1** set out the relationship between these items. Data to calculate the different results of the EAA (according Table **1**) have been obtained from the information supplied by the expert panel contrasted with secondary sources.

Table 1: Economic accounts

Production Account	**Generation of Income Account**	**Generation of Current Profit**
Crop Output (Producer Price*yield)	Net value added	Net operating surplus/net mixed income
- Intermediate Consumption	- Compensation of employees	- Non salaried labour
- Consumption of fixed capital	- Other Taxes on production	- Opportunity cost of the own capital
	+ subsidies on production	= Current Profit after distribution
= Net value added	= Net operating surplus/net mixed income	
- Other Taxes on production		
+ subsidies on production		
= Net Value added at factor cost/factor income		

Source: Authors' own based on EAA (European Parliament and Council of the European Union 2004; Commission of the European Communities, 2008).

[1] The choice of this size is motivated by the fact that, according to statistics from the Spanish National Statistical Institute (INE, 2007), the majority of farms growing herbaceous crops have extents lying in the range 50 to 100 hectares.

Net value added measures the value created after the consumption of fixed capital.

Net value added at factor cost measures the remuneration of all factors of production (land, capital, labour) and can be termed “factor income”, as it represents all the value generated by a production activity.

Net operating surplus measures the yield from land, capital and non-salaried labour. It indicates the distribution of income between these three factors of production.

Current Profit after distribution: Represents the income remaining with the enterprise, which remunerates the management and risk assumed by the holder.

Curren Profit after deducing non-salaried labour hand: Represents the income remaining with the enterprise plus the remuneration of the own capital (opportunity cost of land and investments).

Current profit after deducing the opportunity cost of the own capital: Represents the income remaining with the enterprise plus the remuneration of the non-salaried labour.

Moreover other indicators are calculated:

Employment Rate: It represents the labour required by the crop cultivation. It is measured in two different units: Agricultural working unit (AWU)/ha and ha/AWU.

Break-Event Point (BEP): It’s the point at which cost or expenses and revenue are equal; there is no net loss or gain.

Ratio subsidies on product/Crop output: It represents the importance (in percentage) of the subsidy linked to the energy crop over the total crop output.

Finally, a SWOT analysis was undertaken, using the information of the expert panel and secondary information, to bring together and lay out the main results. This was done by means of the identification of the threats and opportunities offered by the context, together with the strong and weak points of the sector itself.

ANALYSIS OF THE ENVIRONMENT

Policy and Institutional Environment

Energy Policies

In 1997, obligations contracted under the Kyoto Protocol in respect of the emission of gases once again focused attention on what are termed renewable energies. The European Union at that point made a commitment to reduce annual emissions by 8% by 2010. It even set itself the challenge of doubling the proportion of renewable energies in overall energy consumption.

Directive 2003/30/EC of the European Council (European Parliament and Council of the European Union, 2003), relating to the promotion of biofuels or other renewable fuels for transport, established a target of 2% by 2005 and of 5.75% by 2010 for the level of use of such fuels within the overall amount of fuel used in transport. The Biomass Action Plan of December 2005 (Commission of the European Communities, 2005) and the paper “An EU Strategy for Biofuels” (Commission of the European Communities, 2006) gave a clear response for the measures necessary to promote the production and use of biofuels within this new framework. Later, in March 2007, the European Council adopted various measures intended to reduce by at least 20% emissions of CO_2 between then and 2020.

More recently, Copenhagen climate conference reinforced such objectives (Averchenkova, 2010) and two new EU Directives: Directive 2008/28/EC (European Parliament and Council of the European Union, 2009a) and Directive 2009/30/EC (European Parliament and Council of the European Union, 2009b) have tried to respond to the expectations of industry, introducing incentives for the consumption of biofuels. These include an obligation to produce at least 10% of the fuel used for transport from renewable energy sources and a reduction of 6% in the emission of greenhouse gases in the petrol and diesel cycles between 2011 and 2020. This is an attempt to ensure the future of biofuel plants that are currently in production or under construction in the EU.

In order to achieve such commitments, in Spain, a Spanish Renewable Energy Plan (PER) 2005-2010, together with an Action Plan for Energy Savings and Efficiency 2008 to 2012 (PAE4+), have all been put into operation. This has permitted a reduction in the consumption of energy, in Spain's dependence on external sources of energy and in pollution (IDAE, 2007).

PER 2005-2010, is a document processed by the Institute for the Diversification and Saving of Energy (IDAE), responsible for the setting of objectives and implementation measures in the field of renewable energy in order to diversify the excessive dependence on foreign energy supply, to protect the environment and to achieve a sustainable development (IDAE, 2005)

The PER, follows a revision of the Plan for the Promotion of Renewable Energy (PFER) 2000-2010, approved upon agreement of the Council of Ministers on 30 December 1999, which in the year 2004 was not able to meet expectations due to a relevant increase in energy demand and consumption which did not correspond to the expected increase in renewable energy production.

In the field of biofuels, PER raises the objectives set by the previous PFER from 0.5 to 2.2 million tep in 2010, which would set the market share of biofuels for 2010 at 5.83% on the total amount of gasoline and diesel fuel used for transport[2]. To achieve such amount, an increase by nearly 2 million tep is forecast in the period 2005-2010, of which 750,000 tep would correspond to bioethanol and the rest to biodiesel (Table **2**). In this sense, the Plan considers the previously described taxation system as a key element to achieve such objective.

Table 2: Objectives of PER

	Situation in 2004 (tep)	**PFER Objective for 2010 (tep)**	**PER Objective for 2010 (tep)**
Castile and Leon	0	100,000	330,000
TOTAL for Spain	228,200	500,000	2,200,000
Total for Castile and Leon	0 %	20 %	15 %

Source: Authors' own based on PER 2005-2010 (IDAE, 2005).

Finally, as a response to the requirements of Directive 2009/28/EC, a National Action Plan for Renewable Energy (PANER) has been drawn up, so as to attain the national objectives fixed in that Directive (IDAE, 2010). As may be seen from Table **3**, the projections for consumption of biofuels included in this plan double the levels envisaged for 2011. Moreover a new PER is currently being drawn up, PER 2011-2020, a continuation of the current PER 2005-2010. This new plan will incorporate the essential elements of the PANER, together with further studies not considered in that plan.

Tabla 3: Objectives of PANER

	Situation in 2011 (Ktep)	**PANER Objective 2020 (Ktep)**
Bio-ethanol	232	400
Biodiesel	1471	3100

Source: Plan for Renewable Energy in Spain 2011-2020 (IDAE, 2010).

2 Slightly above the objectives set in Directive 2003/30/CE (5.75%).

The implementation of the above mentioned energy policies is expected to increase the domestic use of energy crops, specially for the case of oil seeds over the medium term in the EU (European Commission, D.G. for Agriculture and Rural Development, 2009).

CAP and Market Development

In these circumstances, agriculture and energy policy constitute two closely linked elements. In accordance with what has been stated above, energy crops may act as a strategic tool giving support for the provision of raw material and thus contributing to encouragement for participation by biofuels in energy supplies and achievement of the objectives of current energy policy. Simultaneously, they would boost a sector (agriculture) that is clearly in crisis because of the impossibility of finding market-viable alternative products. Thus, energy crops might become a new output that permits the survival of the activity, with the associated social and environmental functions that it carries with it, as recognized by previous bibliography and by Directive 2003/30/EC itself (European Parliament and Council of the European Union, 2003).

In fact, Agenda 2000 already supported these objectives, through authorizing the use of set aside (introduced in 1992 reforms) for non-food crops, as also new economic incentives for sowing energy crops (energy crops aid). Later reforms of the CAP accentuated even further the crucial role of energy crops through the introduction of a number of measures such as decoupling. Summarizing, three mechanisms: decoupling, the adjusted regime for set-aside and the premium for energy crops, included in Council Regulation 1782/2003/EC (Council of the European Union, 2003), have been interacting over the last few years to promote the introduction of energy crops.

Agricultural policies certainly play a very important part nowadays in determining the profitability of agriculture in Castile and Leon. At present, the single payment scheme has become the main mechanism for direct support for farmers' incomes. This payment system, together with the new proposals for the CAP, especially with reference to the ending of subsidies for energy crops, the abolition of obligatory set-aside and decoupling, set up a new framework which may well be of considerable influence in the case of regions like Castile and Leon. In such zones, the yields and costs of production lead to a very small profit margin for certain products, in which the subsidy for energy crops (no longer in existence after 2010) had much more weight than in other European regions (Vannini *et al.*, 2006).

Hence, the elimination of compulsory set-aside opens up the possibility of using land previously covered by this scheme for any market orientation whatsoever (within the still existing legal limitations on its use for non-food crops). The experts consulted pointed out that this may have the effect of reducing the attractiveness of contracts for energy crops relative to demand for food. This is due to the competitiveness between the two markets (food and energy markets) which is the basis of the scarce development of energy crops up to the moment.

This would give rise to a consequent need to implement new incentives if the intention is to consolidate regional supplies, this being an aspect also stressed in other studies (Editorial team of the journal *Tierras*, 2007, Panoutsou, 2007).

Consumption/Demand of Bio-Energy in Spain

The main feature of the energy demand in Spain is a high dependence on oil, which has resulted in a lack of self-sufficiency and an important level of energy dependency (the energy dependence rate in Spain in 2008 was 80%) much higher than in the EU (53%).

Nevertheless, the structure of this demand has experienced an important change in the last 20 years, especially after 2005, when the new energy policies focused on energy saving and efficiency, mentioned in the precedent section, came into force. In these last years, the share of renewable energies in energy production and consumption has notably risen while the total gross final energy consumption has fallen (Tables **4** and **5**). The above mentioned policies concerning energy efficiency have much to do with this new trend.

Table 4: Share of renewable consumption to gross final energy consumption

	2006	2007	2008	2020 (target)
Spain	9,1%	9,5%	10,7%	20%
EU27	8,8%	9,7%	10,3%	22.7%

Source: Spanish Ministry of Industry, Tourism and Trade (2010) and Europe's energy portal (2011).

Table 5: Final energy consumption

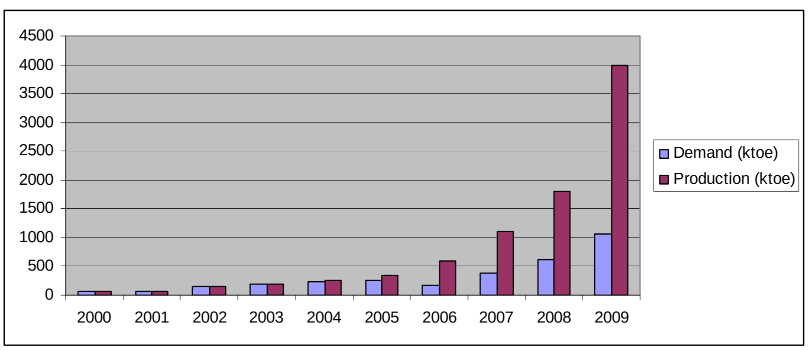
	2008	2012 (target)	2016 (target)	2020 (target)
Renewable energy (ktoe)	10.687	14.505	17.983	22.382
Consumption of gross energy (Ktoe)	101.918	93.321	95.826	98.677
% Renewable energy/Final energy	10.5%	15.5%	18.8%	22.7%

Source: Spanish Ministry of Industry, Tourism and Trade (2010)

Thus, the share of renewable energies in the energy primary consumption in Spain rose by 1,3% in ten years, from 4,5% in 1995 to 5,8% in 2005, and five years later (in 2010), the demand accounts for 10,8% of the primary energy and more than 12% of the final gross energy consumption. The evolution of this share of renewable consumption in Spain has been very similar to the one of the European Union (Table **4**).

Biofuels production has been one of the main responsible of the increasing trend in renewable energy production. Nevertheless, this increasingly production has not been accompanied by a parallel rise in biofuels demand. While the production capacity of the processing plants have notably increased in the last 10 years up to 4000 ktoe in 2009, the evolution of the real demand has not followed this same trend, being just about 1058 ktoe (Fig. **1**).

It's expected that the new policy incentives included in PANER 2011-2020, could contribute to change the upcoming evolution.



Source: PANER 2011-2020 (IDAE, 2010)

Figure 1: Demand and production of biofuels in Spain (2000-2009).

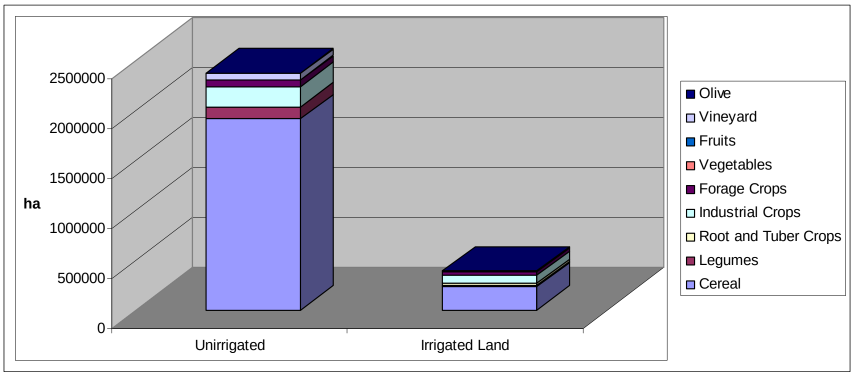
The Agricultural Sector in Castile and Leon

Main Features of the Agricultural Sector

The continental climate existing in Castile and Leon with great contrasts of temperature and sparse rainfall, which is in addition very unequally distributed by location and by season, determines the kind of crop to be grown in this region. Table shows the main crops which are currently being grown in this region. In this sense it's important to stress the important role of irrigation for the development of the agricultural sector in the region, allowing the introduction of new cultivations.

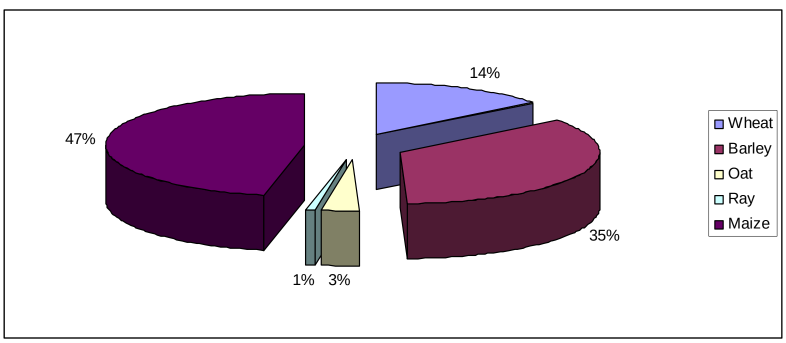
In the agricultural land, cereals and crops for industrial uses are the protagonists (Fig. **2**). Wheat and barley are the predominant cereals, while the most important industrial crop (in surface) is sunflower. Wheat, barley and sunflower are mainly grown on unirrigated land (Figs. **3** and **4**), while maize and sugar beet are the chief crops in irrigated areas (Figs. **4** and **5**), being those ones the most profitable crops existing in the region, specially in which concerns sugar beet.

Currently, the Autonomous Community can count on the highest crop yields and surface of sugar beet, as well as maintaining a central role in the production of cereals and oilseeds at the national level. In the 2005/2006 campaign, and according to the surface subsidized by the CAP, the 35% of the total soil for the production of cereals, 35% for corn, 28% for oilseeds and 27% for set-aside land is located in Castile and Leon.



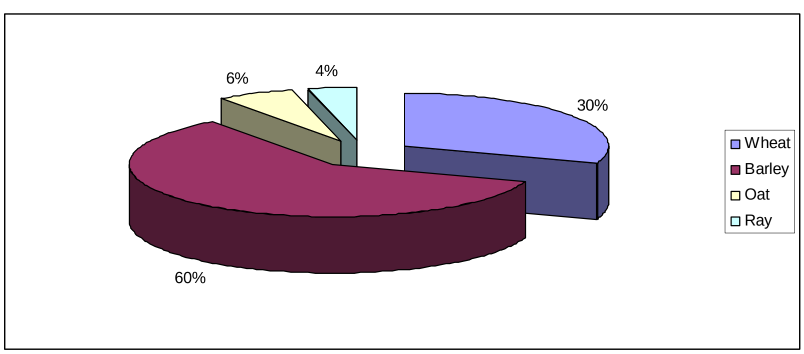
Source: Authors' own based on Junta de Castilla y León (2010).

Figure 2: Surface under crops in Castile and Leon.



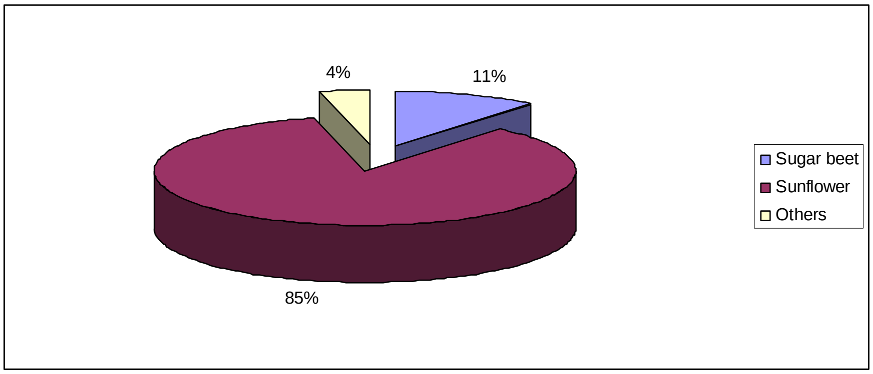
Source: Authors' own based on Junta de Castilla y León (2010).

Figure 3: Cereals grown on irrigated land in Castile and Leon.



Source: Authors' own based on Junta de Castilla y León (2010).

Figure 4: Cereals grown on unirrigated land in Castile and Leon.



Source: Authors' own based on Junta de Castilla y León (2010).

Figure 5: Industrial crops in Castile and Leon.

The structure of productive units may be observed in Table **6**. The main characteristics are the small dimension of these units (the average size per holding is 55,6 ha) together with a high parcelling level. In spite of it, the average size per holding in Castile and Leon is higher than in Spain (23,2 ha).

Table 6: Structure of productive units in Castile and Leon

	Farms (Number)	Farms (%)	Total Surface (ha)	Total Surface (%)	UAA (ha)	UAA (ha)
UAA (ha)	92030	98,81	6900319	99,89	5471306	100
< 1	1232	1,32	1691	0,02	591	0,01
1 a < 2	7693	8,26	20312	0,29	10517	0,19
2 a < 5	11346	12,18	51523	0,75	37067	0,68
5 a < 10	10083	10,83	82764	1,2	73177	1,34
10 a < 20	11254	12,08	207900	3,01	165503	3,02
20 a < 30	10287	11,04	280602	4,06	249794	4,57
30 a < 50	11638	12,49	500134	7,24	451704	8,26
50 a < 100	13395	14,38	1086795	15,73	970075	17,73
100 or more	15101	16,21	4668598	67,58	3512877	64,21

Source: Authors' own based on Spanish Institute of Statistics (INE, 2007).

The main features of the regional farmers are the following: high level of aging of the rural population (45% of the agricultural business men are over 60 years old), the lack of generational change in business management, farmers' risk aversion, lack of incentives or the scarce entrepreneurial tradition of farmers regarding the adoption of new initiatives.

The average economic size of these agricultural farms is about 23,68 European Size Units (ESU), predominating those farms of a small or medium economic size (more than 76% could generate an added value between 2 and 100 ESU). An idea of the profitability obtained in Castile and Leon farms according the type of crop grown could be observed in Table **7**.

Table 7: Percentage of farms according to their economic size and productive orientation

ESU	< 1	1 to < 2	2 to < 4	4 to < 6	6 to < 8	8 to < 12	12 to < 16	16 to < 40	40 to < 60	60 to < 100	100 or more
Cereals	8%	6%	12%	10%	10%	10%	8%	23%	7%	5%	1%
Wheat	5%	3%	11%	7%	13%	10%	9%	27%	8%	6%	2%
Barley	8%	6%	10%	9%	8%	10%	7%	26%	8%	6%	2%

Table 7: cont….

Maíze	1%	1%	11%	11%	17%	13%	9%	29%	3%	4%	1%
Sugar beet					8%	0%	3%	53%	21%	11%	4%

Source: Authors' own based on Spanish Institute of Statistics (INE, 2007).

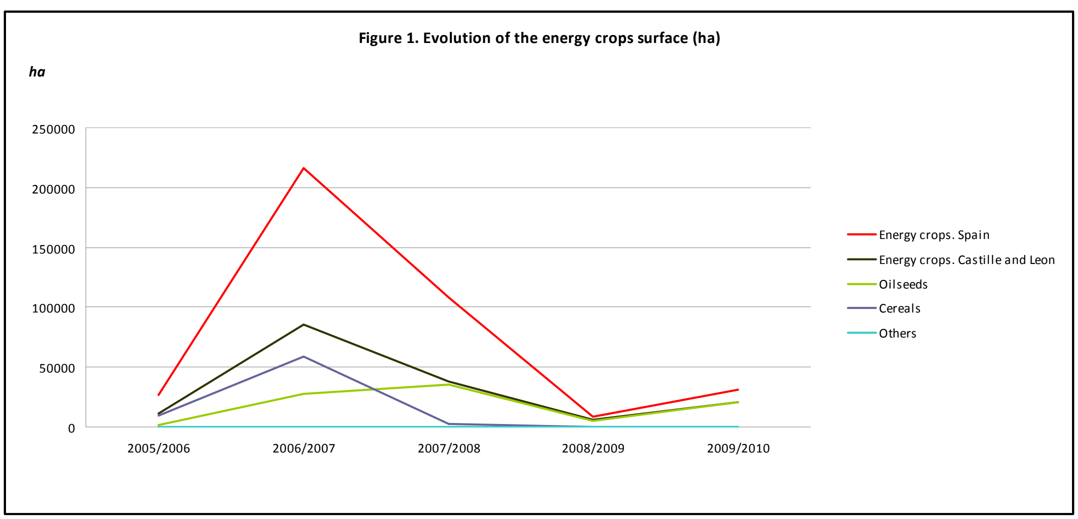
Energy crops in Castile and Leon

The use of crops for energy in the region is relatively recent, having its origin in the contracts for cereals grown on set-aside lands that have been signed between farmers and the production industry since 1997/1998. In Castile and Leon, as well as in Spain and most part of Europe, energy crops have been traditionally grown on set-aside lands, appearing in new places when the subsidy for energy crops started to apply (Vannini *et al.*, 2006). An idea of the kind of crops and the area sown may be got from the data in Fig. **6**.

As may be observed, there was an important increase up to 2006 coinciding with the coming into force of specific subsidies for energy crops and with the new sowings in the set-aside. Lastly, during recent harvests, there has been a decline in the area given over to this sort of crop, due to the increase in the prices for cereals arising from various different factors (declining reserves, poor harvests because of bad weather, increased demand). This fact has even triggered debate about the substitution relationship between food and energy uses of cereals. In particular, the capacity of local agriculture to produce enough to meet the new demands for energy without neglecting the requirement for foodstuffs, both human and animal, has been much discussed (COAG, 2007).

Among crops, cereals stand out up to 2007, occupying the greater part of the land used. In 2005, the only oilseed sown was sunflower, while among cereals, barley and wheat shared the surface sown, the former (at 89%) clearly outstripping the latter. After 2007, this situation has changed and oilseeds have surpassed the cereal area with a continuous increase. This increase for oil seeds is mainly due to the importance of rape-seed, the main oilseed for energy market in Castile and Leon, as well as in the EU (Blanco Fonseca *et al.*, 2010), while the presence of other crops is no relevant..

It cannot be said that there are any really representative farms in respect of such productions, since the area given over to these crops up to the moment is very limited (less than 1% of the total Utilized Agricultural Area). Average yields for the main crops vary notably in accordance with the province (or even the municipality) and with whether they are grown on unirrigated or irrigated land



Source: Authors' own based on data from FEGA (Spanish Agricultural Guaranty Fund).

Figure 6: Evolution of the energy crops surface.

RESULTS

Profitability of Energy Crops

Scenario 1 (Trend up to 2006 Harvest)

Tables **8** and **9** show the detailed results for economic accounts under this scenario. In them it may be observed that if the prices received and paid by farmers up to 2006 are taken as the basis, none of the crops considered would be able to generate profits, even taking into account the €45 community aid payment (which is no longer available after 2010).

Both on unirrigated and on irrigated land, rape-seed gives better results with regard to the net mixed income generated (for all the production systems analysed), this revenue being higher on irrigated land, and with alternative cultivation systems. Sunflower seed gives a positive net mixed income only on irrigated land and with minimum cultivation and direct sowing systems on unirrigated land, with negative results under conventional cultivation. This would imply losses for the farmer, who would not even cover the costs of intermediate inputs and the use of fixed capital.

The opportunity costs of capital factors (land, machinery) are not covered in any of the cases studied, let alone the making of any profit. This is because the amounts remaining after deduction of the cost of non-salaried labour involved in the net mixed income do not reach a level sufficient to cover this opportunity costs (see current profit after deducing opportunity costs of the own capital, in Table **4**). As none of the crops is able to provide adequate remuneration in respect of the production factors land and capital, from an entrepreneurial point of view their cultivation would be inadvisable. This is due to their very limited profitability, arising from low prices and yields, on the one hand, and on the other, to the size of farm considered (75 hectares), which does not allow capital investments to be fully profitable. In fact, profit excluding the opportunity cost of investments would be positive in the case of rape-seed and sunflower seed on irrigated land with alternative cultivation systems, that is, it would be possible to pay adequate wages for non-salaried labour and leave a profit margin for the entrepreneur (although very small, especially if the amount of investment required is kept in mind). Increasing the size of farms is a key factor in making investments more viable and achieving better financial outcomes[3].

Break-even point (BEP) for rape-seed lies in a range between 2500 kilograms per hectare (kg/ha) on unirrigated land, somewhat lower than the BEP found in some other Spanish studies, where rapeseed BEP oscilates from 2600 to 2900 kg/ha (Lafarga *et al*, 2009). On irrigated land BEP is about 5200kg/ha to 5500kg/ha. The equivalent figures for sunflower seed are around 1800kg/ha on dry land, being this value close to some other Spanish studies (Lafarga *et al*, 2009), where it oscilates from 1500 kg/ha to 2000 kg/ha. On irrigated land BEP is 4500kg/ha, decreasing somewhat when alternative cultivation systems are used. Such yields are a long way from those found on most of the farms given over to these crops at present.

These results largely explain the sparse regional development of these crops. This is true in the European Union as a whole, if only those cultivated areas not covered by the set-aside scheme are taken into account (Commission of the European Communities, 2006b).

For rape-seed, subsidies accounted for more than 9% of the crop output generated from unirrigated land and 5% from irrigated land. For sunflower seed these percentages lay between 15% for unirrigated land and 5.6% for irrigated land, respectively. The disappearance of these aids entails, on the one hand, a shrinkage in income of the proportions quoted, and on the other a raising of the BEP by amounts ranging from 4% (irrigated land) to 9% (unirrigated land) in the case of rape-seed, and from 4% (irrigated land) to 10% (unirrigated land) in the case of sunflower seed.

Thus, the disappearance of subsidies is unlikely to involve an absolute block to the development of these crops. However, such aids did constitute a certain compensation for those production methods that yielded

[3] In fact, an increase in the size of the farm to 100 hectares would mean that all the crops would at least pay their non-salaried labour costs.

a net positive income. Thus, for example, in the case of sunflower seed on irrigated land they made it possible to pay for non-salaried labour with alternative cultivation systems, although not opportunity costs.

Scenario 2 (Situation During the Last Few Harvests)

During recent harvests, there has been an increase in the price of energy crops. This trend seems to have become consolidated in respect of rape-seed.

If the analysis is repeated with these price levels, the results improve notably, especially with regard to rape-seed. With prices rising from around €0.21 per kilogram to levels of the order of €0.42 to €0.48 per kilogram, even though an increased cost for inputs has to be taken in consideration, net income reaches figures of around €800 for irrigated land and €400 for unirrigated land. This implies adequate remuneration for the factors land and capital, together with profits for the entrepreneur that range from about €200 from unirrigated land and €400 for irrigated. Its inclusion among alternative choices, whether seen from a technical and environmental viewpoint or from an entrepreneurial angle, then becomes feasible. This is not true for sunflower seeds, which with prices of about €0.30 per kilogram continue to show negative figures for profits with all systems.

BEP for rape-seed drop relative to the previous scenario, reaching figures of about 1500kg/ha for unirrigated land and 3000kg/ha for irrigated land. For sunflower seed they come to around 1200kg/ha and 3200kg/ha, respectively, dropping lower as alternative cultivation systems are introduced. This brings yield levels which are close to values currently achievable by farmers.

The part played by aids in the financial results is even less crucial than in the previous scenario. This is because the amount of income generated has risen considerably, owing to the increased prices, so that the percentage that subsidies represent in the total revenue drops noticeably in comparison with the former scenario. In fact, with subsidies abolished, none of the crops that produced a positive profit flips into the opposite situation; the only change is that the profit is cut by €45.

Table 8: Economic accounts results: Scenary 1

Results Scenary 1	**Irrigated Rape Seed**			**Non Irrigated Rape Seed**			**Non Irrigated Sunflower**			**Irrigated Sunflower**		
	Conventional	**Mínimum Tillage**	**Direct Sowing**	**Conventional**	**Mínimum Tillage**	**Direct Sowing**	**Conventional**	**Mínimum Tillage**	**Direct Sowing**	**Conventional**	**Mínimum Tillage**	**Direct Sowing**
Yield (Kg/ha)	3800,00	3800,00	3800,00	2000,00	2000,00	2000,00	1000,00	1000,00	1000,00	3000,00	3000,00	3000,00
Producer Price (€/Kg)	0,21	0,21	0,21	0,21	0,21	0,21	0,25	0,25	0,25	0,25	0,25	0,25
Production Account (€)												
Crop Output (Producer Price*yield)	798,00	798,00	798,00	420,00	420,00	420,00	250,00	250,00	250,00	750,00	750,00	750,00
Intermediate Consumptions	439,92	407,54	414,13	288,97	263,69	282,80	218,56	218,27	220,18	445,05	422,39	421,46
Fixed Capital Consumption	164,33	164,56	155,80	51,83	45,51	43,30	47,18	41,18	40,96	167,89	162,46	158,48
Net Value Added	193,75	225,90	228,07	79,20	110,80	93,90	-15,74	-9,45	-11,13	137,06	165,15	170,06
Taxes	104,13	104,13	104,13	3,47	3,47	3,47	3,47	3,47	3,47	104,13	104,13	104,13
Subsidies on products	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00
Net Value added at factor cost/factor income	134,62	166,77	168,94	120,73	152,33	135,43	25,79	32,08	30,40	77,93	106,02	110,93
Generation of Income Account (€)												
Net Value Added	193,75	225,90	228,07	79,20	110,80	93,90	-15,74	-9,45	-11,13	137,06	165,15	170,06
Compensations of Employees	28,16	28,16	28,16	28,16	28,16	28,16	28,16	28,16	28,16	28,16	28,16	28,16
Taxes	104,13	104,13	104,13	3,47	3,47	3,47	3,47	3,47	3,47	104,13	104,13	104,13
Subsidies on products	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00
Net operating surplus/net mixed income	106,46	138,61	140,78	92,57	124,17	107,27	-2,37	3,92	2,24	49,77	77,86	82,77
Generation of Current Profit (€)												
Net operating surplus	106,46	138,61	140,78	92,57	124,17	107,27	-2,37	3,92	2,24	49,77	77,86	82,77

Table 8: cont….

Non-salaried Labour	56,46	42,96	41,46	23,46	14,46	12,96	19,50	9,00	9,00	52,08	44,58	41,10
Opportunity cost of the own capital (land and investments)	406,06	404,94	402,30	187,37	184,47	183,94	184,64	182,30	182,25	405,42	402,91	401,47
Current Profit after distribution	-356,07	-309,29	-302,98	-118,25	-74,76	-89,64	-206,51	-187,38	-189,02	-407,73	-369,63	-359,80
Curren Profit after deducing just non-salaried labour	50,00	95,65	99,32	69,11	109,71	94,31	-21,87	-5,08	-6,76	-2,31	33,28	41,67
Current profit after deducing just the opportunity cost of the own capital	-299,61	-266,33	-261,52	-94,79	-60,30	-76,68	-187,01	-178,38	-180,02	-355,65	-325,05	-318,70
Other items												
Employment Rate (AWU/ha)	0,005	0,004	0,004	0,002	0,001	0,001	0,002	0,001	0,001	0,005	0,004	0,004
Employment Rate (ha/AWU)	193,84	254,75	263,97	466,50	756,85	844,44	561,23	1216,00	1216,00	210,14	245,49	266,28
BEP (ha)	5496	5273	5243	2563	2356	2427	1826	1750	1756	4631	4479	4439
Ratio subsidies on product/Crop Ourput (%)	5,34	5,34	5,34	9,68	9,68	9,68	15,25	15,25	15,25	5,66	5,66	5,66

Source: Authors' own

Table 9: Economic accounts results: Scenary 2

	Irrigated Rape Seed			**Non Irrigated Rape Seed**			**Non Irrigated Sunflower**			**Irrigated Sunflower**		
Scenary 2: Results	**Conventional**	**Mínimum Tillage**	**Direct Sowing**	**Conventional**	**Mínimum Tillage**	**Direct Sowing**	**Conventional**	**Mínimum Tillage**	**Direct Sowing**	**Conventional**	**Mínimum Tillage**	**Direct Sowing**
Generation of Current Profit (€)												
Net operating surplus	61,46	93,61	95,78	47,57	79,17	62,27	-47,37	-41,08	-42,76	4,77	32,86	37,77
Current Profit after distribution	-401,07	-354,29	-347,98	-163,25	-119,76	-134,64	-251,51	-232,38	-234,02	-452,73	-414,63	-404,80
Curren Profit after deducing just non-salaried labour	5,00	50,65	54,32	24,11	64,71	49,31	-66,87	-50,08	-51,76	-47,31	-11,72	-3,33
Current profit after deducing just the opportunity cost of the own capital	-344,61	-311,33	-306,52	-139,79	-105,30	-121,68	-232,01	-223,38	-225,02	-400,65	-370,05	-363,70
Other items												
BEP (ha)	5710	5487	5457	2777	2570	2641	2006	1930	1936	4811	4659	4619
Increase of BEP above Scenary 1 (%)	3,9%	4,1%	4,1%	8,3%	9,1%	8,8%	9,9%	10,3%	10,3%	3,9%	4,0%	4,1%

Other Items: Occupation Levels and the Environment

In all cases, the amount of labour required is rather small, both because of the extensive nature of cultivation and because of its mechanization, especially in respect of sustainable farming systems. Employment indices (Table **8**) are at very low levels, similar for both crops, and varying only in accordance with the production techniques chosen. Evidently, such indices are higher with respect to irrigated land and drop as the amount of cultivation undertaken is reduced, through moves along the range running from conventional cultivation to minimum cultivation, and from this to direct sowing.

In relation to environmental aspects, these are extensively produced crops, not involving a massive use of inputs, and based on sustainable cultivation systems. Experts point out that their implementation will contribute to maintaining rural populations, with the ensuing survival of culture and traditions, as also rebalancing and territorial organization as pointed out by previous literature (Launder, 2002; Ericsson *et al.*, 2009).

Nonetheless, one possible negative environmental impact might occur if there was an intensification of production, or if production of energy crops led to monoculture. This situation would doubtless bring about a reduction in biodiversity, together with an increase in weeds, pests and diseases, leading to an expansion in the use of pesticides and fertilizers, as also the residues arising from them, with consequent effects of air, soil and water pollution.

Bear in mind these positive effects and that the delivery of public goods and services will be a key element in a reformed CAP, introducing an appropriated subsidy for those crops which don't get to be profitable (sunflower, cereals, rape seed -in some conditions-) would be advisable. This idea is supported by other studies which reveals the importance of setting up an economic support at least at the first stages of market development (Panoutsou, 2007). Moreover, we must consider that a correct payment to farmers for the delivery of public goods and services will be a key element in a reformed CAP (European Commission, 2010a) and has the EU citizens' support (European Commission, 2010b).

Likewise, some interviewed groups state that growing these crops may involve an increase in the total area under cultivation in comparison with the present state of affairs. In these circumstances, it would be necessary to take into consideration the quantities of CO_2 emitted, arising from the mineralization of fertilizers and organic material.

Aspects Regarding the Adoption of Energy Crops by Farmers

Finally, economic viability is an important factor, but it is not the only one (Panoutsou 2007; Robles & Vannini, 2008). Current situation may evolve as a function of various aspects that might limit or encourage the sector producing the raw materials. SWOT analysis allows us to identify some of the more important ones, which are listed below:

Opportunities

As was noted above, the features of climate and markets do not give many choices of crop to the region's farmers and this constitutes a challenge to their continued involvement in agricultural activities. Hence, energy crops, as a new line of production that permits them to carry on farming, and even increases their self esteem, through the perception that they are acting to contribute to reducing pollution and improving national energy supplies, are a strongly encouraging novelty.

This is all the more so, if it is kept in mind that lands newly converted to irrigated status are on the point of being brought into production. These have involved considerable funds in investments and farmers must seek out new viable crop alternatives for them, in the light of the fact that these lands have no rights to, or quotas for, aid under the CAP.

Thus, as noted by other authors (Rivas Garrido, 2010; Lafarga *et al*, 2009), energy crops becomes the possibility for farmers to find a new line of production that allows them to continue farming in the face of the problem of surpluses of many of the crops produced in the region, particularly after the changes brought in by the most recent reforms of the CAP and of certain CMO (like sugar).

Energy crops, as a new option on the market, permit the range of crops to be broadened and can be seen as a fresh choice for crop alternation, always assuming they are economically viable. As pointed by different studies, introducing energy crops in the rotation is an advisable practice with a view to avoid effects such as soil exhaustion, and reduce the presence of plant pests and diseases (Lafarga *et al*, 2009; Editorial team of the Journal *La Tierra*, 2005; Lumbreras, 2006). In regions like Castile and Leon, whose soil and climate conditions favour desertification and erosion in most areas, this practice is all the more necessary (Rivas Garrido, 2010).

Policy and institutional environment is an important opportunity (Lumbreras, 2006): International agreements and the need to reach the energy objectives set in the legislation imply an increase in the demand of renewable energies, which will promote the demand of the raw materials (energy crops). Moreover, there is considerable support from government, notably in the form of: (i) exemption of taxation, implying discrimination in favour of biofuels as opposed to conventional fuels; (ii) creation of pilot plants to carry out various technology trials or participation in the funding of production plants¸(iii) research applied both to manufacturing technologies and to the production of energy crops (iv) studies and reports analysing the problems of the sector.

New trends in the CAP, as decoupling, means the need to look for crop profitability without the support of the previous direct payments coupled to the production. Many of these crops are no longer profitable without this support. This fact opens the possibility to consider other crop uses for this land (Rivas Garrido, 2010).

Rural Development Programmes are focusing on enhancing the agricultural sector competitiveness, including environmental and diversification strategies. Energy crop production is an important alternative to be considered in order to achieve such objectives. Thus, different regions in Spain (Castile and Leon among others) are implementing new strategies to promote these crops as a tool for rural development.

Castile and Leon population is expressing general concern about the future of regional economy and, especially, about rural development. The population in Castile and Leon is displaying a widespread awareness on environmental issues, a positive evaluation of agriculture, and certain empathy towards the local production of regional biofuels.

Strengths

The existence of energy crops with a short cycle and permitting the use of new technologies like direct sowing allows the growing of two crops on one piece of land in the same farming season (Lumbreras, 2006), thus improving productivity per hectare and the annual financial results.

Restructuring and modernization of production infrastructure has been achieved through consolidation of scattered plots of agricultural land (allowing the unit size of plots to become greater) and bringing under irrigation (permitting much increased yields and the introduction of new types of crop). These actions make it easier to initiate the growing of energy crops on a large scale.

Moreover, the regional tradition of growing cereals, beet and sunflowers for food use, means that suitable machinery, equipment and awareness of production techniques are available. Hence, a change in orientation towards energy use does not in this case require important additional investments to be made or new knowledge to be acquired, as would be the case with the introduction a totally different sort of crop.

The agricultural population has a feeling of concern facing crop alternatives, due to the effect of CAP reforms, especially after the latest reform on sugar, which may negatively impact the region. Thus, farmers in Castile and Leon are starting to develop new alternatives, as energy crops, looking to participate in the value chain through different ways, as vertical integrations or horizontal associations.

Weaknesses

Problems to adapt energy crops to the conditions of the region; This is true even in the case of crops, which without being traditional in the area are at least somewhat known there, such as cardoon thistles or rapeseed, for which it is necessary to solve problems of resistance to frosts or of lack of homogeneity in ripening or sprouting. It is all the truer in respect of the possible introduction of previously unknown crops, like sorghum, for which the difficulty of adaptation is greater.

Low profitability of these crops as found in this and other studies (APPA, 2006) due to:

- The non-existence of varieties adapted to the local climate and to be able to reach suitable yields. An effort in this sense is needed (Calcedo Ordóñez,2006; Lumbreras and Mendiburu, 2008).

- The need to define the technical conditions for cultivation (sowing patterns, production techniques and so on) and to adapt the fleet of machinery in the case of new crops.

- Unfamiliarity on the part of farmers with some of the crops and lack of custom of including them in traditional patterns.

- Low yields and price, below than that offered for competing food crops (Lumbreras, 2006).

- The high cost of crop production (view Tables **8** and **9**), is another important weakness, which is also true for some other Spanish regions (Aroca Gallardo, 2008).

Other weaknesses are:

- The absence of funds for farmers can face the needed investments which accompany the introduction of a new crop.
- Farmers' disliking for risk (risks arise in this instance both from climate conditions and from the chance of not being able to sell the output or from the potential failure to adapt of a new crop, among other things).
- The limited extent of such crops is in itself a brake on their development (Launder, 2002). The adoption of a technique by one farmer generally encourages others to do the same, and vice versa.

Nonetheless, none of these drawbacks constitutes an insuperable barrier. In fact, considerable effort is being put into research to solve the problems listed and into publicizing results. Bio-technology can offer interesting improvements as regards species to be used as raw materials, or with a better production yield or environmental effects (Duffield et al, 1998). In addition, the producers themselves are favourably inclined towards energy crops and deeply interested in them.

In any case, it is hoped that the opening of processing plants and the implementation of the new energy policies in the near future will boost the sector and that little by little more farmers will join the trend.

Threats

It's proved in the past, that economic crisis use to drive to a reduction in the consumption of energy. This fact together with the need to reduce the public expenditure could threaten the funds to finance the different policies to promote energy crops and/or the demand for renewable energy.

CAP new trends, as the recent abolition of energy crops premium makes it more difficult to compensate the existing differences between food and energy crops prices, thus reducing the incomes. Moreover, the abolition of compulsory set-aside opens the possibility for growing food crops on those lands.

Climate and soil conditions in the region limit the yields of these energy crops, especially on unirrigated land.

The uncertainty and the risk involved in the introduction of a new crop (as it's the case of energy crops) or the need of investments to improve the economic results is an important threat, taking into account the above mentioned features of Castile and Leon farmers.

Some features of the agricultural population, such as the lack of generational change, the lack of incentives, the scarce entrepreneurial tradition existing in Castile and Leon agricultural sector regarding the adoption of new initiatives…, limit both the production of energy crops, and the acceptance of such processing process by farmers.

In general, the poor entrepreneurial attitude of the population (as compared to other areas, such as the Basque Country or Catalonia), the inertia and the delayed reaction of all those taking part in the supply chain to proactively face events, contributed to the poor development displayed by the sector at al levels (agriculture, processing and consumption).

Finally, as also noted by other Spanish studies (Lafarga *et al*, 2009; Lumbreras, 2006, Aroca Gallardo, 2008), the import of energy crops and/or oils at a lower price than those which are being currently produced in the region together with the competition between crop and food markets, with prices clearly higher for food markets, are the main threats which the sector must face at the present moment.

To face some of these threats, a considerable effort is being carried out by all those implied in the sector to support research, aimed at the adaptation of crops to the local environment and at reducing production costs, thus to improve energy crops competitiveness. As well, the Administration has performed different policies in order to enhance the demand for biofuels or to promote the diversification of the land use.

Finally, important investment in farmers' training and information is also being carried.

CONCLUSIONS

The energy policies have not got to enhance the growing of energy crops in a large scale, up to the moment. This is due to the low level of prices of these items (up to the last harvests) and to the important competitiveness between both markets food and energy.

In general, as perceived by the various players involved in the operation of the chain, the principal factors limiting production of energy crops in Castile and Leon, are the following:

- Low price levels.
- Low levels of subsidy paid to farmers up to the present.
- Little demand for the crops, due to limited demand for the final product in the Spanish market, the importation of raw materials by industry.
- Unfamiliarity with the crops and sparse results from research carried out up to the present.
- International competition over the prices of alternative raw materials (such as palm oil), encouraging imports.
- The abolition of compulsory set-aside land.

Sunflower seed and rape-seed as energy crops are not able to generate entrepreneurial benefits, unless prices remain at least at the levels paid for recent harvests. In this case, rape-seed might indeed be a viable choice for entrepreneurs, with the financial results improving on irrigated land and as there is a move from conventional cultivation to minimum tillage, or onward to direct sowing.

It may be observed that the Break-even point drops as the amount of cultivation is reduced by the use of systems of direct sowing and minimum tillage. These techniques of growing together with further research aimed at adapting crops to local conditions is the only way of compensating for the disadvantages from which this region suffers in comparison with others, making it possible to attain yields that might make these crops profitable in situations in which they are not at present viable.

The CAP subsidies for energy crops have played no great role, in view of the limited amounts involved and the absence of any differentiation between unirrigated and irrigated land. However, they have contributed to a minor improvement in outcomes, so that their disappearance will entail a slight worsening, which may be decisive for some production choices (sunflower). In this sense, as pointed out by other authors (Panoutsou, C., 2007), to set up an appropriate level of public economic support for the first stages of these crops could enhance the introduction of them. This idea could be supported for the multifunctional role of energy crops: From an environmental viewpoint, the production of energy crops on the basis of extensive farming systems combined with sustainable cultivation methods and as the raw material for less contaminating fuels would be of great environmental value. However, this would be true only as long as there is no intensification in production methods, and as long as its expansion does not entail a very great increase in the area under cultivation.

In view of the limitations imposed by climate and markets on the possible introduction of crops into the range of options, both rape-seed, cultivated under all the systems investigated, and sunflower seed, on irrigated land with minimum cultivation and direct sowing systems, might have a part to play in diversifying risks in farming and crop rotation. This would have environmental and technical advantages, since they are able to generate a positive revenue that allows payment to be made for the labour used.

Furthermore, any circumstances that involve a loss of viability by these crops at a regional level would negatively affect not just income and employment for farmers, but also all linked activities. These include the supply of inputs, transport, service enterprises and the like. This would have negative repercussions on the level of employment and the economic tissue of the whole region (Vannini *et al.*, 2006, Launder, 2002).

For this purpose, the government should consider the introduction of financial assistance that would aid in covering the costs arising from investments in land, machinery and installations. This help should be appropriate and differentiate between unirrigated and irrigated land, and even between crops. There should in addition be incentives that might facilitate an increase in the size of farms with an eye to reaching viability thresholds.

Other formulae that would permit farmers to improve their financial results would be:

- Increasing average farm sizes.
- Associations of a horizontal nature for production, shared use of machinery and installations and joint marketing of the raw material produced.
- Association with industry, involving vertical integration, which would permit participation in decision-making.

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CHAPTER 7

Governing of Agro-Ecosystem Services in Bulgaria

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Abstract: This paper incorporates interdisciplinary New Institutional and Transaction Costs Economics and analyzes the governance of agro-ecosystem services in Bulgaria. Firstly, it presents a comprehensive framework of analyses of environmental governance including: definition of agro-ecosystem services and governance; specification of governance needs and spectrum of governing modes (formal and informal institutions, market, private, public and hybrid forms); assessment of efficiency of different modes of governance in terms of their potential to protect diverse eco-rights and investments, assure a socially desirable level of agro-ecosystem services, minimize overall costs, co-ordinate and stimulate eco-activities, meet individual and social preferences and reconcile conflicts of related agents *etc.* Secondly, it identifies and assesses the governance of agro-ecosystem services in Bulgaria. It proves that post-communist transition and EU integration brought about significant changes in the state and the governance of agro-ecosystems services. Newly evolved market, private and public governance has led to a significant improvement of the part of agro-ecosystems services introducing modern eco-standards and public support, enhancing environmental stewardship, disintensifying production, recovering landscape and traditional productions, diversifying quality, products and services. At the same time, the novel governance is associated with new challenges such as unsustainable exploitation, lost biodiversity, land degradation, water and air contamination *etc.* Moreover, it demonstrates that implementation of the EU common policies would have no desired impact on agro-ecosystem services unless special measures are taken to improve management of public programs, extend public support to dominating small-scale and subsistence farms.

Keywords: Agro-ecosystem services; environmental management; market, private, public and hybrid governance; eco-impact of EU policies; Bulgaria.

INTRODUCTION

The governance and assessment of ecosystem services is among the most topical issues in academic, business, and policy debates in recent years (Boyd and Banzhaf, 2007; Daily, 2000; Duraiappah, 2007; Farber *et al.*, 2002; Hanson *et al.*, 2008; MEA, 2005). It is recognized that the maintenance and improvement of ecosystem services requires an effective social order (governance) and coordinated actions at various levels (individual, organizational, community, regional, national, and transnational).

It is also known that the effective forms of governance are rarely universal and there is a huge variation among different ecosystems, regions, countries *etc.* The efficiency of environmental management depends on the specific governing structures which affect in dissimilar ways individual's behavior, gives unlike benefits, commands different costs, and leads to diverse actual performances (Daily, 2000; Duraiappah, 2007; Bachev, 2007).

Agro-ecosystems comprise a considerable portion of the ecosystems and they are associated with diverse services (Bachev, 2009). Nevertheless, research on the management of this specific ecosystem services is still at the beginning stage (AEHP, 1996; Antle, 2007; Jolejole *et al.*, 2009; WISP, 2008).

Most studies focus on certain hotspots or type agro-ecosystems (*e.g.* pastoral, crop), and individual modes of management (formal, contract, business, public). What is more, significant costs associated with the eco-system services management (known as transaction costs) are not entirely taken into account. Furthermore,

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uni-disciplinary approach dominates, and efforts of ecologists, economists, lawyers, behavioral and political scientists are rarely united. Besides, there are little studies on specific natural, economic, institutional, international *etc.* factors responsible for the variation among different ecosystems, regions and countries.

With few exceptions (Bachev, 2009; Gatzweiler *et al.*, 2002) there are no publications on specific modes and efficiency of management of agro-ecosystem services in transitional and new EU member states like Bulgaria.

This paper incorporates the interdisciplinary New Institutional and Transaction Costs Economics (Coase, 1960; Furuboth and Richter, 1998; North, 1990; Williamson, 1996), suggests a holistic framework for analysis of management agro-ecosystem services, and analyzes forms, efficiency and perspectives of management of agro-ecosystem services in Bulgaria.

The first part of the paper presents a comprehensive framework for analyses and assessment of management of agro-ecosystem services including: definition of the agro-ecosystem services and the governance; specification of governance needs of agro-ecosystem services and the spectrum of available governing modes (formal and informal institutions, market, private, public and hybrid forms); assessment of efficiency of different modes of governance in terms of their potential to protect diverse eco-rights and investments, assure a socially desirable level of agro-ecosystem services, minimize overall costs, coordinate and stimulate eco-activities, meet individual and social preferences and reconcile conflicts of related agents *etc.*

The second part of the paper identifies the specific modes for governance of agro-ecosystem services in Bulgaria; accesses the efficiency of market, private and public forms of governance; analyzes structures for management of agro-ecosystems services in Zapadna Stara Planina region; and estimates the prospects for evolution of environmental governance in the conditions of EU common policies implementation.

1. FRAMEWORK FOR ANALYSES

1.1. Agro-Ecosystem Services and the Governance

Humans benefit from multiple resources, products and processes supplied by natural ecosystems known as *ecosystem services* (MEA, 2005). They include:

- *Provisioning services* - food; water; pharmaceuticals, biochemicals, and industrial products; energy; genetic resources *etc.*;
- *Regulating services* - carbon sequestration and climate regulation; waste decomposition and detoxification; purification of water and air; crop pollination; pest and disease control; mitigation of floods and droughts, *etc.*;
- *Supporting services* - soil formation; nutrient dispersal and cycling; seed dispersal; primary production, *etc.*;
- *Generation and maintenance of biodiversity*;
- *Cultural services* - cultural, intellectual and spiritual inspiration, recreational experiences, scientific discovery, *etc.*

The *agro-ecosystem services* comprise ecosystem services provided by the agro-ecosystems. The later are commonly defined as spatially and functionally coherent units of agricultural activity incorporating the living and nonliving components and their interactions (AEHP, 1996; Shiferaw *et al.*, 2005). That implicitly includes as a *key* component the agricultural activity such as crop production, raising animals, natural resource management (land modification, set aside measures) *etc.*

According to their specific characteristics and the goals (and levels) of the analysis, the *boundaries* of individual agro-ecosystem could be a part of a separate farm (*e.g.* a cultivated parcel, a meadow, a pond), located in numerous farms, or cover a larger region in a country or (sub)continent. Moreover, the individual agro-ecosystem could include, be a part, or overlap with other ecosystems - dryland, mountain, coastal, urban *etc.*

The *type* and the *amount* of agro-ecosystem services depends on the natural evolution of ecosystems, the progression of farming practices and technologies, the development of social demand and preferences *etc.* (Fig. **1**). Moreover, the particular value (and priority) that individual communities and societies give on diverse agrarian resources, activities, outputs and services are quite specific at any moment of time, and depends on socio-economic development, endowment with natural resources, culture, progress in science, public education and awareness of potential benefits and hazards *etc.*

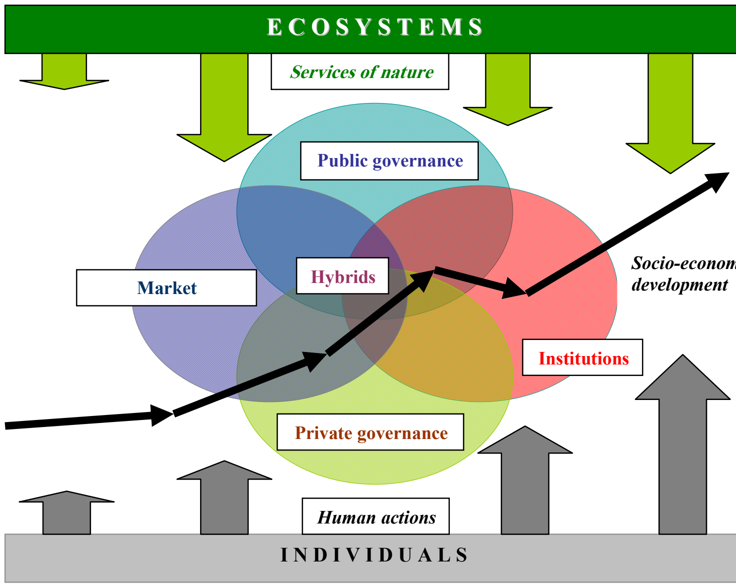

Figure 1: Mechanism of governance of ecosystem services.

Therefore, *in the beginning* the analysis is to specify various ecosystem services associated with different agro-ecosystems. Modern science offers quite precise methods to classify diverse ecosystems and their services (including agro-ecosystems ones), and their spatial and temporal scales (MEA, 2005). For instance, Fig. **2** illustrates the spectrum of services of Agro-ecosystems in Zapadna Stara Planina – a mountainous region in North-West part of Bulgaria.

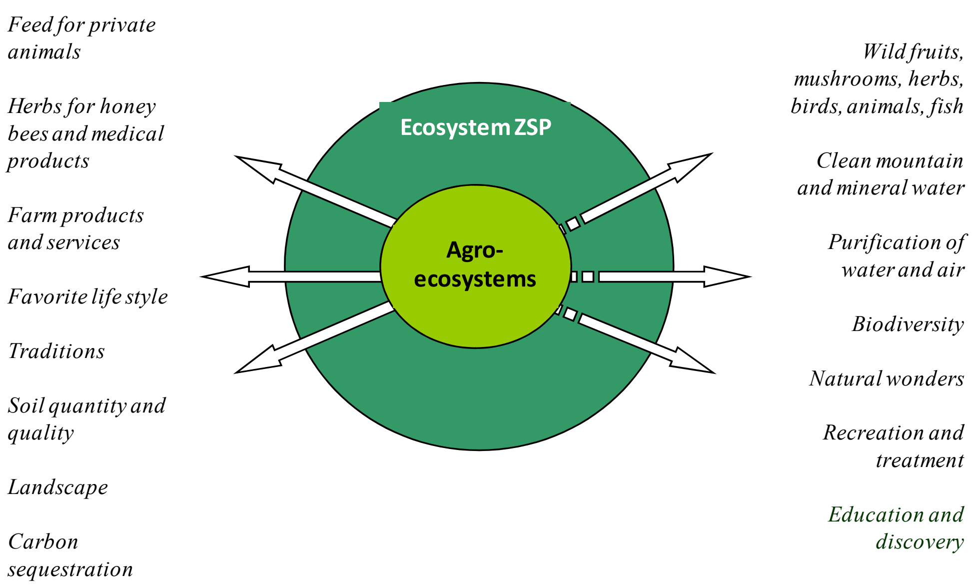

Figure 2: Services of Agro-ecosystems in Zapadna Stara Planina in Bulgaria.

Maintaining a sustainable supply of agro-ecosystem services requires an effective *social order* (governance) regulating behavior and relations of individuals related to ecosystem services (Bachev, 2009). The management of agro-ecosystem services does not mean "management of services of nature" but management of environment preservation and improvement activities of various agents. The later requires a system of coordination and stimulation of eco-activity which is to induce *appropriate behavior* of individuals[1] and *coordinated actions* at local, national, and transnational levels.

According to (awareness, symmetry, strength, harmonization costs of) interests of agents associated with agro-ecosystem services (consumers, contributors, transmitters, interest groups *etc.*) there are different *needs for management* of actions.

For instance, Farm 1 must govern its efforts and relations with Farm 2 since both receive services from Ecosystem 1 and affect (positively or negatively) the service supply of the ecosystem (Fig. **3**). Moreover, both farms are to govern their relations with consumers of services from Ecosystem 1 (Social System 1) to meet total demand and compensate costs for maintaining ecosystem services in that direction. In addition, Farms 1 and 2 must coordinate efforts with Social System 1 to mitigate conflicts with Social System 2. Furthermore, Farm 1 is to govern its relations with Farm 3 for effective service supply from Ecosystem 3, and manage its interaction with Ecosystem 2. Moreover, Farms 1 and 3 have to govern their relations with Farm 4 and Social Systems 1 and 2. Finally, Farm 1, affecting adversely Ecosystem 4 services, is to govern relations with agents in Social System 2 to reconcile conflicts and secure the effective flow of ecosystem services. Therefore, Farm 1 is to be involved in *seven* different systems of governance in order to assure the effective supply of services from ecosystems it belongs to or affects.

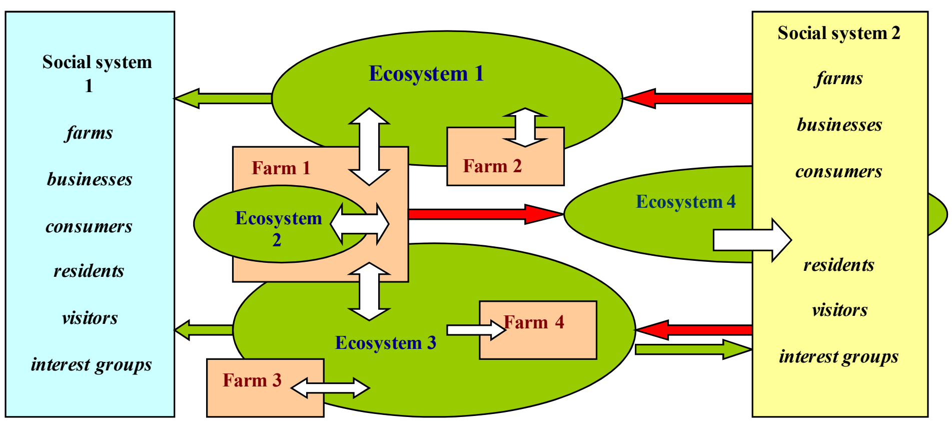

Figure 3: Governance needs for effective supply of agro-ecosystem services.

Therefore, the *second step* of the analysis is to identify the specific management needs for each agro-ecosystem service. The later depend on particular characteristics of the ecosystem (services, scale, interactions with other eco-systems), and the number and interests of related agents.

Simultaneously *trends, factors, problems* and *risks* associated with services of agro-ecosystems are to be clarified. Modern science offers precise methods to evaluate trends and risks in the evolution of various ecosystems, and to identify driving ecological and social factors for their progression (MEA, 2005).

In any case *persistence* of serious eco-problems and risks is an indicator that an effective system of management is not put in place.

Individuals behavior (actions, restriction of actions) are affected and managed by a number of distinct *modes* and *mechanisms* of governance including (Fig. **1**):

[1] "pro-environmental" actions, "anti-environmental" inactions.

– *Institutional environment* (or "rules of the game") – that is the distribution and evolution of formal and informal rights and obligations between individuals, groups, generations, and the system(s) of enforcement of these rights and rules (Furuboth and Richter, 1998; North, 1990).

The spectrum of rights could embrace material assets, natural resources, intangibles, certain activities, labor safety, clean environment, food security, intra- and inter-generational justice *etc.* A part of the rights and rules are constituted by the formal laws, regulations, standards, court decisions *etc.* In addition, there are important informal rules and rights determined by tradition, culture, religion, ideology, ethical and moral norms. Enforcement of rights and rules is done by the state, community pressure, trust, reputation, private modes, and self-enforcement.

Institutions and institutional modernization create dissimilar incentives, restrictions and costs for maintaining and improving eco-system services, intensifying eco-exchange and cooperation, increasing eco-productivity, inducing private and collective eco-initiatives, developing new eco and related rights, decreasing eco-divergence between social groups and regions, responding to ecological and other challenges *etc.* For example, (socially, legally) acceptable norms for use of labor, plant, livestock, and environmental resources; employment of certain forms of contracts or organizations; trade with particular resources and products *etc.*, all they could differ even between various regions of the same country[2].

The institutional "development" is initiated by the public (state, community) authority, international actions (agreements, assistance, pressure), and the private and collective actions of individuals. The later is associated with the modernization and/or redistribution of the existing rights; and the evolution of new rights and the emergence of novel (private, public, hybrid) institutions for their enforcement.

In the modern society a great deal of individuals' activities and relations are regulated and sanctioned by some (general, specific) formal and informal institutions. However, there is no perfect system of preset outside rules that can govern effectively the entire activities of individuals in all possible (and quite specific) circumstances of their life and relations associated with diverse ecosystems (services).

– *Market modes* ("invisible hand of market") – those are various decentralized initiatives governed by free market price movements and market competition – *e.g.* spotlight exchanges, classical contracts, production/trade of organic products, origins *etc.*

The importance of free market for the coordination (direction, correction) and stimulation of economic activities, exchanges and allocation of resources is among fundamentals of modern economics. Individual agents use (adapt to) markets profiting from the specialization and mutually beneficial exchange (trade) while their voluntary decentralized actions govern the overall distribution of efforts and resources between activities, sectors, regions, eco-systems, countries.

Nevertheless, there are many instances of lack of individual incentives, choices and/or unwanted exchanges - *e.g.* missing markets, monopoly and power relations, positive or negative externalities *etc.* Consequently, free market "fails" to govern effectively the entire activity, exchanges, and resources of individuals.

– *Private modes* ("private or collective order") – those are diverse private initiatives and special contractual and organizational arrangements – *e.g.* voluntary actions, codes of behavior, eco-contracts, eco-cooperatives *etc.*

Individual agents take advantage of economic, market, institutional *etc.* opportunities and deal with institutional and market deficiency by selecting or designing mutually beneficial private modes (rules) for governing of their behavior, relations and exchanges. The private mode negotiates own rules or accepts

[2] In Valonia for instance, the environmental standards are much more restrictive than in other two Belgium regions - Flandria and Brussels (Sauvenier *et al.*, 2005).

existing private (collective) order, transfers existing rights or gives new rights to counterpart(s), and safeguards absolute (assigned by the dominating institutions) and/or contracted rights.

In modern society a great part of the agrarian activity is governed by private negotiations, “visible hand of the manager”, or collective decision-making. Nevertheless, there are many examples of “private sector deficiency and failures” in governing of socially desirable activity such as environmental preservation, eco-system services *etc.*

– *Public modes* (“public order”) – these are various forms of public (community, government, international *etc.*) intervention in market and private sectors - *e.g.* public guidance, public regulation, public taxation, public assistance, public funding, public provision, property right modernization *etc.*

The role of public (local, national and transnational) governance has been increasing along with the intensification of activity and exchange, and the growing interdependence of social, economic and environmental activities.

In many cases, the effective management of individual behavior and/or organization of certain activity through a market mechanism and/or a private negotiation would take a long period of time, be very costly, could not reach a socially desirable scale, or be impossible at all. Thus a centralized public intervention could achieve the willing state of the system faster, cheaper or more efficiently[3]. Nonetheless, there are a great number of bad public involvements (inaction, wrong intervention, over-regulation) leading to significant problems of sustainable development around the globe (Bachev, 2010).

– *Hybrid forms* – some combination of other modes of governance.

“Governance matters” and depending on the (efficiency of) the system of governance “put in place”, the outcome of the development is quite different with diverse levels of socio-economic progression, environmental conservation and ecosystem services (Fig. **1**).

1.2. Factors for Governance Choice

The choice of management mode depends on a number of *key factors*:

- *Personal characteristics of individual agents* – preferences, believes, ideology, knowledge, capability, training, managerial experience, risk-aversion, bounded rationality, tendency for opportunism, reputation, trust, power *etc.* For instance, “sustainability movements” initially developed as a new ideology and later on formally institutionalized in programs, norms, legislation *etc.* Farming organization is often restricted to a family partnership. If farmer is a good manager he will be able to design and control a bigger organization managing effectively more internal (labor) and outside (market and contract) transactions. When counterparts are family members (or close friends) there is no need for complex organization since relations are easily “governed” by the good will and mutual interests of parties.

Furthermore, *benefits* for agrarian agents could range from monetary or non-monetary income; profit; indirect revenue; pleasure of self-employment or family enterprise; enjoyment in agricultural activities; desire for involvement in environment, biodiversity, or cultural heritage preservation; increased leisure and free time; to other non-economic benefits.

- *Formal and informal institutions* - often the choice of governing mode is (pre)determined by the institutional restrictions as some forms for carrying farming, environmental *etc.* activities

[3] At current stage (“globalization”) many of the challenges facing economical and agrarian development (food security, eco-management, fight against diseases, climate change,) requite *trans-border* or even *global governance*.

could be socially unacceptable or illegal[4]. For instance, corporate and cooperative organization of farming is forbidden in many countries; market trade of farmland, natural resources, and some outputs (inputs) is illegitimate, private management of natural ecosystems (parks, reserve zones) is not allowed *etc.*

What is more, the institutional environment considerably affects the level of governance costs and thus the choice of one or another form of organization. For instance, in conditions of well-working public system of regulations (quality standards, price guarantees) and laws and contract enforcement, a preference is given to spotlight and classical (standard) contracts. On the other hand, when rights on major agrarian and natural resources are not defined or not well defined, and absolute and contracted right effectively enforced, that lead to domination of primitive subsistence farming, informal, personal and over-integrated forms, unsustainable organizations, undeveloped and missing markets etc (Bachev, 2004).

- *Natural and technological factors* - eco-governance strongly depends on natural recourses endowment and the specific features of each eco-system (type, scale, services, interactions, risks *etc.*) as well as on development of technologies and agro-techniques. For instance, the governance of water resources would depend on the natural supply of water and its correspondence (over-supply, shortage) to water demands. Furthermore, it will depend on development of water conservation, use and recycle technologies *etc.*

In some cases there is *only one* practically possible form for governance of a particular eco-activity. For example, in Japanese dispersed paddy agriculture water supply could not have been conducted by individual farmers (high interdependency, nonseparability of water use) and since earliest period water use organization developed as public projects (Mori, 1991).

Very often, an effective governance of environmental activities requires a *certain scale* and thus collective actions at local, regional, national or transnational scale (Bachev, 2004).

Nevertheless, most eco-activity and exchange could be governed through a great *variety* of alterative forms (Bachev, 2009). For instance, a supply of environmental preservation service could be governed as: a voluntary activity of a farmer; though private contracts of the farmer with interested or affected agents; though an interlinked contract between the farmer and a supplier or a processor; though a cooperation (collective action) with other farmers and stakeholders; though a (free) market or assisted by a third-party (a certifying and controlling agent) trade with special (eco, protected origins, fair-trade) products; though a public contract specifying farmer's obligations and compensation; though a public order (regulation, taxation, quota for use of recourses or emissions); within a hierarchical public agency or by a hybrid form.

Different governance modes are alternative but not *equally efficient* modes for the organization of a particular eco-activity. Each of governing modes has distinct *advantages* and *disadvantages* to protect eco-rights and investment, and coordinate and stimulate socially desirable eco-behavior and activities, explore economies of scale and scope, save environmental maintenance (enhancement) and governance costs *etc.*

For instance, the *free market* has a big coordination and incentive advantages ("invisible hand of market", "power of competition"), and provides "unlimited" opportunities to benefit from specialization and exchange. However, market governance could be associated with a high uncertainty, risk, and costs due to low appropriability of some rights ("public good" character), price instability, a great possibility for facing an opportunistic behavior, "missing market" situation *etc.*

The *special contract form* ("private ordering") permits a better coordination and intensification of activity, and safeguard of agent's rights and investments. However, it may require large costs for specification of

[4] When costs associated with illegitimate governance are not high (possibility for disclosure low, enforcement and punishment insignificant) while benefits considerable, then the more effective modes prevail – large gray (black) sectors of the economy are common around the globe.

contract provisions, adjustments with constant changes in conditions, enforcement and disputing of negotiated terms *etc.*

The *internal (ownership) organization* allows a greater flexibility and control on activity (direct coordination, adaptation, enforcement, and dispute resolution by a fiat). However, extension of the internal mode beyond family and small-partnership boundaries (allowing achieving the minimum technological or ecological requirements; exploration of technological economies of scale and scope) may command significant costs for development (initiation and design, formal registration, restructuring), and for current management (collective decision making, control on coalition members opportunism, supervision and motivation of hired labor *etc.*).

The *separation of ownership from management* (cooperative, corporation, public farm/firm) gives enormous opportunities for growth in productivity and management efficiency – internal division and specialization of labor; achieving ecosystem's requirements; exploration of economies of scale and scope; introduction of innovation; diversification; risk sharing; investing in product promotion, brand names, relations with customers, counterparts and authorities. However, it could be connected with huge transaction costs for decreasing information asymmetry between management and shareholders, decision-making, controlling opportunism, adaptation *etc.* In addition, the *cooperative and non-for profit form* suffers from low capability for internal long-term investment due to non-for-profit goals and non-tradable character of shares (so called "horizon problem").

Besides proper "production" (technological, agronomic, ecological *etc.*) costs for maintaining and improving eco-system services their management is usually associated with significant *governance* (known as transaction) costs. The later could be defined as costs for protection, contracting and exchange of individual rights or *costs for governing relations with other agents* - individuals, private entities, public authorities. For example, agents related to ecosystem services have costs for identification and protection of various (eco, ownership *etc.*) rights; complying with diverse institutional restrictions (norms, standards, rules); finding best prices and partners; negotiating conditions of exchange; contract writing and registration; enforcing negotiated terms through monitoring, controlling, measuring and safeguarding; disputing through a court system or another way; adjusting or termination along with evolving conditions of exchange etc[5].

If transaction costs were *zero* then the mode of management would have no economic importance (Coase, 1960; Williamson, 1996). Individuals would govern their relationships with the *same (equal) efficiency* though *free market* (adapting to price movements), and *private modes* of different types (contracts, firms), and *collective decision making* (cooperative, association), and in a *nationwide hierarchy* (a single private or state company). Then ecological requirements and technological opportunities for economies of scale and scope (the maximum ecosystem services and productivity of resources, "internalization of externalities") would be easily achieved (Coase, 1960). All information for the effective potential of activity and exchange (optimization of resources, meeting various social demands, respecting assigned and transferred rights) would be costlessly available to everybody, and individuals would costlessly define new rights, and protect their (absolute[6] and contracted) rights, and trade owned resources (and products) in mutual benefit until exhausting the possibilities for increasing productivity and sustainable development.

However, when transaction costs are significant, then costless assignment, protection, negotiation and exchange of rights are not possible. Therefore, the initial allocation of the property rights between individuals is critical for the overall efficiency and sustainability[7]. What is more, when important rights are not well-defined and/or enforced, then the high transaction costs could block the efficient use of resources

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[5] Transaction costs have two *behaviour origin* – agents *bounded rationality* and *tendency for opportunism* (Williamson, 1996).

[6] determined by dominating *institutional environment* (Furuboth and Richter, 1998).

[7] development could be significantly impeded if rights on critical resources or activities are not held by the most efficient user – *e.g.* constant, costly and unsolvable conflicts between landlords and tenant-farmers, highly sustainable unproductive monopolies, *etc.*

and/or (mutually) beneficial exchanges. For instance, if "rights of sustainable environment" are not well defined, significant difficulties in effective ecosystem service supply are created - costly disputes between polluting and affected agents, disregards of interests of certain groups or generations *etc.* Consequently, the institutional structures for carrying out the agrarian and environmental activities become an important factor, which eventually determines the outcome of the system (the efficiency) and the type of development (sustainability) (Bachev, 2007).

The *type of the governance* becomes crucial since various modes give unequal possibilities for participants to coordinate activities, and stimulate an acceptable behavior of others (counterparts and dependents), and protect their contracted and absolute rights from unwanted expropriation (Williamson, 1996). In the *specific economic, market, institutional and natural environment*, the rational agrarian agents will *seek, choose*, and/or *develop* such modes for governing their activities and relations with others, which will maximize their benefits and minimize their *total* (production *and* transacting) costs. Moreover, both *(current)* costs for using individual governance forms and the *long-term costs* for their development (initiation, maintenance, modernization, and liquidation) have to be taken into account (Bachev, 2004).

Eventually, the distribution of overall (agrarian, environmental *etc.*) activities between different farms, organizations, and markets would be determined by the comparative costs for using various governing arrangements as the *most efficient* one(s) will tend to prevail (Bachev, 2004). However, a high efficiency and sustainability of the different governing forms (farms, business organizations, collective actions, and public forms) does not always mean a high efficiency and sustainability of the development. As North and Williamson have proved, the history of institutional development is full of examples of "failures" while the (business) organization modernization is usually a success story (North, 1990; Williamson, 1996). Furthermore, the high sustainability of (inefficient) public forms is a result of the high transaction costs for their reformation (political decision-making and bargaining, strong vested interests of powerful groups) and/or the "inefficiency by design" making that transformation complicated (Williamson, 1996).

Therefore, *the third step* of the analyses is to identify *practically possible* (existing and other feasible) alternatives for governance for the *specific* conditions of each eco-system and its services. The available (alternative) management modes are to be assessed in terms of *absolute* and *comparative potential* (limits) of protect eco-rights and investments of agents, assure socially desirable level of agro-ecosystem services, minimize overall costs, coordinate and stimulate eco-activities, reconcile conflicts, recover long-term costs for organizational development *etc.* in the *specific economic, institutional and natural environment.*

1.3. Principle Governance Matrix

Comparative analysis is to include the *overall* (private *and* public) eco-system related *production* (eco-maintenance, eco-enhancement *etc.*) and *transaction costs* associated with the individual management forms.

The assessment of the precise levels of transaction costs in eco-activity is often not possible or very expensive (Bachev, 2009). That is why the analysis is to focus on the *combination of critical dimensions* of eco-activity and transaction[8] - the factors responsible to the *variation* of transacting costs between alternative governance modes. As Williamson puts it "*align* transactions (which differ in their attributes) with governance structures (which differ in their costs and competence) in *discriminating* (mainly transaction cost economizing) *way*" (Williamson, 1996). Accordingly, depending on the specific characteristics of each activity and transaction, there will be different the *most effective* form of economic organization for that particular activity (Fig. **4**).

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[8] *"Frequency", "uncertainty",* and *"asset specificity"* are identified as critical factors of transaction costs by Williamson (1996) while *"appropriability"* added by Bachev and Labonne (2000).

Generic modes	*Critical dimensions of transactions*								
	Appropriability								
	High								*Low*
	Assets Specificity								
	Low				*High*				
	Uncertainty								
	Low		*High*		*Low*		*High*		
	Frequency								
	High	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	
Free market	ϒ	ϒ							
Special contract form			ϒ			ϒ			
Internal organization					ϒ		ϒ		
Third-party involvement				🚑				🚑	
Public intervention									🚑

ϒ - the most effective mode; 🚑 - necessity for a third party involvement

Figure 4: Principle modes for governing of ecosystem services.

Eco-activity (transactions) with good appropriability of rights, high certainty, and universal character of investments could be effectively managed by *free market* through *spotlight* or *classical contracts*. There are widespread market modes for selling *pure* "ecosystem services" (eco-visits, hunting, fishing, harvesting wild plants and animals) or "ecosystem services" *interlinked* with other products and services (*e.g.* organic, fair-trade, special origins, on-farm sale, self-pick, eco-education, eco-tourism, horse-riding, eco-restaurants *etc.*).

Transactions with low specificity and high appropriability could be effectively managed through a *special contract*. For example, eco-contracts and cooperative agreements between farmers and interested businesses[9] or communities are widely used including a payment for ecosystem services, and leading to production methods (enhanced pasture management, reduce use of agrochemicals, wetland preservation) protecting water from pollution, mitigating floods and wild fires *etc.*

Transactions with high frequency, big uncertainty, great assets specificity, and high appropriability, have to be governed *within* internal organization. Very often the effective scale of specific investment in agro-ecosystem services (minimum required for eco-impact, exploring economies of scale and scope) exceeds borders of traditional agrarian organizations (family farm, small partnership). If specific capital (knowledge, technology, equipment, funding) cannot be effectively organized within a singe organization[10], then effective external form(s) is to be used – joint ownership, interlinks, cooperative, lobbying for public intervention. For instance, environmental cooperatives are very successful in some EU countries (Hagedorn, 2002). Nevertheless, costs for initiation and maintaining collective organization for overcoming *unilateral dependency* are usually great (big number of coalition, different interests of members, opportunism of "free-riding" type) and it is unsustainable or does not evolve at all.

The *next step* of analysis is to identify situations of *market* and *private* sector *deficiency* (failures) and the *needs for public intervention* in ecosystem services.

For instance serious problems arise when condition of assets specificity is combined with high uncertainty and low frequency, and when *appropriability* is low (Fig. **4**). In all these cases, *a third part* (private agent, NGO, public authority) *involvement* in transactions is necessary (through assistance, arbitration, regulation) in order to make them more efficient or possible at all. Emergence and unprecedented development of special origins, organic farming and system of fair-trade, are good examples in that respect. There is

[9] *e.g.* drinking water companies in Germany (Hagedorn, 2002), mineral water company Vittel in France (Hanson, 2008).

[10] coalition made, minimum scale of operations reached, economy of scale and scope explored.

increasing consumer's demand (price premium) for these products but their supply could not be met unless effective *trilateral governance* (including independent certification and control) is put in place.

Respecting others rights or *granting out* additional rights could be managed by *"good will"* or *charity actions*. For instance, a great number of voluntary environmental initiatives ("codes of behavior") have emerged driven by farmers' preferences for eco-production, competition in industries, and responds to public pressure for a sound environmental management. However, environmental standards are usually "process-based", and "environmental audit" is not conducted by independent party, which does not guarantee a "performance outcome". In any case, voluntary (charity) initiatives could hardly satisfy the entire social demand especially if they require considerable costs.

Management of most ecosystem services requires large organizations with diversified interests of agents (providers, consumers, destructors, interest groups). Emergence of special *large-members* organizations for dealing with low appropriability is slow and expensive, and they are not sustainable in long run ("free riding" problem). Therefore, there is a strong need for *a third-party public* (Government, local authority, international assistance) *intervention* to make such eco-activity possible or more effective (Bachev, 2009).

The next step of the analysis is to identify feasible (technically, economically, politically possible) modes of public intervention in agro-ecosystem services. Efficiency of different modes of public intervention is to be assessed in terms of *correspondence* to the needs of third-party involvement (Fig. **4**) and the comparative (coordinating, stimulating, costs-minimization) efficiency to *other feasible modes* of public intervention (assistance, public-private partnership, property rights modernization *etc.*) (Bachev, 2009).

The *overall* (*public* and *private*) implementation *and* transaction costs are to be taken into account. The later would depend on uncertainty, frequency, and necessity for specific investment of public involvement (Fig. **5**).

Level of Uncertainty, Frequency, and Assets specificity					
Low ←-----------------------------------→ High					
New property rights and enforcements	Public regulations	Public taxation	Public assistance	Public funding	Public provision

Figure 5: Principle modes for effective public intervention in ecosystem services.

Generally, the interventions with a low uncertainty and assets specificity would require a *smaller* public organization (more regulatory modes; improvement of the general laws and contract enforcement *etc.*).

When uncertainty and assets specificity of the transactions increases a *special contract mode* would be necessary – *e.g.* employment of public contracts for provision of private services, public funding (subsidies) of private activities, temporary labor contract for carrying out special public programs, leasing out public assets for private management *etc.*

And when transactions are characterized with high assets specificity, uncertainty and frequency then an *internal mode* and a *bigger public organization* would be necessary – *e.g.* permanent public employment contracts, in-house integration of crucial assets in a specialized state agency or public company *etc.*

Initially, the *existing and emerging problems* (difficulties, costs, risks, failures) in the organization of market and private transactions have to be specified. The appropriate pubic involvement would be to create an environment for: *decreasing the uncertainty* surrounding market and private transactions, and increasing the *intensity of exchange*, and *protecting* private rights and investments, and making private investments *less dependent etc.* For instance, the State establishes and enforces quality, safety and eco-standards for farm inputs and produces, certifies producers and users of natural resources, regulates employment relations, transfers water management rights to farms associations, sets up minimum farm-gate prices *etc.* All that facilitates and intensifies (market and private) transactions and increases efficiency of economic organizations.

Next, practically possible modes for *increasing appropriability* of transactions have to be considered.

The low appropriability is often caused by unspecified or badly specified private rights (Bachev, 2004). In some cases, the most effective government intervention would be to introduce and enforce *new private property rights* – *e.g.* rights on natural, biological, and environmental resources; rights on issuing eco-bonds and shares; marketing and stock trading of ecosystem services protection; tradable quotas for polluting; private rights on intellectual agrarian property and origins *etc.* That would be efficient when the privatization of resources or the introduction (and enforcement) of new rights is not associated with significant costs (uncertainty, recurrence, and level of specific investment are low). That public intervention effectively transfers the organization of transactions into the market and private governance, liberalizes market competition and induces private incentives (and investments) in certain activities. For instance, tradable permits (quotas) are used to control the overall use of certain resources or level of a particular type of pollution. They give flexibility allowing farmers to trade permits and meet their own requirements according to their adjustment costs and specific conditions of production. That form is efficient when a particular target must be met, and the progressive reduction is dictated through permits while trading allows the compliance to be achieved at least costs (through a private governance). The later let also a market for environmental quality to develop[11].

In other instances, it would be efficient to put in place *regulations* for trade and utilization of resources and products – *e.g.* standards for labor (safety, social security), product quality, environmental performance, animal welfare; norms for using natural resources, introduction of foreign species and GM crops, and (water, soil, air, comfort) contamination; a ban on application of certain chemicals or technologies; regulations for trading ecosystem service protection; foreign trade regimes; mandatory eco-training and licensing of farm operators *etc.*

The large body of environmental regulations in developed countries aim changing the farmers behavior and restricting the negative impact on environment. It makes producers responsible for the environmental effects (externalities) of their products or the management of products uses (*e.g.* waste). This mode is effective when a general improvement of the performance is desired but it is not possible to dictate what changes (in activities, technologies) is appropriate for a wide range of operators and environmental conditions (high uncertainty and information asymmetry). When the level of hazard is high, the outcome is certain and the control is easy, and no flexibility exists (for timing or the nature of socially required result), then the bans or strict limits are the best solution. However, the regulations impose uniform standards for all regardless of the costs for compliance (adjustment) and give no incentives to over-perform beyond a certain level.

In other instances, using the incentives and restrictions of the *tax system* would be the most effective form for intervention. Different sorts of tax preferences (exception, breaks, credits) are widely used to create favorable conditions for the development of certain (sub)sectors and regions, forms of agrarian organization, segment of population, or specific types of activities. The environmental taxation on emissions or products (inputs or outputs of production) is also applied to reduce the use of harmful substances. The later impose the same conditions for all farmers using a particular input and give signals to take into account the "environmental costs" inflicted on the rest of society. Taxing is effective when there is a close link between the activity and the environmental impact, and when there is no immediate need to control the pollution or to meet the targets for reduction. However, an appropriate level of the charge is required to stimulate a desirable change in farmers behavior. Furthermore, some emissions vary according to the conditions of application and attempting to reflect this in tax may result in complexity and high administrating costs.

In some cases, a public *assistance* and *support* to private organizations is the best mode for intervention. Large agrarian and rural support and development programs have been widely used in all industrialized countries. They let a "proportional" development of agriculture and improvement of farmers welfare ("income parity").

[11] Permits can be taken out of market in order to raise the environmental quality above the "planned" (by the Government) level.

The public *financial* support for the environmental actions is the most commonly used instrument for the improving environment performance of farmers. It is easy to find a justification for the public payments as a compensation for the provision of an "environmental service" by farmers. However, the share of farms covered by various agri-environmental support schemes is not significant. That is a result of the voluntary (self-selection) character of this mode which does not attract farmers with the highest environment enhancement costs (most intensive and damaging environment producers). In some cases, the low-rate of farmers' compliance with the environmental contracts is a serious problem. The later cannot be solved by augmented administrative control (enormous enforcement costs) or introducing bigger penalty (politically and juridical intolerable measure).

A disadvantage of "the payment system" is that once introduced it is practically difficult ("politically unacceptable") to be stopped when goals are achieved or there are funding difficulties. Moreover, an withdraw of the subsidies may lead to further environmental harm since it would induce the adverse actions such as intensification and return to the conventional farming. The main critics of the subsidies are associated with their "distortion effect", the negative impact on "entry-exit decisions" from polluting industry, the unfair advantages to certain sectors in the country or industries in other countries, not considering the total costs (transportation and environmental costs, and "displacement effect" in other countries). It is estimated that the agri-environmental payments are efficient in maintaining the current level of environmental capital but less successful in enhancing the environmental quality.

Often providing public *information, recommendations, training* and *education* to farmers, other agrarian and rural agents, and consumers are the most efficient form. In some cases, a *pure public organization* (in-house production, public provision) will be the most effective as in the case of as in case of important agro-ecosystems and national parks; agrarian research, education and extension; agro-meteorological forecasts; border sanitary and veterinary control *etc.*

Usually, the specific modes are effective if they are applied alone with other modes of public intervention. The necessity of *combined intervention* (a governance mix) is caused by: the complementarities (joint effect) of the individual forms; the restricted potential of some less expensive forms to achieve a certain (but not the entire) level of the socially preferred outcome; the possibility to get an extra benefits (*e.g.* "cross-compliance" requirement for participation in public support programs); the particularity of the problems to be tackled; the specific critical dimensions of the governed activity; the uncertainty (little knowledge, experience) associated with the likely impact of the new forms; the practical capability of Government to organize (administrative potential to control, implement) and fund (direct budget resources and/or international assistance) different modes; and not least important the dominating (right, left) policy doctrine (Bachev, 2010).

Besides, the level of an effective public intervention (governance) depends on the *kind of the problem* and the *scale* of intervention. There are public involvements which are to be executed at *local* (ecosystem, community, regional) level, while others require *nationwide* governance. And finally, there are activities, which are to be initiated and coordinated at *international* (regional, European, worldwide) level due to the strong necessity for *trans-border actions* (needs for a cooperation in natural resources and environment management, for exploration of economies of scale/scale, for prevention of ecosystem disturbances, for governing of spill-overs) or consistent (national, local) government failures. Very frequently the effective governance of many problems (risks) requires *multilevel* governance with a system of combined actions at various levels involving diverse range of actors and geographical scales.

The public (regulatory, inspecting, provision *etc.*) modes must have built *special mechanisms* for increasing the competency (decrease bounded rationality and powerlessness) of the bureaucrats, beneficiaries, interests groups and public at large as well as restricting the possible opportunism (opportunity for cheating, interlinking, abuse of power, corruption) of the public officers and other stakeholders. That could be made by training, introducing new assessment and communication technologies, increasing transparency (*e.g.* independent assessment and audit), and involving experts, beneficiaries, and interests groups in the management of public modes at all levels. Furthermore, applying *"market like"* mechanisms (competition, auctions) in the public projects design, selection and implementation would significantly increase the incentives and decrease the overall costs.

Principally, a pure public organization should be used as a *last resort* when all other modes do not work effectively (Williamson, 1996). The "in-house" public organization has higher (direct and indirect) costs for setting up, running, controlling, reorganization, and liquidation. What is more, unlike the market and private forms there is not an automatic mechanism (such as competition) for sorting out the less effective modes[12]. Here a public "decision making" is required which is associated with high costs and time, and it is often influenced by the strong private interests (the power of lobbying groups, policy makers and their associates, employed bureaucrats) rather than the efficiency. What is more, widespread "inefficiency by design" of public modes is practiced to secure (rent-taking) positions of certain interest groups, stakeholders, bureaucrats *etc.* (Williamson, 1996). Along with the development of general *institutional* environment ("The Rule of Law", transparency) and the measurement, communication *etc. technologies,* the efficiency of pro-market modes (regulation, information, recommendation) and contract forms would get bigger advantages over the internal less flexible public arrangements.

Usually *hybrid modes* (public-private partnership) are much more efficient than the pure public forms given the coordination, incentives, and control advantages. In majority of cases, the involvement of farmers, farmers organizations and other beneficiaries increases efficiency - decreases asymmetry of information, restricts opportunisms, increases incentives for private costs-sharing, reduces management costs *etc.* (Bachev, 2004). For instance, a hybrid mode would be appropriate for carrying out the supply of preservation and improvement of environment, biodiversity, landscape, historical and cultural heritages. That is determined by the farmers information superiority, the strong interlinks of that activity with the traditional food production (economy of scope), the high assets specificity to the farm (farmers competence, high cite-specificity of investments to the farm and land), and the spatial interdependency (needs for cooperation of farmers at a regional or wider scale), and not less important – the farm's origin of negative externalities. Furthermore, the enforcement of most labor, animal welfare, biodiversity *etc.* standards is often very difficult or impossible at all. In all these cases, stimulating and supporting (assisting, training, funding) the private voluntary actions are much more effective then the mandatory public modes in terms of incentive, coordination, enforcement, and disputing costs.

Anyway, if there is a strong need for a *third-party public* involvement but an effective (government, local authority, international assistance *etc.*) intervention is not introduced in a due time, the agrarian "development" would be substantially deformed (Bachev, 2004). Thus the public *(Government) failure is also possible* and often prevails. In Bulgaria, there have been a great number of bad examples for public under- and over-interventions in agrarian sector during post-communist transition now (Bachev, 2010). Consequently, a primitive and uncompetitive small-scale farming; predominance of over-integrated and personalized exchanges; ineffective and corrupted agrarian bureaucracy; blocking out all class of agrarian transactions (innovation and extension supply, long-term credit supply, supply of infrastructure and environmental goods); and development of a large informal (gray) sector, all they have come out as a result.

Suggested analysis let us define *efficiency* and *potential* of divers mechanisms and modes of management (institutions, market, private, public) to deal with diverse problems and risks for sustainable flow of agro-ecosystem services. Moreover, it let us *improve the design* of the new forms of public intervention according to the *specifi*c market, institutional and natural *environment* of a particular eco-system region, sub-sector, country,[13] and in terms of *perfection of the coordination, adaptation, information, stimulation, restriction of opportunism, controlling* (in short – minimization of transaction costs) of participating *actors* (decision-makers, implementers, beneficiaries, other stakeholders).

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[12] It is not rare to see highly inefficient but still "sustainable" public organizations around the world.

[13] The effective institutions can not be "imported" but must be designed for the specific conditions of different countries, regions, sectors *etc.* (North, 1990).

What is more, that analysis unable us to *predict* likely cases of *new* public (local, national, international ec.) *failures* due to impossibility to mobilize sufficient political support and necessary resources and/or ineffective implementation of otherwise "good" policies in the specific economic and institutional environment of a particular country, region, sub-sector *etc.* Since the public failure is a feasible option its timely *detection* permits foreseeing the persistence or rising of certain problems in agrarian development, and *informing* (local, international) community about associated risks.

2. BULGARIAN EXPERIENCE

2.1. Post-Communist Evolution of Environmental Management

Post-communist transformation and EU integration has been associated with significant challenges and opportunities for agro-ecosystems and their services. During most transition diverse eco-rights (on clean and athetie nature; preservation of natural resources, biodiversity) were not defined or badly defined and enforced (Bachev, 2009, 2010). Inefficient public enforcement of laws and contracts has been common. Out-dated system of public regulations and control dominated until recently which corresponded little to the contemporary needs of eco-management. There was no modern system for monitoring state of soil, water, and air quality, and credible information on the extent of eco-degradation.

There existed no social awareness of "concept" of eco-sustainability and ecosystem services nor "needs" to be included in public policy and private and community agenda. Lack of eco-culture and knowledge has impeded evolution of voluntary measures, and private and collective actions for effective management of ecosystem services.

Before EU accession (January 1, 2007), country's laws and standards were harmonized with immense EU legislation. The later introduces modern framework for eco-management including new rights and rule for environment and biodiversity protection, integrated water management, polluter pay principle, and relevant institutions for controlling, monitoring and assessment (Executive Environment Agency, Executive Hydro-melioration Agency *etc.*). The EU accession established and enforces "new order" - strict regulations and control; tough quality, food safety, eco-standards; financial support. The external monitoring, pressure, likely sanctions by EU improve enforcement of laws and standards.

Good part of new "rules of the game" is not well-known or understood by various authorities, private organizations, individuals. There is not enough readiness for effective implementation of new public order because of lack of experience in agents, administrative capacity, and possibility for enforcement of novel norms (comprehension, deficient court system, corruption). Often enforcement of eco-standards is difficult or impossible since detection and penalizing costs are high, or there is no direct links between performance and eco-impact. For example, although burning fields is banned this harmful for environment practice is widespread. Permanent deterioration of soil quality, wasting accumulated (photosynthesis) soil energy, extermination of soil micro-flora and habitats, significant contribution to green-house emissions, multiplying forests fires, diminishing visibility, increasing traffic accidents, come out as result (EEA, 2007).

Harmonization with the EU legislation and the emergence of eco-organizations generate new conflicts between private, collective, public interests. Results of public choices are not always for effective eco-management – *e.g.* strong lobbying efforts of particular individuals/groups led to 20% reduction in numbers and 50% reduction in area of initially identified sites NATURA 2000.

Newly evolving market and private structures were inefficient in dealing with various eco-issues. Privatization of farmland and assets of ancient public farms took 10 years to complete. During much of that period, the management of farmland, land related assets (permanent crops; buildings; irrigation, drainage and flood protection facilities *etc.*), eco-systems and water-resources, was in ineffective "temporary" structures (Privatization Boards, Liquidation Councils, Land Commissions). Sales and long-term lease markets for land and other natural resources did not emerge until 2000, and annual leasing was the major form for management until recently. That was combined with high economic and institutional uncertainty and a big inter-dependency of agrarian assets (Bachev, 2010).

Most farming activities were carried-out in less efficient and unsustainable structures - reorganizing public farms, part-time and subsistence farms, production cooperatives, huge business farms based on provisional lease-in contracts (Table **1**). What is more, market adjustments and intensifying competition has been associated with a significant decrease in number of unregistered farms and cooperatives since 1995.

Dominating modes for carrying out farming activities have had little incentives for long-term investment to enhance productivity and environmental performance [20]. The cooperative's big membership makes individual and collective control on management very difficult and costly. That focuses managerial efforts on current indicators, and gives a great possibility for using coops in the best private (managers) interests.

Besides, there are differences in the investment preferences of diverse coops members due to the non-tradable nature of the cooperative shares ("horizon problem"). Given the fact that most members are small shareholders, older in age, and non-permanent employees, the incentives for long-term investment for land improvement, and renovation of material and biological assets have been very low. Last but not least important, the "member-oriented" (non-for-profit) nature of the cooperatives prevents them to adapt to diversified needs of members, and market demand and competition.

Table 1: Number, size and importance of different farms in Bulgaria

	Public Farms	Unregistered	Cooperatives	Agro-firms	Total
Number of farms					
1989	2101	1600000	na	na	1602101
1995	1002	1772000	2623	2200	1777000
2000	232	755300	3125	2275	760700
2007		458617	1281	5186	465084
Share in number (%)					
1989	0.13	99.9			100
1995		99.7	0.1	0.1	100
2000		99.3	0.4	0.3	100
2007		98.6	0.3	1.1	100
Share in farmland (%)					
1989	89.9	10.1			100
1995	7.2	43.1	37.8	11.9	100
2000	1.7	19.4	60.6	18.4	100
2007		32.2	24.7	43.1	100
Average size (ha)					
1989	2423.1	0.4			3.6
1995	338.3	1.3	800	300	2.8
2000	357.7	0.9	709.9	296.7	4.7
2007		2.2	613.3	364.4	6.8

Source: National Statistical Institute

Table 2: Number and size of livestock holdings, 2008

Type of holdings	**Share**		**Share**		**Share**		**Average**
	farms	**heads**	**farms**	**heads**	**farms**	**heads**	**heads**
	1-2		*3-9*		*20 and >*		
Dairy cows	79.8	36.1	16	25.2	1.6	26.8	2.7
	1-9		*10-49*		*100 and >*		
Ewes	85	37.1	12	24.5	1	23.4	8.6

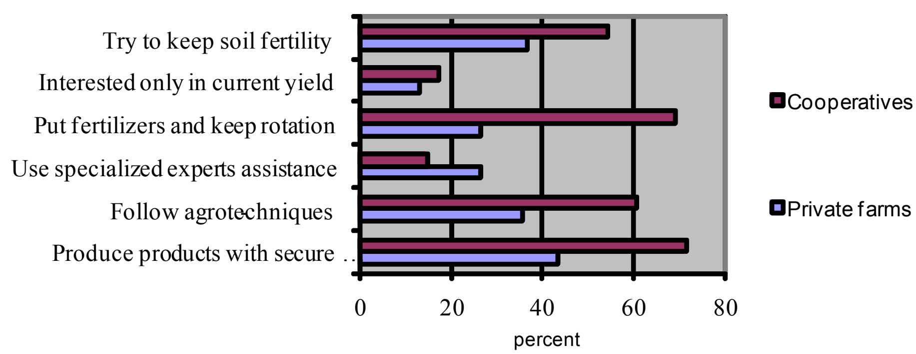
Table 2: cont….

She-goats	97.1	75.3	2.7	17.4	0.1	3.2	2.8
	1-2		*3-9*		*200 and >*		
Breeding pigs	78.8	12.8	14.9	8.8	0.5	57.4	7.8

Source: Ministry of Agriculture and Food

On the other hand, small-scale and subsistent farms[14] possess insignificant internal capacity for investment, and small potential to explore economy of scale and scope (big fragmentation and inadequate scale). Besides, they have little incentives for non-productive (environment and biodiversity conservation, animal welfare *etc.*) investment. Moreover, there has been no state administrative capacity nor a political will to enforce the quality and eco-standards in that vast informal sector of the economy.

Likewise, the larger business farms operate mainly on leased land and concentrate on high pay-off investment with a short pay-back period (*e.g.* cereals, sunflower). That has been coupled with ineffective outside pressure (by authority, community) for respecting the official standards for ecology, crop rotation, nutrition compensation, and biodiversity *etc.* In general, survivor tactics and survivor tactics ("concentration on products with secure marketing") rather than a long-term strategy toward sustainability (preserving soil fertility, observing crop rotation and agro-techniques requirements) are common among commercial farms (Fig. **6**).



Source: interviews with farm managers, 2009

Figure 6: Share of farms implementing different strategies in Bulgaria (%).

Furthermore, during most of the transition agrarian long-term credit market was practically blocked while newly evolving farming left unassisted by government (Bachev, 2010). Despite the progress in public support in recent years (SAPARD[15], EU CAP measures) the overall support to agriculture rests very little (Table **3**). Due to the poor design, restricting criteria, little awareness, complicated procedures, high related costs *etc.* most farms can not participate in public schemes. A small proportion of farms benefits from public aid most of them large enterprises from regions with less socio-economic and eco-problems.

The EU accession has brought new opportunities for a public support for private and collective activities related to agro-ecosystem services. The National Plan for Agrarian and Rural Development 2007-2013 (NPARD) provides significant funding for area-based and agro-environmental payments (organic farming, management of agricultural lands with high natural value and handicaps, traditional livestock, protection of soils and water, preservation of landscape); modernization of farms, processing, marketing; diversification of activity; infrastructural development; keeping traditions; training *etc.* The specialized budget of NPARD

[14] Subsistence and semi-market farms comprise the best part of the farms as almost 1 million Bulgarians are involved in farming mostly on a part-time base and for "supplementary" income (MAF, 2009).

[15] SAPARD introduced measure "Agro-ecology" but it was not approved by the end 2006 and few projects were actually supported. In 2008 EC suspended SAPARD dues to mismanagement and corruption and a significant funding lost.

directed for various environmental measures accounts for 27% of the total funding. What is more, cross-compliance (with safety, animal-welfare, eco-standards) for receiving public support is introduced. Funding for projects related to eco-system services is also available from the Fund LIFE+, and EU Operational Programs “Environment”, “Fishery and Aquaculture”, “Regional Development”.

Table 3: Share of EU and national support in Net Income of farms, 2008 (%)

Type of farm	Share of subsidies in Net Income	
	Current	**Investment**
Field crops	63.2	2.1
Horticulture	1.3	1.8
Permanent crops	0.4	2.2
Livestock	0.3	0

Source: Ministry of Agriculture and Food

Nevertheless, mostly bigger farms participate in public programs because they have a superior entrepreneurial experience, available resources, capability for adaptation to requirements, and wining projects. Besides, due to restrictive criteria, unattainable formal requirement, high costs for participation, and widespread mismanagement (and corruption) the new public support is not effectively utilized and benefits unevenly different farms (Bachev, 2010).

Furthermore, it has been difficult to reform the inefficient system of management of public programs and significant EU funding was blocked by EC (2008) while Special Assistance Pre-accession Program for Agrarian and Rural Development (SAPARD) support lost.

Similarly, in 2007 no public payment was made for projects associated with NPARD measures but area based payments for regions with handicaps. The progression in implementation of public support since 2007 has been very slow and far behind the targets (Table **4**). While measures “Setting up of young farmers” and “Payments to farmers in regions with handicaps” have been quite successful, the number of approved projects in other areas are insignificant and the amount of actually funded projects even smaller.

What is more, the bulk of public contracts and funding continues to go to a limited number of farms while many effective small-scale farms receive no or only a tiny fraction of the public support (Bachev, 2010). The minor amount of supported farms and agro-ecosystems, deficiency of clear criteria for eco-performance, and the lack of effective control leads to little contribution of new public measures to improvement of the eco-situation in the country.

Bad coordination, gaps, ineffective enforcement, and corruption are still typical for public forms. For instance, up to date the issues of ground water management are not incorporated in the public system of management and effective system of monitoring and control introduced. Besides, due to technical and organizational reasons implementation of EU water monitoring programs was delayed and EEA gets no water information from the Bulgarian Academy of Sciences.

Market adjustment has been associated with a sharp decline in all crop (but sunflower) and livestock (but goat) productions since 1989[16]. Furthermore, a large portion of agricultural lands have been left abandoned for a long period of time and the average yields for all major products shrunk to 40-80% of the pre-reform level. All that has relaxed the overall agricultural pressure on environment and natural resources (water, biodiversity).

[16] For potatoes by 33%, wheat 50%, corn and burley 60%, tomatoes, Alfalfa hay and table grape 75%, apples 94%, pig meat 82%, cattle meat 77%, sheep and goat meat 72%, poultry meat 51%, cow milk 45%, sheep milk 66%, buffalo milk 59%, wool 85%, eggs 45%, and honey 57% (NSI, 2009).

Table 4: Progress in implementation of 2007-2013 NPARD in Bulgaria

Measure	December 31, 2008		December 31, 2009		August 23, 2010	
	Approved projects	Funding 000 Euro	Approved projects	Funding 000 Euro	Approved projects	Funding 000 Euro
111 Vocational training and information actions	0	0	0	0	15	764
% target	*0*	-	*0*	-	*na*	-
112 Setting up of young farmers	461	10616	2261	53009	4085	102125
% target	*11.25*	-	*55.20*	-	*99.73*	-
121 Modernization of agricultural holdings	365	60933	1502	156169	1920	247476
% target	*6.77*	*6.27*	*27.86*	*16.09*	*35.62*	*25.49*
122 Improvement of the economic value of forests	0	0	0	0	0	0
123 Adding value to agricultural and forestry products	0	0	0	0	36	23829
% target	*0*	*0*	*0*	*0*	*5.81*	*4.41*
141 Semi-subsistence farming	0	0	0	0	708	5310
% target	*0*	-	*0*	-	*3.37*	-
142 Producer groups	0	0	0	0	0	0
143 Providing advice and consultation in agriculture	982	2	2525	779	6621	2132
% target	*3.62*	-	*9.30*	-	*24.38*	-
211 Payments to farmers in mountainous areas with handicaps	24026	23882	26104	41978	26104	na
% target	*40.04*	-	*43.50*	-	*43.50*	-
212 Payments to farmers in areas with handicaps different from mountainous	10017	7562	10785	12137	10785	na
% target	*100.17*	-	*107.85*	-	*107.85*	-
214 Agri-environment payments	1120	4839	1781	5034	1781	na
% target	*2.80*	-	*4.45*	-	*4.45*	-
223 First afforestation of non-agricultural land	0	0	20	610	37	2320
% target	*0.00*	-	*1.00*		*1.85*	-
226 Restoring forestry potential and introducing prevention.	0	0	18	848	23	1107
% target	*0.00*	-	*0.90*	-	*2.30*	-
311 Diversification into non-agricultural activities	0	0	0	0	4	425
% target	*0*	-	*0*	-	*0.09*	*0*
312 Business creation and development	0	0	0	0	88	13832
% target	*0*	-	*0*	-	*2.09*	-

Table 4: cont….

313 Support to agro and rural tourism	0	0	0	0	0	0
321 Basic services to rural population and economies	0	0	72	123461	123	197446
% target	*0.00*	-	*4.77*	-	*8.15*	*46.19*
322 Village renewal and development	0	0	144	81208	156	89771
% target	*0.00*	-	*18.00*	-	*19.50*	*43.07*
431-32 Implementing local development strategies and cooperation projects	0	0	0	0	103	8461
% target	*0*	-	*0*	-	*7.92*	-

Source: Ministry of Agriculture and Food

Smaller size and owner operating nature of most farms avoided certain problems of large public enterprises from the past such as lost natural landscape, biodiversity, nitrate and pesticide contamination, huge manure concentration, and uncontrolled erosion (Bachev, 2010). Subsistent and small-scale farming has also revived some traditional and more sustainable technologies, varieties, and products.

Private mode has introduced incentives and possibilities for integral eco-management (including revival of eco/cultural heritage; anti-pollution, esthetic, comfort measures) profiting from inter-dependent activities such as farming, fishing, agro-tourism, recreation, processing, and trade. There are also good examples for foreign investment in cereals, oil crops, integrated with farming vine and food processing, which introduce modern governance, technologies, quality, and eco-standards.

Private management is associated with improved environmental stewardship on owned and marketed resources, but less concern to manure and garbage management, over-exploitation of leased and common resources, contamination of soils and waters *etc.* On the other hand, free market management of giant and semi-monopoly water supply, servicing and insurance companies usually comes with unfavorable pricing and terms for farmers.

Restructuring of farms continues as most of them apply survival tactics rather than a long-term strategy for improving efficiency. What is more, a great portion of subsistent, smaller commercial farms and cooperatives are unable to adapt to evolving market, institutional and natural environment[17].

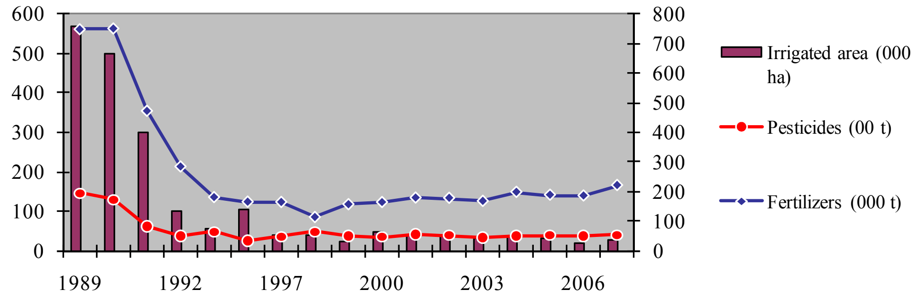
A by-product from dominating *market and private management* has been considerable disintensification of agriculture, ease of general eco-pressure and pollution comparing to pre-reform level.

The total amount of used chemical fertilizers and pesticides has declined considerably, and now their per hectare application represent merely 22% and 31% of the 1989 level (Fig. **7**).

A sharp reduction in chemical use has diminished drastically the risk of chemical contamination of soils, waters, and farm produce. A good part of farm production has got (semi) "organic" character obtaining reputation for high quality and safety.

However, a negative rate of fertilizer compensation of N, P, K intakes dominate and average of 23595,4t N, 61033,3t P205 and 184392t K20 have been irreversibly removed annually from soils since 1990 [26]. What is more, monoculture or simple rotation is constantly practiced by large operators concentrating on few profitable crops (sunflower, cereals). These practices further contributed to deterioration of soil quality and organic matter.

[17] market competition, and new EU quality, safety, and eco-standards (Bachev, 2010); challenges associated with the climate change (Alexandrov, 2010) *etc.*



Source: National Statistical Institute

Figure 7: Irrigation and chemical application in Bulgarian agriculture

There has been more than 21 folds decline in water used in agriculture comparing to 1989 (Table **5**). In recent years sector "Agriculture, hunting, forestry and fishery" comprises merely 3,17% of total water use and 0,34% of generated waste waters (NSI, 2009). All that contributes to a considerable reduction of water stress in the country. For instance, since 1990 Water Exploitation Index decline considerably from 55% (2d in Europe) to 33% (EEA, 2007).

Table 5: Evolution and agricultural use of water resources in Bulgaria

Indicators	1988-1992	1993-1997	1998-2002	2003-2007
Total water resources (10^9/m^3/year)	21	21	21	21
Water resources per capita (m^3/inhabitant/year)	2427	2562	2661	2748
Total water withdrawal (10^9/m^3/year)	14,04	na	8,674	na
Agricultural water withdrawal (10^9/m^3/year)	3,058	0,141	0,144	0,143
Share of agricultural water withdrawal in total (%)	21,78	-	1,66	-
Share of total actual renewable water resources withdrawn by agriculture (%)	14,36	0,66	0,68	0,67
Area equipped for irrigation (1000 ha)	1263	789	622	104,6
Share of cultivated area equipped for irrigation (%)	29,17	17,55	17,36	3,18
Area equipped for irrigation actually irrigated (%)	na	5,42	4,96	51,29

Source: FAO, AQUASTAT

There is a huge reduction of irrigated farmland since 1990 as 2-5% of irrigation network has been actually used (Fig. **7**). What is more, a considerable physical distortion of irrigation facilities has taken place affecting most part of the internal canals. Furthermore, water losses in the irrigation system amount 70% as a result of poorly maintained facilities, low efficiency, and water stealing (Alexandrov, 2010). Nevertheless, irrigation impact on erosion and salinization has been diminished considerably after 1990.

Erosion has been a major factor contributing to land degradation. Its progressing level is a result of extreme weather but it has been also adversely affected by dominant agro-techniques, deficiency of anti-erosion measures, uncontrolled deforestation and recultivation of permanent grasslands. Due to ineffective management one-third of arable lands are subjected to wind erosion and 70% to water erosion (EEA, 2007). Annual losses of earth masses from water erosion are estimated at 145Mt and two-third of it comes from the arable land[18].

Decline in irrigation has also had a direct harmful effect on crop yields and structure of rotation. The level of irrigation depends on the humidity in each year, kind of irrigated crops and water prices. Nevertheless,

[18] soil losses range from 8 t/y for permanent crops to 48 t/y for arable lands (EEA, 2007).

irrigation has not been effectively used to correct inappropriate seasonal and regional distribution of rainfalls, and mitigate effect of climate change[19] on farming and land degradation. Farms little capability for adaptation has resulted in huge crop, livestock and property losses during recent droughts and floods.

There has been a considerable amelioration of the quality of surface and ground waters as a result of unintended decrease of negative impact of agriculture caused by sharp decline in chemical fertilizers and pesticides application.

This trend diminished drastically pressure on environment and risk of chemical contamination of soils and waters.

Nitrate and phosphate content in surface water decreases throughout transition and now only 0,7% of samples exceed Ecological Limit Value (ELV) for nitrate (EEA, 2007). Despite improvement, many water eco-systems are at risk cased by agricultural emissions in water and increasing application of chemicals. In drinking water around 5% of analyses show deviation of nitrates up to 5 times above appropriate level (EEA, 2007). The later is mostly restricted to 400 small residential locations but it is also typical for almost 9% of the big water collection zones. Improper use of nitrate fertilizers, inappropriate crop and livestock practices, and non-compliance with specific rules for farming in water supply zones, are responsible for that problem.

Around a quarter of riverlength does not meet standards for water quality (MAF, 2009). Monitoring of water for irrigation shows that in 45% of samples, the nitrates concentration exceeds contamination limit 2-20 folds (EEA, 2007). Nitrates are also most common polluter of ground waters with slight excess over ecological limit (EEA, 2007). Besides, around country a trend for reduction in pesticides concentration in underground water is reported with occasional cases of triasines over the ELV since 2000.

Nitrate Vulnerable Zones cover 60% of country's territory and around 7% of UAA. The lack of effective manure storage capacity and sewer systems in majority of farms, challenge posed by inadequate storage and disposal of expired and prohibited pesticides, and illegal garbage dumps in rural areas, all contributes significantly to the persistence of the problem. Most part of the post-communist livestock activity is carried out by a great number of small and primitive holdings often located within residential borders. Moreover, only 0,1% of the livestock farms possess safe manure-pile sites, around 81% use primitive dunghills, and 116 thousands holdings have no facilities (MAF, 2009). Furthermore, illegal garbage yards in rural areas have noticeably increased reaching an official figure of 4000 and real number far bigger than reported amount (EEA, 2007). Farms contribute extensively to waste "production" with organic and industrial materials, leading to negative changes in beauty of scenery, and air, soil, and water pollution.

Pollution of soil and water from industrial activities, waste management, and improper farming activities is also a serious environment and health risk - in 7% of soils the concentration of pollutants is higher than the critical limits (EEA, 2007). All that contributes significantly to pollution of air, water, soils, and disturbing population comfort (noise, odor, dirty roads).

There has been considerable increase in farmland affected by acidification (Fig. **8**). That is a result of long-term application of specific nitrate fertilizers and unbalanced fertilizer application without adequate input of phosphorus and potassium. Besides, since 1990 no effective measures are taken to normalize soil acidity and salinity.

Fraction of salinized land doubled after 1989 but it is merely 1,1% of the total farmland (EEA, 2007). Widespread application of primitive irrigation techniques, and inappropriate crop choice, rotation and agro-techniques augment inefficiency of water use and local soil erosion.

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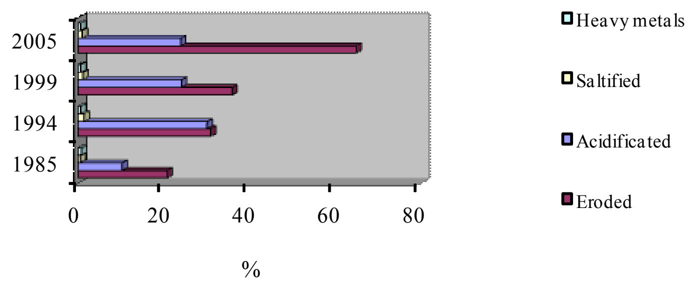
[19] According to climate forecasts temperature will continue to increase, rains quantity to decrease, and more extreme events (thunderstorms, floods, droughts, hurricane winds) to occur. By 2030 water availability on more than 50% of the territory will decrease 5-10%, a severe water stress is projected for South-Eastern parts and a medium in some other places (EEA, 2007).



Source: Executive Environment Agency

Figure 8: Share of degradated agricultural lands in Bulgaria

There has been also a significant reduction of overall GHG emissions from agriculture. N2O emissions comprise 59% of total agriculture emissions, as sector is the major ammonia source accounting for two-third of the national (EEA, 2007). Most NO2 emissions come from agricultural soils (87%), manure management and burning fields (13%). Methane emission from agriculture represents about quarter of the national. The biggest portion of CH4 comes from the fermentation from domestic livestock (72%) and manure management (24%).

There is significant degrading impacts of agriculture on biodiversity as all 37 typical animal breeds have been endangered during the last decades, among them 6 are irreversibly extinct, 12 are almost extinct, 16 are endangered, and 3 are potentially endangered (MEW, 2007).

Since 1990 a considerable portion of farmlands have been left uncultivated for a long time or entirely abandoned. Consequently, a significant part of agro-ecosystems lost their “agro” character turning into natural ecosystems. That has caused uncontrolled “development” of species allowing development of some and suppressing others. Some of most valuable ecosystems (natural grassland) have been severely damaged. Part of the meadows has been left under-grazed or under mowed, and intrusion of shrubs and trees took places. Some fertile semi-natural grasslands have been converted to cultivation (crops, vineyards, orchards). This has resulted in irreversible disappearance of plant species diversity. Certain public (municipal, state) pastures have been degraded by unsustainable use (over-grazing) by private and domestic animals. Besides, a reckless collection of valuable wild plants (berries, herbs, flowers) and animals (snail, snakes, fish) have led to destruction of all natural habitats.

Market-driven organic farming has emerged recently and registered a significant growth. There has been 11 folds increase in number of organic operators[20] since 2003 and the organic producers comprise the largest part (74%) of organic operators[21]. There has been enormous augmentation of organic areas and livestock but the organic area is still 0.33% of the Utilized Agricultural Area (UAA) while organic cattle and sheep comprise merely 0.14% and 0.21% of livestock accordingly (EUROSTAT, 2010). “Fully converted organic areas” accounts for 25.4% of total organic areas with Industrial crops, Pastures and meadows, and Permanent crops comprising the biggest shares of fully converted areas. There are few livestock farms and apiaries certified for bio-production with highest growth in organic goats and sheep, and a lion share of bees (80%). There are also 242677 ha approved for gathering wild organic fruits and herbs (MAF, 2009).

Organic form has been introduced by business entrepreneurs who managed to organize and fund this new venture arranging independent certification and finding buyers for highly specific output. Produced bio-fruits, vegetables, oil plants, herbs, spices, and honey are mostly for export since a tiny market for organic products exists in the country. Slow development of organic market is caused by the high prices of products, and limited consumer confidence in authentic character of products and certification. Eco-

[20] Organic operator is any natural or legal person who produces, prepares, imports, exports or deals with organic products (EUROSTAT, 2010).

[21] totaling 432 farms, processors, and traders (EUROSTAT, 2010).

labeling of processed farm products (self-regulation) has also appeared but it is perceived more as a part of marketing strategy of companies rather than a genuine eco-action.

In 1990s the State monopoly Irrigation Systems was reorganized into a Joint-stock company owned by Ministry of Agriculture and responsible for the management of state assets, provision of irrigation and drinking water, drainage and flood protection. Furthermore, Union of Water Users was initiated and 176 Water User Associations (WUA) emerged. This collective form was unable to improve efficiency (low incentives, lack of ownership) and deal with monopoly position of 21 semi-autonomous regional branches of Irrigation Systems. Since 2001 the user-wrights on irrigation assets of Irrigation Systems have been freely transferred to newly-registered (re-established) Water User Associations. Around 70 Water User Associations are formed servicing 30% of the total irrigation area. However, the expected "boom" in efficiency from collective management of irrigation has not materialized because of the semi-monopoly situation (terms, pricing) of regional water suppliers, few incentives for water users to innovate facilities and expand irrigation, and uncompleted privatization of state assets.

Evolution of farmers and eco-associations has been hampered by the big number and diversified interests of agents – a different ownership size, operation, type of farming, preferences, age, and horizon. There are few examples for effective organizations mostly with small-membership and strong common interests of participants (*e.g.* tobacco, silk-warm, bee-honey *etc.*).

Government and local authority involvement in eco-governance has not been significant, comprehensive, sustainable, or even related (Bachev, 2010). For instance, the budget of the Ministry of Water and Environment accounts for 1,5% of National, and agriculture is getting a tiny portion of total public eco-spending (MEW, 2007). Recent financial and economic crisis further deteriorated funding of public (including eco) projects. Recultivation of degradated farmlands by MAF is under way recently accounting merely for 200-250ha per year [26]. Serious eco-challenge is caused by state deficiency in storing and disposal of out-of-dated pesticides of ancient public farms. Currently 28% of all polluted localities in the country are associated with these dangerous chemicals (EEA, 2007).

In passed years a number of national programs have been developed to deal with specific eco-challenges - preservation of biodiversity and environment; limitation of emissions of Sulphur Dioxide, VOC, Ammonia; waste management; development of water sector; combating climate change; developing organic agriculture; management of lands and fights against desertification; agrarian and rural development. National monitoring systems of environment and biodiversity are set up and mandatory eco-assessment of public programs introduced. Nevertheless, actual eco-policies rest fragmented and largely reactive to urgent eco-problems (natural disasters, floods, storms, drought) rather that based on a long-term strategy for sustainable development.

There have been a numerous international (UN, EU, NGO *etc.*) assistance projects to "fill the gap" in local failures but they are limited in scale, unsustainable in time; often overtaken by local groups, funding improperly used; and with no significant impact.

Moreover, agrarian education and the National Agricultural Advisory Service (NAAS) does not provided modern and continues training on rural development and eco, climate change, and water-management; neither it reaches all agents via effective methods of education, advice and information suited to their specific needs.

Furthermore, the integral approach of soil, water and biodiversity management in planning, funding, management, monitoring, controlling and assessment is not applied, and stakeholders involved in decision-making process at all levels. Neither modern eco-system services, life-cycle, water accounts, and other modern approaches have been incorporated into program management.

Up to date, adequate water and eco-data collection, monitoring, and independent assessment have not been secured including agricultural benefits and impacts; waters quality; total costs; eco and water-foot prints;

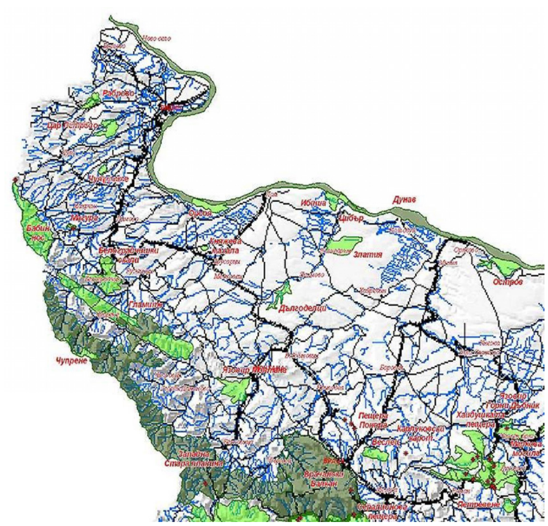
impacts of climate change; existing and likely risks *etc.* Nor mechanisms for timely disclosure and effective communication to decision-makers, stakeholders and public at large are assured. Furthermore, environment related research has been severely underfunded in last twenty years. Consequently, the understanding of agricultural environment use and impacts, and various aspects, factors and impacts of eco- governance, ignored.

As a result of inefficient priority setting and management (bad coordination, incompetence, corruption), and insufficient administrative capacity a minor impact of public programs prevails.

2.2. Management of Agro-Ecosystem Services in Zapadna Stara Planina

Zapadna Stara Planina [22] is a mountainous region in the North-West Bulgaria (Map 1). Agro-ecosystems in Zapadna Stara Planina are a part of the unique ecosystem of Zapadna Stara Planina providing a wide range of services (Fig. **2**).

Map 1. Zapadna Stara Planina ecosystem in Bulgaria



Map 2. Natura 2000 Habitat directive (light), Bird directive (dark)

[22] Zapadna Stara Planina region covers 4043 km^2 (2099 km^2 in Bulgaria and rest in Serbia) of which 60% is forests and rest is farmland (Grigorova and Kazakova, 2008).

A great number of agents from and outside region benefit from and affect services of ago-ecosystems – natural resources owners[23], farmers, residents, businesses, visitors, consumers, scientists, interest groups.

Approximately 70% of the farmland comprises meadows and pastures (MAF, 2009). They provide abandon feed for farm and household animals creating good conditions for grazing livestock (sheep, goats, cattle, buffalos, horses) and domestic animals (poultry, rabbits, pigs). There are also plenty of wild flowers and herbs which favor a herbal honey production, and collection of natural medical plants.

A wide range of farm products is produced used for provisioning of population and marketing. Local farm-based produces are well-known for quality, unique taste, original character (strawberry, raspberry, blackberry, berry jams, herb honey, sheep yogurt and cheese, lamb meat, wool, fur, prune, plum brandy) and marketed at regional, national, and international markets. They favor development of related productions and services being important income source for population – (jam, dairy, brandy, leather) processing, dying wool, weaving and crafts making, on-farm and direct marketing, agro and rural tourism.

For many local and not-permanent residents interactions with agro-ecosystems are favorite mode of recreation (part-time and hobby farming, short and longer-term visits) or life-style (weekend and summer houses). Traditions and ethnic culture of Torlaks and Karakachans are closely related to agro-ecosystems and farming system – specific agricultural and related products (Chiprovtsi hand-made carpets), crop verities and animal breeds, production methods and technologies, festivals, cuisine, and crafts.

Unique shape and quality of landscape is a critical feature of agro-ecosystems dominating by natural and semi-natural mountain pastures, riparian meadows, stony and rocky terrains. All these attract many visitors from region, country, and abroad.

Agro-ecosystems contribute significantly for maintaining soil quality - vegetation cover reducing soil loss, degradation, promoting water infiltration. Carbon sequestration is important service of grasslands, berry bushes, orchards, and vineyards storing considerable amount of CO_2.

Agro-ecosystems provide combined services with the larger ecosystem of Zapadna Stara Planina. A great variety of wild fruits, herbs, chestnuts, mushrooms, birds, animals, and fish are picked up or hunted by population and visitors. Some are commercially gathered for processing and sells bringing additional incomes for 20% of population (Grigorova and Kazakova, 2008).

Ecosystem Zapadna Stara Planina is a source of clean mountain and mineral water used by farmers (animals, irrigation), residents (drinking, household needs), businesses (inputs, bottling), and health centers (balneotherapy) in the region and neighboring areas. It purifies water and air, and regulate climate making region one of the destination for tourism, recreation, and treatment.

Well-known mountainous resorts like Berkovitza, Varshetz, and Izketz are located there. Some of country's most popular natural wonders (Belogradchik Rocks, Iskar Gorge), and a number of picks, waterfalls, and caves is situated there enhancing cultural services of the ecosystem.

Territory of Zapadna Stara Planina is with a high ornithological and botanical importance designated as NATURA 2000 site (Map 2). Maintaining this rich biodiversity is a great service of the ecosystem. These increase educational and scientific services of this ecosystem as well.

Various market, private and public modes are used for managing agro-ecosystem services (Fig. **9**). Post 1989 reforms transferred agrarian and agro-ecosystem services related activity from large public farms into market and private governance. Private management and market adjustments have been associated with domination of small-scale and subsistence holdings (Table **6**), a sharp decline in crop and livestock productions, and general disintensification of activity.

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[23] 50% of the population own farmlands.

Private ownership introduced better incentives for environmental stewardship while small size led overcoming eco-problems of public enterprises. It also revived some traditional and sustainable technologies, varieties, and products. A positive result of market and private management has been the overall improvement of agro-ecosystems services. Farm and related productions have got "organic" character obtaining a reputation for products with high quality and safety. Region has become attractive destination for many tourists willing to experience genuine nature, traditional cuisine and lifestyle, or buy authentic farm products.

Market	Private	Public
Informal branding	Voluntary initiatives	Environmental regulations
Organic (berry) farming	Long-term supply contracts (milk, berries)	Eco-information, monitoring, assessment
Organic apiaries	Vertical integration of farming into processing, services, marketing (shops, hotels, restaurants, export)	Promotion or joining eco-initiatives (festivals, networks, ads)
Organic livestock	Interlink organization (dairy)	Designated zones of eco-importance (natural parks, NATURA)
Organic wild fruits, herbs gathering	Diversification of production/services	Area-based direct payments
Specific origins (lamb, cheese, berries, carpets, crafts)	Cooperatives	Area-based payments for mountainous regions with handicaps
Organic processing (berries, milk, herbs)	NGO's	Leasing out public land for private management
Eco-labeling	Organic alliances	Cross-compliance requirement
On farm and direct marketing		Agro-ecological payments (voluntary contracts)
Clientatlisation (cheese, meat, berries)		Support to traditional, original productions
Agro and eco-tourism		Support to farms, processing modernization
		Support for semi-market farms
		Support to young farmers
		Support for adaptation of quality, safety, eco-standards
		Support to collective actions (producers groups, cooperation)
		Support for diversification of activity (eco-tourism, heritage)
		(Mandatory) eco-training
		Program for development of agriculture North-West Bulgaria
		Fox vaccination
		Recultivation of degradated farmlands
		Garbage taxation
		State company Vratza Natural Park
		Support to trans-border initiatives

Figure 9: Modes of management of agro-ecosystem services in Zapadna Stara Planina in Bulgaria

Table 6: Major characteristics of farms in Zapadna Stara Planina in Bulgaria.

Indicators	**Value**	**Indicators**	**Value**
Number farms	12151	Share farms with cattle (%)	17,2
Average UAA (ha)	0,997	Average cattle per farm	2,9
Share arable land (%)	33,6	Share farms with sheep (%)	51,1
Share cereals (%)	18,4	Average sheep per farm	5,5
Share horticulture (%)	4,3	Share farms with goats (%)	62,7
Share grassland (%)	58,7	Average goats per farm	2,6
Share permanent crops (%)	4,9	Share farms with pigs (%)	47,2
Share farms with bees (%)	6,3	Average pigs per farm	1,5
Bees colonies per farm	7,1	Share farms with poultry (%)	69,0
		Average poultry per farm	14,2

Source: Ministry of Agriculture and Food, 2005

Market-driven certified organic production has also emerged but it is restricted to few farms, processors, and traders. Country's biggest producers of organic raspberries and bee honey are located in Zapadna Stara Planina. Informal branding of fresh and processed farm (eco, origin, quality, low costs) produces has been increasing and marketed though farmers and street markets or clientalisation between individual sellers and buyers (on-farm sells, home delivery).

A number of effective private modes have evolved and manage relations between farmers, processors, food stores, and consumers. High specificity and capacity dependency are widely safeguarded by cooperation (services, processing), long-term contracts (marketing of milk, organic berries), interlinked organization (milk marketing against free-provision of cooling vanes, credit), or a compete integration (diversification of farming into processing, agro-tourism). Often non-agrarian agent (processor, food store, restaurant chain, exporter) driven by market or institutional demand initiates, funds, and integrates eco-farming. That is the case with Danon baying milk from big dairy farms (enforcing safety, quality, animal-welfare, eco-standards), a Japanese investor financing organic apiaries and exporting bio-honey, a leading restaurant-chain (from Sofia) integrating dairy farming and processing.

There are cases of informal small–scale (milk, meat) processing and marketing enterprise developed for petit-producers aiming to overcome missing-market and monopoly situation, and (more recently) significant institutional (milk and meat safety standards, quotas) restrictions. Output is mostly for households consumption or marketed though informal channels.

The cooperatives have been typical mode having a great potential to organize highly specific to members transactions (critical inputs and services, processing, marketing), explore economies of scale and scope, manage common resources, diversify in new businesses (eco-tourism), mediate relations landowners-users, adapt to requirements of banks and public institutions.

Market, private, voluntary, non-for-profit, and for-profit forms contribute significantly to improvement of eco-governance but their scope is restricted to a portion of agro-ecosystems (services).

A fifth of agricultural lands is abandoned which caused expansion of some species, and suppressing others. A part of permanent natural and semi-natural meadows have been left under-grazed or under-mowed, and intrusion of shrubs and trees took places putting pressure on priority species (like Souslik) and related chain (Marbled Polecat). Some of fertile semi-natural grasslands are converted to cultivation (crops, berries, vineyards, orchards) which caused irreversible disappearance of plant species diversity.

Communal and private pastures close to settlements have been degraded by unsustainable use (over-grazing). Uncontrolled collection of wild plants (berries, herbs, flowers) and animals (snail, snakes) have jeopardized natural habitats.

Erosion has been a major factor for land degradation as a result of land abandonment, inappropriate agro-techniques, deficiency of anti-erosion measures, and uncontrolled deforestation. Lack of effective manure storage capacities in most farms and modern sewer and garbage collection systems in the rural areas bring about air, soil, water pollution, and affect the beauty of scenery.

Furthermore, a great number of smaller commercial farms and agricultural cooperatives have ceased to exist due to inefficient management, low adaptability to market competition, aging population, and labor exodus. Most dairy farms and processors have failed to adapt to tough EU (safety, environment *etc.*) standard and had to stop commercial activity.

What is more, private interests have harmed legitimate public rights to ecosystem services due to restricting access, conversion of proper use (farmland and forest into construction), or escaping public order on natural resource management.

Due to restricting criteria[24], complicated procedures, bad design, and high transacting costs, most farms (small-scale, subsistent holdings) can not participate in public support schemes. Less than 5% of farms

[24] For direct and agro-ecological payments minimum farm size is 1ha (permanent crops 0,5 ha) and 0,5 ha (landless livestock holdings are not-eligible). NPARD does not provide support for restoration of abandoned farmland, and organic livestock (but forage) production.

comprising 18% of grasslands and 8% of arable land, are registered in Land Parcels Identification System (land eligible for CAP support). From SAPARD agro-ecological measures benefited few pilot farms (MAF, 2009). Due to limiting requirements and insufficient funding few farmers got support under measure "Young farmers". Insufficient "demand" is responsible for few applications and low utilization of funds for "Semi-market farms", and "Organizations of producers".

Introduction and enforcement of most biodiversity and eco-standards is difficult in remote mountainous region with insufficient administrative, financial, and training capacities. Often costs for detection of offenders are extremely high and formal enforcement unproductive – *e.g.* prohibited marketing of fresh milk, uncertified cheese and meat is common; fake labeling, certification is widespread; forbidden fields burning is practiced; minimum-maximum numbers of animals on pastures, milk quotas are not respected; and illegal lodging common.

2.3. Prospects of Eco-Management in Conditions of EU Policies Implementation

EU integration and CAP implementation provides new opportunities for Bulgarian farms. EU funding alone which agriculture receives for 2007-2009 is 5,1 times higher than the overall support to farming before acceding. Huge EU markets are opened which will enhance competition and let local farms explore comparative advantages (low costs; high quality, produce specificity and purity). Novel conditions of market competition and institutional restrictions give strong incentives and pressure for new investments for increasing productivity and conforming to higher product, technology, and eco-standards.

Larger and business farms are most sensitive to new market demand and institutional regulations since they largely benefit or lose from timely adaptation to new eco-regulations. They have a higher capacity to generate resources and find outside (credit, equity, public) funding to increase competitiveness and meet institutional requirements. Process of adaptation is associated with appropriate land management and intensification of production. The later could revive or deepen some eco-problems (erosion, acidification, pollution) unless a pro-environmental management (public order, enforcement) is put in place.

Small-scale producers and most livestock farms are having hard time adapting to new competition, investment needs, new food safety, animal-welfare, and eco-standards.

Our, recent analysis of the *level of adaptability* of different farms in the country has found out that more than a quarter of them are with a low potential for adaptation to *new state and EU quality, safety, environmental etc. standards,* almost 37% are less adaptable to *market demand, prices and competition,* and every other one is inadaptable to *evolving natural environment* (warning, extreme weather, droughts, floods, *etc.*) (Table **7**).

Table 7: Share of farms with different level of adaptability in Bulgaria (percent)

Type of Farms	Adaptability to:								
	Market			Institutions			Nature		
	low	good	high	low	good	high	low	good	high
Unregistered	51,72	48,28	0,00	31,03	68,97	0,00	37,93	55,17	6,90
Cooperatives	34,62	65,38	0,00	23,08	71,15	5,77	61,54	36,54	0,00
Firms	0,00	66,67	33,33	22,22	22,22	55,56	22,22	44,44	33,33
Field crops	41,18	54,90	3,92	21,57	64,71	13,73	54,90	41,18	3,92
Crop-livestock	38,46	61,54	0,00	38,46	61,54	0,00	38,46	61,54	0,00
Mix crops	25,00	75,00	0,00	16,67	83,33	0,00	58,33	25,00	16,67
Mix livestock	0,00	100,00	0,00	0,00	100,00	0,00	0,00	100,00	0,00
Grazing livestock	100,00	0,00	0,00	0,00	100,00	0,00	0,00	100,00	0,00
Pigs and poultry	100,00	0,00	0,00	0,00	100,00	0,00	0,00	100,00	0,00

Table 7: cont….

Permanent crops	25,00	75,00	0,00	37,50	62,50	0,00	50,00	37,50	0,00
Vegetables	0,00	66,67	33,33	33,33	33,33	33,33	0,00	66,67	33,33
All farms	36,67	60,00	3,33	25,56	65,56	8,89	50,00	43,33	5,56

Source: interviews with farm managers, 2010

The significant EU funds for agrarian and rural development would let more and smaller farms to get access to public support and invest in modernization. New essential activities are also effectively funded allowing a diversification and pro-environmental activity. These would bring additional employment and income increasing economic and eco-sustainability of many farms. Mostly bigger farms participate in public programs and get bulk of public support because of superior entrepreneurial capability, resources, possibilities for adaptation, and potential for wining projects. Thus, agrarian and rural development funds will less contribute to decreasing economic and eco-discrepancy between different farms, sub-sectors, and regions.

CAP implementation will improve eco-performance of commercial farms. There is "eco-conditionality" for participating in public programs. Besides, direct payments are inducing farming on previously abandoned lands, and improve eco-situation. There is huge budget allocated for special eco-measures and the number of farms joining agri-environmental programs gradually increases.

CAP measures would affect positively eco-performance of large business farms and cooperatives. These enterprises (potential big polluters) are under constant administrative control and punishment (fines, losing licenses, ceasing activities) for obeying new biodiversity, an eco-standards. They are strongly interested in transforming activities according to new eco-norms making necessary eco-investments, and changing production structures. Larger producers are motivated to participate in special agro-environmental programs, since they have lower costs (economies of scale and scope) and higher benefits from long-term public contracts.

Experience of old EU states demonstrates that some terms of eco-contracts are very difficult to enforce (Dupraz et al, 2004). The rate of compliance with these standards would be even lower in Bulgaria because of the unawareness, insufficient control, "personal" relations, and bribes. Therefore, more farms than otherwise would enroll will participate (including biggest polluters) and outcome of implementation would be less than desirable ("European") level.

Costs for conforming to requirements of eco-programs in different farms vary considerably, and they have unequal incentives to participate. Voluntary character of most support instruments would leave biggest producers of negative impacts (large polluters, non-compliant) outside of schemes (highest eco-enhancement costs). Moreover, Government is less likely to set up high performance standards because of perceived "insignificant" eco-challenges, strong political pressure from farmers, and possible problems (punishment) with EU control on cross-compliance. Therefore, CAP implementation will probably have a modest positive impact on eco-performance of farms.

Public support and demand will push further development of market modes such as organic farming, industry driven eco-initiatives (eco-labeling, standards, codes of behavior), protected high-quality products, system of fair-trade, alternative (wind, manure) energy at farm *etc.* Significant EU market and lower local costs create strong incentives for investment in organic and specific productions by large enterprises - farms, partnerships and joint ventures (including with non-agrarian and foreign participants). New incentives for production of bio-fuel and clean energy would induce development of a new area of farm activity to meet that new market and public demand.

Small farms have less capacity to put together necessary capital and expertise for initiating, developing, certifying and marketing in these ventures. Coalition (development, management, exit) costs between small-scale producers are high to reach effective operations (economies of scale and scope, required minimum inputs). The later either stay out of these new businesses or have to integrate into larger ventures. Assuring (origin, quality) traceability for small farms is costly and they are not preferable partner for integrators (processor, retailers, exporters). Internal market for organic and specialized farm products would unlikely develops fast having in mind low income of population and confidence in public and private system of control.

Some economic and ecological needs (economizing on scale and scope, high interdependency of assets) would continue to bring about change in size and management of individual farms, evolution of group organization, cooperation, and joint ventures – *e.g.* a big interdependency of activities require concerted actions for achieving a certain eco-effect; a high asset dependency between livestock manure supplier and nearby organic crop farms necessitate a coordination *etc.* A special management size or mode is imposed by some institutional requirements – a mandatory minimum scale of activities for joining certain public programs (marketing, agri-ecology, biodiversity, organic farming, tradition, cultural heritage); signing a 5 year public eco-contract dictates a long-term lease or purchase of land.

Our survey proves that 41% of non-cooperative farms and 32% of cooperatives are investigating possible membership in professional organization. Besides, producers grouping are stimulated by available public support (training, advising, funding) for farmers association.

Some production cooperatives profit from comparative advantages (interdependency and complementarily to individual farms, potential for exploring economy of scale and scope on institutionally determined investment, adapting to formal requirements for support, using expertise, financing and executing projects, non-for-profit character), and extend activities into eco-projects, eco-services, and eco-mediation.

Immediate result of new market and public opportunities for getting additional benefits from eco-products and services will be amelioration of economic and eco-performance of number of farms and households and augmentation of agro-ecosystem services.

CAP implementation pushes modernization of farms structures through widening contractual and organizational innovations - specific sort contracts, new types producers associations, spreading vertical integration *etc.* Special forms emerge allowing agents to take advantage of public programs - specialization in project preparation, management, and execution; investing in “relations capital” and “negative” entrepreneurship; forming lobbying modes and representation; making coalitions for complying with formal criteria (minimum size of UAA for direct and agro-ecology payments, membership requirements for producers’ organizations *etc.*).

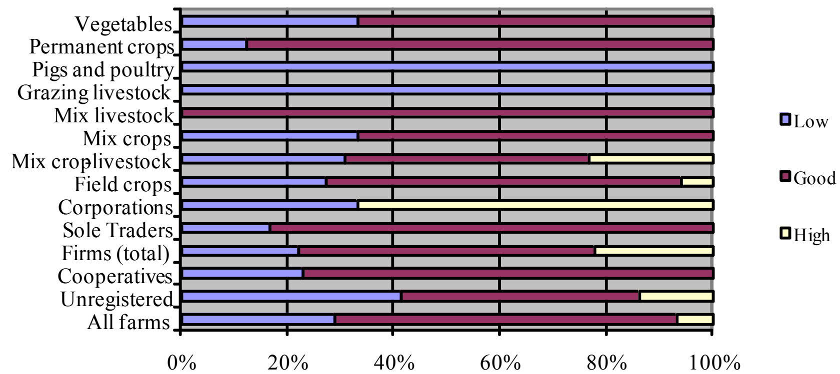
CAP and competition foster restructuring of commercial farms according to modern market, technological, and eco-standards. A large part of agrarian inputs, technologies, and outputs increasingly has mass and standardized character, and market transacting dominate at farm gates. There is a parallel tendency toward specialization into productions for niche markets and products with special quality - specific technologies, special time of delivery, special origins *etc.* That requires investments with higher specificity to particular buyer(s), and “integrated” management in farming, eco-conservation, processing, retailing, exporting.

Moreover, diversification of enterprises into related activities (trade with origins, agro-tourism) for dealing with market risk is growing. All these bring more special modes for private management - long-term contracts, collective agreements (codes of behavior), trilateral modes (independent certification and control), “quasi” or complete integration.

According to farms managers the *medium-term sustainability* of farms is low for 29% of surveyed farms. The share of unregistered holdings, grazing livestock, and pigs and poultry farms with a small sustainability is the biggest (Fig. **10**).

On the other hand, less that 7% of all farms “forecast” a high mid-term sustainability. A particular type of firms – the *companies,* is the only exception among surveyed farms, and two-third of these enterprises envisages being highly sustainable in years to come.

Detailed analysis of the diverse factors diminishing farms long-term efficiency and sustainability indicates that the *significant problems* in the effective *marketing of products and services*, and in the effective *supply of needed innovation and know-how*, are the most important for the good part of surveyed farms (Table **8**). Apparently, the later farms have no (internal) adaptation potential to overcome these type of problems and will be unsustainable (inefficient) is a longer run[25].



Source: interviews with farm managers, 2010

Figure 10: Share of farms with different levels of mid-term sustainability in Bulgaria

The serious (unsolvable) problems associated with the *marketing* are critical for a considerable section of agri-firms, and farms specialized in mix crop-livestock, and permanent crops. The severe problems in the effective *supply of needed innovation and know-how* are most important for the sustainability of cooperatives, mix crop-livestock, and vegetable farms. Furthermore, great difficulties in effective *supply of needed land and natural resources* face a quarter of farm specialized in vegetables and permanent crops. Harsh problems in effective *supply of needed labor* are critical only for grazing livestock holdings. Big difficulties in effective *supply of needed inputs* experience a good fraction of unregistered holdings, and farms specialized in vegetables, permanent crops, and mix crop-livestock production. Significant problems in effective *supply of needed finance* are reported by a main part of unregistered holdings, and farms specialized in grazing livestock, mix crop-livestock, and permanent crops. Finally, substantial difficulties in effective *supply of needed services* are common for a big section of unregistered holdings, and farms specialized in permanent crops and mix crop-livestock operations.Many livestock farms are unsustainable because of the low productivity, competitiveness, and adaptability to safety, animal welfare, and eco-standards. That is particularly truth for small-scale producers dominating the sector. Few livestock farms will be able to adapt through specialized investment for enlargement and conforming to institutional restrictions and will be closed or restrict to subsistency. Reduction of farms and animals, and improved manure management, will be associated with a drop of eco-burden by the formal sector (less over-grazing, fewer manure production and mismanagement).

Table 8: Share of farms with different level of problems of farm sustainability in Bulgaria (percent)

Type of problems	All farms	Unregistered	Cooperatives	Firms	Field crops	Crop-livestock	Mix crops	Mix livestock	Grazing livestock	Pigs & poultry	Permanent crops	Vegetables
Effective supply of needed land and natural resources												
Insignificant	23,33	37,93	17,31	11,11	23,53	15,38	25,00	0,00	0,00	100,00	25,00	33,33
Normal	61,11	44,83	67,31	77,78	62,75	69,23	66,67	100,00	100,00	0,00	37,50	33,33
Significant	14,44	17,24	13,46	11,11	13,73	15,38	8,33	0,00	0,00	0,00	25,00	33,33
Effective supply of needed labor												
Insignificant	34,44	51,72	26,92	22,22	33,33	30,77	33,33	0,00	0,00	100,00	50,00	33,33
Normal	51,11	31,03	61,54	55,56	50,98	53,85	58,33	100,00	0,00	0,00	50,00	33,33

[25] These farms either have to restructure production, or reorganize farm (new governance), or will disappear in near future.

Significant	14,44	17,24	11,54	22,22	15,69	15,38	8,33	0,00	100,00	0,00	0,00	33,33
Effective supply of needed inputs												
Insignificant	32,22	48,28	25,00	22,22	29,41	46,15	41,67	0,00	100,00	100,00	12,50	0,00
Normal	56,67	31,03	69,23	66,67	66,67	30,77	50,00	100,00	0,00	0,00	62,50	33,33
Significant	11,11	20,69	5,77	11,11	3,92	23,08	8,33	0,00	0,00	0,00	25,00	66,67
Effective supply of needed finance												
Insignificant	30,00	55,17	13,46	44,44	31,37	38,46	25,00	0,00	0,00	100,00	0,00	66,67
Normal	54,44	20,69	73,08	55,56	56,86	30,77	66,67	100,00	0,00	0,00	75,00	33,33
Significant	14,44	24,14	11,54	0,00	9,80	30,77	8,33	0,00	100,00	0,00	25,00	0,00
Effective supply of needed services												
Insignificant	48,89	51,72	44,23	66,67	49,02	46,15	66,67	0,00	0,00	100,00	37,50	33,33
Normal	41,11	27,59	51,92	22,22	43,14	30,77	25,00	100,00	100,00	0,00	62,50	33,33
Significant	10,00	20,69	3,85	11,11	7,84	23,08	8,33	0,00	0,00	0,00	0,00	33,33
Effective supply of needed innovation and know-how												
Insignificant	42,22	62,07	30,77	44,44	43,14	23,08	41,67	0,00	100,00	100,00	50,00	66,67
Normal	36,67	20,69	44,23	44,44	37,25	46,15	41,67	100,00	0,00	0,00	25,00	0,00
Significant	20,00	17,24	23,08	11,11	19,61	30,77	16,67	0,00	0,00	0,00	12,50	33,33
Effective marketing of products and services												
Insignificant	17,78	34,48	5,77	33,33	17,65	15,38	16,67	0,00	100,00	100,00	0,00	33,33
Normal	50,00	37,93	59,62	33,33	56,86	46,15	50,00	100,00	0,00	0,00	12,50	66,67
Significant	30,00	27,59	30,77	33,33	23,53	38,46	33,33	0,00	0,00	0,00	75,00	0,00

Source: interviews with farm managers, 2010

On the other hand, for the authority is practically (technically, politically) impossible to enforce the official standards in that huge informal sector of economy. Therefore, massive (semi)subsistence farming with primitive technologies, food safety, animal welfare, and eco-standards will exist in years to come. Enforcement of most labor, animal welfare, and eco-standards is very difficult (or impossible) especially for the informal sector (high political and economic costs). Here “punishments” do not work well while the overall damages from incompliance are immense. Thus policies should be oriented to market orientation of subsistence farms, support for collective modes, and eco-programs for informal farms and groups.

Principally public support to voluntary eco-initiatives of farmers and rural organizations (informing, training, assisting, funding) and hybrid modes (public-private; public-collective) would be more effective than mandatory or pure public modes (given incentive, coordination, enforcement, disputing advantages). Besides, involvement of farmers, farmers organizations, interests groups in priority setting and management of public programs at all level is to be institutionalized in order to decrease information asymmetry and possibility for opportunism, diminish costs for coordination, implementation and control, and increase overall efficiency and impact.

Many of EU regulations are not known by the implementing authorities and majority of farmers. Our survey proved that 47% of non-cooperative farms and 43% of cooperatives are still “not aware or only partially aware” with support measures of CAP different from direct payments. Furthermore, 62% of farms will not apply for public support due to the “lack of financial resources” (26%), “not compliance with formal requirements” (18%), and “clumsy bureaucratic procedure” (17%).

Most farm managers have no adequate training and managerial capability, or are old in age with small learning and adaptation potential[26]. Improving education and training of agents (farmers, residence, consumers, administrators) and relaxing of (some)eligibility criteria for public support is essential.

[26] Average age of farm managers is 61, 70% are older than 55 (MAF, 2009).

Furthermore, improving organization (access, efficiency) and programs (environmental, project management) of NAAS is crucial.

Some "blank points" in national legislation must be filled – *e.g.* terms "agro-ecosystem services" have to find adequate place; the "whole farm" is a subject of support in agri-environmental measures but its borders are not defined. The later creates serious difficulties since land and resources of most farms are considerably fragmented and geographical dispersed.

Lack of readiness, experiences, and potential for adaptation in public and private sectors alike would require some time-lag until "full" implementation of CAP in "Bulgarian" conditions. The later will depend on pace of building effective public and private capacity, training (learning by doing experience) bureaucrats, farmers, and other agents. Consequently, farms modernization and adaptation will be delayed, and their competitiveness and contribution to agro-ecosystem services diminished. Besides, there will be inequalities in application (enforcement) of laws and standards in diverse regions, agrarian sectors, and farms of different type and size.

Finally there is a growing competition for eco-resources between different industries and interests. That push further overtaking natural resources away from farm governance and change into non-agricultural (urban, tourism, transport, industry) use. What is more, needs to compete for and share resources would deepen conflicts between various interests and social groups, regions, and states. That would require special management (cooperation, public order, hybrid form) at local, national and transnational scales to reconcile conflicts related to ecosystem services.

CONCLUSION AND POLICY RECOMMENDATIONS

We have demonstrated that the suggested new framework let us better understand, assess and improve the governance of agro-ecosystem services in the specific market, institutional and natural environment of individual ecosystems, regions, countries *etc.*

We have also showed that post-communist transition and EU integration has brought about significant changes in the state and the governance of agro-ecosystems services in Bulgaria. Newly evolved market, private and public governance has led to a significant improvement of the part of agro-ecosystems services introducing modern eco-standards and public support, enhancing environmental stewardship, disintensifying production, recovering landscape and traditional productions, diversifying quality, products, services. It is also associated with some new challenges such as unsustainable exploitation, lost biodiversity, land degradation, water and air contamination.

Furthermore, implementation of "common" EU policies is having unlike results in "Bulgarian" conditions. In short and medium term it will enlarge income, technological, and eco-discrepancy between different farms, sub-sectors, regions. In a longer-term eco-hazard(s) caused by agriculture will enlarge unless effective public and private measures are taken to mitigate existing eco-problems. Moreover, the specific structures for management of farming activity (small commercial, semi-market, subsistence farms, production cooperatives, large business firms) will continue to dominate in years to come.

Therefore, a significant improvement of public (Government, EU etc.) interventions is needed to enhance sustainability of prospective farms and sustainable agrarian development. Implementation of the EU common (agricultural, environmental, regional) policies would have no desired impacts (on socio-economic development, regional and sectoral discrepancies, flows of agro-ecosystem services) unless special measures are taken to improve management of public programs, and extend public support to dominating small-scale and subsistence farms.

More particularly policy attention is to be directed to:

- better integration of environmental (including the neglected eco-system services and ground water) policy in agrarian and development policies as effective design and enforcement of long-term eco-measures get a high priority;

- complete application of the integral approach of soil, water and biodiversity management in planning, funding, management, monitoring, controlling and assessment at all levels with involving all stakeholders in decision-making process. Moreover, eco-system services, life-cycle, eco- and water accounts, and other modern approaches to be incorporated into program management at all levels;
- improving coordination and efficiency of actions of various public and private agents involved in eco-, eco-system services and water management;
- better defining, regulating and further privatizing (collectivizing) property, user, management, trading, discharge *etc.* rights and assets related to eco-system services, natural and water resources, diverse emissions and wastes *etc.*;
- employing greater range of economic instruments including appropriate pricing, quotas, public funding and insurance, taxing, interlinking *etc.* to improve efficiency of natural and water resources use, and prevent over-intensification and negative impact on environment, and support farms adaptation to changing environment;
- securing adequate eco-, eco-system services and water data collection, monitoring, and independent assessment including agricultural benefits and impacts; waters quality; total costs; eco and water-foot prints; impacts of climate change; existing and likely risks *etc.* What is more, mechanisms for assuring timely disclosure of available data and effective communication to decision-makers, stakeholders and public at large is to be put in place;
- better adapting CAP instruments to specific Bulgarian conditions supporting farm modernization and adaptation; and irrigation, drainage and flood protection innovations; relaxing EU criteria for semi-market and young farmers; directing funds to prospective (*e.g.* Farm modernization and adaptation, Young farmers) and unsupported (*e.g.* Organic livestock) measures;
- employing more hybrid modes given coordination, incentives, and control advantages. Public organization and enforcement of most eco-standards is very difficult (especially in huge informal sectors and remote areas). Public support to voluntary initiatives of professional, community and non-governmental organizations (informing, training, assisting, funding), and assistance in cooperation at eco-system, watershed, trans-regional and trans-border levels will be much more efficient. Accordingly, real participation of farmers and stakeholders in priority setting, management, and assessment of public programs and regulations at all levels is to be institutionalized;
- improving eco-, eco-system services and water training of farmers, administrators, and public at large modernizing agrarian education and Agricultural Advisory Service. The later is to reach all agents via effective methods of education, advice and information suited to their specific needs; set up a system of continues training and sharing experiences; include eco- and water management and climate change issues; cooperate closely with academic institutions and private organizations;
- improving the overall institutional environment and public governance perfecting property rights protection and laws and contracts enforcement, combating mismanagement and corruption in public sector, removing restrictions for market, private and collective initiatives *etc.*;
- giving more public support to research directed to better understanding the agricultural use and impacts on eco-resources, and various aspects, factors and impacts of divers modes of environmental, water, and ecosystem services governance.

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CHAPTER 8

Ex Post Liability for Loss vs. Ex Ante Liability Insurance as Solutions to Reversal Risk in Carbon Offset Projects

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Abstract: When included as part of a larger emissions rights trading system, carbon offset projects can automatically achieve a given reduction of emissions in a cost-effective manner. One major concern with this system, however, is the risk of emissions reversal—the deliberate or accidental release of carbon back to the atmosphere long after carbon credits have changed hands. This downside risk may adversely affect the market value of offset credits and undermine the integrity of the carbon trading system. To address this weakness, at least two financial responsibility rules have been proposed. One calls for the imposition of liability, *ex post*, upon project developers. The other alternative, an *ex ante* measure, requires that project developers have adequate liability insurance coverage prior to undertaking any offset projects. Taking the view that project developers can control the severity of financial losses arising from reversal and assuming a negligence rule of liability for harm, this paper employs the methods of mechanism design to examine the impact of *ex-post* liability rules and *ex ante* liability insurance requirements on incentives to reduce risk. We find that the relative ranking of these two rules crucially depends on the extent of uncertainty regarding the legal standard under liability rules: if uncertainty regarding the legal standard is sufficiently large, then incentives are more pronounced under insurance rules than under liability rules; if the uncertainty regarding the legal standard is sufficiently small, however, then the converse is true.

Keywords: Liability, carbon offsets, climate change, emissions reversal risk.

INTRODUCTION

Combating climate change has received considerable attention in the recent past. Globally, the Kyoto Protocol represents an unprecedented action plan for resolving a major contemporary global environmental problem. Regionally, the European Union identifies tackling climate as a top priority. In US, the federal government administers a wide array of public-private partnerships to reduce U.S. greenhouse gas emissions and is extensively engaged in international climate change activities.

In tandem with this focus, a number of mitigation strategies have been proposed, one of which is the idea of carbon offsets. Under this protocol, an entity can earn tradable carbon credits by supporting or directly undertaking projects that reduce carbon emissions or sequester carbon. The appeal of this system stems from the fact that it represents a cost-effective way for reducing emissions (*e.g.*, Fischer *et al.*, 2002; Lile *et al.*, 1998). This idea is not without its fair share of detractors, however. Critics point to the risk of emissions reversal—the deliberate or accidental release of carbon back into the atmosphere after the underlying credits have been certified and/or changed hands (Kim *et al.*, 2008). Clearly, absent any intervention, this possibility can adversely affect the market value of the resultant offsets and undermine the integrity of the carbon market.

At least two rules of `financial responsibility' have been proposed to address this weakness. One policy calls for the imposition of liability upon project developers, presumably because they have direct control over the reversal risk ex post (Toman and Cazorla, 1998; United Nations, 2000, Kerr, 1998, Wiser and Goldberg 2000). Liability rules owe their attractiveness to the fact that they enhance cost recovery for third

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parties (*i.e.*, the victims) to whom the spurious offsets are sold. Another advantage of these rules is that the threat of wealth loss compels the potentially responsible parties to internalize the expected liability costs. The other rule stipulates financial assurance, which requires that project developers demonstrate that they have adequate liability insurance coverage prior to executing their projects.

It is natural then to ask how these alternative intervention measures can affect reversal risk. This paper employs the methods of mechanism design in order to rank ex post liability rules and ex ante liability insurance requirements in terms of their relative impact on expected reversal losses. We use a model of the simple. In the model, a firm (or a host) that is eligible to host a greenhouse gas reduction or carbon sequestration project lacks the requisite resources to undertake the project and must therefore turn to an investor for external financing. Initially, the project generates offset credits, which are appropriated by the investor and then sold off to a third party in a competitive carbon market.[1] During a subsequent period, however, some carbon is released back into the atmosphere with a positive probability. A release causes a pro rata reduction in the value of credits that initially changed hands and as a consequence inflicts a financial loss (or harm) on the third party holding them at the end of the planning period. We assume that the host can, at a cost, reduce the severity of the losses by expending costly effort. The host is, however, better informed about its costs than is the investor. Thus, the model features an adverse selection problem on the part of the host.

In this setting, the optimal contracts have to serve many functions. They need to compensate the investor and facilitate the transmission of information from the host to the investor. In our model, investors hold the balance of bargaining and can therefore dictate the terms of the contract. This implies that they must take account of the adverse selection consequences created by the host's private information. In such a setting and in a standard fashion, investors find it in their best interest to distort the optimal level of effort and hence expected losses. In so doing, investors capture some of the information rent that the host enjoys by virtue of her private information.

We demonstrate that the relative ranking of the two financial responsibility rules in terms of their impact on the amount of effort that is optimally supplied crucially depends on the extent of uncertainty regarding the legal standard. If uncertainty regarding the legal standard is sufficiently large, then the optimal level of effort is more pronounced under insurance rules than under liability rules; if the uncertainty regarding the legal standard is sufficiently small, however, then the converse is true.

This result can be explained as follows. Under insurance requirements, the investor faces a certain upper limit (*i.e.*, the loss amount) on the marginal benefit of supplying effort. Hence, inducing the host to exceed this limit provides no further reward. With liability rules, however, the investor's and/or the host's actions are weighed against what the court deems to be an appropriate legal standard. Exceeding this standard not only reduces the magnitude of third-party losses. It also lowers the likelihood that the investor will be found liable at all and hence the expected liability costs. When there is very little uncertainty in the determination of the legal standard, there is a strong incentive to exceed the legal standard because exceeding this limit results in only slightly higher expenditure of effort, but a highly reduced likelihood of being held liable, and therefore paying for the third party's losses. When there is a great deal of uncertainty in the determination of the legal standard, however, supplying effort below the legal standard is particularly appealing because it greatly reduces the disutility of effort while only slightly increasing the expected reversal losses.

The implication of this result depends upon the interpretation applied to the phrase "uncertainty regarding the legal standard." Suppose the unpredictability of the legal standard varies across different jurisdictions due to culture, customs, institutions, *etc.* Then the result presented here cautions against the imposition of a general financial responsibility rule that does not pay due regard to jurisdictional idiosyncrasies. It suggests,

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[1] A number climate exchanges have been established to provide a spot market in allowances, as well as futures and options market. These include, the Chicago Climate Exchange, European Climate Exchange, Nord Pool, PowerNext and the European Energy Exchange.

for example, that a prudent financial responsibility policy would call for the adoption of liability rules in jurisdictions where the judicial process is not prone to uncertainty and the employment of insurance requirements in jurisdictions where the judicial process is characterized by a great deal of uncertainty.

This study is in the same spirit as previous works that have examined the problem of optimal regulation of externalities. In studies by Polinsky (1993), Feess (1999) and Privileggi *et al.*, (2001), for example, individuals or corporations engage in risky activities, which can cause large harms. The magnitude or probability of these harms can be reduced through precautionary action. The models employed in all these studies are in the principal-agent framework. Polinsky (1993) analyze the interaction between penalties on harms and contracting in a model with "hidden action" but no adverse selection. Feess (1999) compares strict liability, partial liability and vague negligence in a model with moral hazard and environmental auditing.

The present paper differs from those cited above in two respects: First, the focus of the model presented herein emphasizes the hitherto unexplored interrelationship between financial responsibility and the integrity of project-based emissions credits. Second, rather than examine the implication of only one policy for correcting the externality, namely, liability allocation, our study expands the range of policies in order to evaluate their relative strengths.

Closely related are those studies that have examined the problem of enforcement and compliance in a system of tradable emissions permits. Standlund and Dhanda (1999), Keeler (1991) and Malik (1990) have focussed on the efficiency of permits systems relative to command and control instruments and the optimal allocation of enforcement effort by an enforcement agency. In the context of project-based mechanisms, non-compliance arises if the actual level of emissions reduction falls short of the anticipated level or emissions reduced are not sustained over the long-term. Additionally, enforcement is by way of post-trade liability allocation or financial assurance. Thus, this paper differs from those by Standlund and Dhanda (1999), Keeler (1991) and Malik (1990) in the two important ways: First, enforcement is made exogenous. Second, compliance is made endogenous by conditioning it on effort.

Limited attempts have been made to examine the implications of project-based mechanisms for environmental policy. A short list of existing work includes Janssen (1999), Fischer (2002) and Wirl *et al.*, (1998). Janssen (1999) focuses on the problem of contract enforcement. Fischer (2002) evaluates the efficacy of alternative baseline rules in a situation with asymmetric information while Wirl *et al.*, (1998) focus on strategic reactions by hosts in a three-layer hierarchical framework. However, none of these studies is specifically concerned with how to enhance and maintain the credibility of project-based mechanisms.

The rest of this chapter is structured as follows: The next section presents the basic model and a benchmark solution. Sections 3 and 4 derive the optimal solutions under the two financial responsibility requirements. Section 5 compares incentives under the two financial requirements. Section 6 concludes.

BASIC MODEL

There are three risk-neutral players in the model: a firm that is eligible to host a carbon reduction project (hereafter referred to as the `host'), an investor (or financier) and a third party (or the victim). To abstract from international issues, we assume that all the parties operate in the same jurisdiction. The host currently uses a technology and/or management practices that involve an inefficiently high rate of emissions of carbon. However, by adopting an "offset system protocol" at a sunk cost of K, emissions can be significantly reduced. The offset system protocols can be thought of as any carbon mitigation strategies, such as energy conservation, a shift to renewable energy, afforestation initiatives, fuel switching and improved land management practices (*e.g.*, reduced-tillage techniques). We assume throughout that the host has `shallow' pockets; it must raise all the requisite funds from the investor. The third party is assumed either to be an individual or a representative of a group of individuals who, as we explain shortly, suffer financial losses as a result of the project's inherent risk.

There are three important periods $t\in[1,2,3]$ in the model. For simplicity, we assume no discounting. In period t=1, the host gets the requisite financing and also negotiates a compensation package with the investor. In period t=2, the host implements the carbon reduction strategy; it adopts a cleaner technology or switches to a management practice (at fixed cost K) that has a lower carbon footprint. With this switch, it is assumed that the rate of carbon emission falls below some business as usual (baseline) level. Every unit reduction in the emissions of carbon below the baseline threshold generates an emissions reduction credit (*ERC*).[2] We will denote by R the quantity of *ERCs* generated by the project in period t=2. These *ERCs* are appropriated by the investor, who in turn sells them, at a unit price of v, to the third party in a perfectly competitive carbon market.[3] For simplicity, we normalize the unit price of *ERCs* to unity.

Period t=3 is the period of `affirmation' in the sense that the validity or otherwise of the offset credits that changed hands in period *2* is confirmed. More concretely, a release of carbon back into the atmosphere renders these offsets spurious causing a pro rata financial loss (or injury) to the third party, while a non release ratifies their validity. Formally, we assume that a reversal occurs with probability p and causes an amount $z\in Z\subseteq\Re_+$ of carbon to be injected back into the atmosphere. Since the price of the offsets is normalized to unity, z also represents the amount of financial loss that is potentially suffered by the third party in the event of a reversal. In general, the severity of reversal loss can depend on a raft of factors. Some depend on factors that can be controlled by the host. For example, in an afforestation project, a land owner could employ proper management techniques such as thinning, stand spacing, and rotation length to reduce stand susceptibility to carbon-releasing damage. Some are, however, the subject of unintentional, natural disturbances (*e.g.*, fire, insect damage, and severe weather) and are therefore beyond the control of the host. To capture more simply the combination of managerial and nonnatural factors in the make up of carbon releases, we let $z=\bar{z}+\varepsilon-e$, where $e\in[0,\infty)$ is reversal-avoidance managerial effort that the host supplies and ε is a random variable that is normally distributed with mean 0 and variance σ^2. The density function of z is denoted $\varphi(z,e)$. Effort causes disutility $C(e,\omega)$, where ω is a cost parameter, a firm's type, that is unknown to the investor. Type can be interpreted as a productivity parameter that reduces cost, all else equal. To keep the problem mathematically tractable, we shall assume that the disutility structure is multiplicatively separable in that $C(e,\omega)=\omega\psi(e)$, where $\psi'(e)>0$ and $\psi''(e)>0$.

While the host knows exactly the value of its cost parameter ω from the outset, the investor's knowledge of ω is limited. Furthermore, the investor is not assumed to be able to audit the cost actually incurred by the host, so the financial contract cannot be based on the true cost of the host. Thus, if the investor asks for a cost report from the host, we must anticipate that the host will have the incentive to misreport its cost function whenever this was to its advantage. The investor knows, however, that the cost parameter ω belongs to some closed connected set $\Theta\subset\Re_+$. Without loss of generality we take $\Theta=[\underline{\omega},\overline{\omega}]$. Following the Bayesian approach, we assume that the investor has some subjective a priori probability on Θ, which is associated with a continuous probability density function $f(\omega)\equiv dF(\omega)/d\omega$, where $F(\omega)$ is the distribution function of ω. Denote by ω the most efficient type possible. As is standard in the incentive literature, we assume the following with respect to $F(\omega)$:[4]

Assumption 1. The distribution of types $F(\omega)$ satisfies the monotone hazard rate property:

$$\frac{\partial}{\partial\omega}\frac{1-F(\omega)}{f(\omega)}\leq 0,\qquad \frac{\partial}{\partial\omega}\frac{F(\omega)}{f(\omega)}>0.$$

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[2] For heuristic reasons, we abstract from the determination of project baseline.

[3] Today, there is a burgeoning carbon offset market. Globally, the carbon credit market is now worth approximately $144 billion (World Bank, 2010). The most well known markets include, the EU Emissions Trading Scheme (EU-ETS), which allows "covered entities" to purchase carbon offsets and the Chicago Climate Exchange (CCX). The CCX includes a carbon offset scheme that allows offset project proponents to sell emissions reductions to CCX members.

[4] See, for example, Fudenberg and Tirole [10], p. 267.

To motivate the host to supply effort, the investor could employ a combination of penalties and rewards that depend upon the occurrence or non-occurrence of reversal. Specifically, the principal could reward the host for the avoidance of a reversal, penalize the host for the occurrence of a reversal, or both. In our context, however, such incentive contracts would be subject to one complication in particular: the host has no wealth of his own so that penalty provisions would be largely ineffectual. We thus assume that the investor implements linear incentive scheme that comprises only a reward structure. More specifically, the investor offers a transfer of the form

$$s(\omega) = \begin{cases} \kappa(\omega) - (1-p)\beta(\omega)z & \text{if there is no reversal} \\ \kappa(\omega) & \text{otherwise} \end{cases}$$

where $\kappa(\omega)$ denotes the fixed component of the compensation package, and $\beta(\omega)$ a reward for reversal-avoidance or an incentive scheme.[5]

The nature of the contractual arrangement between the investor and the host will depend on the bargaining capabilities of the two parties. In this paper, we will assume that the investor has all the bargaining power when designing the contract. This is a reasonable assumption in situations where there is competition for investor funds among potential hosts. Thus, during contract negotiation, it will be appropriate to assume that the balance of the bargaining power is in favour of the investor, who can therefore make a take-it or leave-it offer to the host.

Benchmark solution. Before proceeding to characterize the investor's private optimum under information asymmetry, we consider an important benchmark. Assume a setting where no adverse selection problem arises because ω is observable, and the optimal level of effort is prescribed by a regulator maximizing social welfare. In this case, the net value of the project is R, the expected damage from the project is pz and the costs of taking care is $C(\omega,e)=\omega\psi(e)$. These costs and benefits are borne by any of the three parties. Accordingly, social welfare is $S = R\text{-}pz\text{-}C(\omega,e)$. The social problem can therefore be stated as follows: $\max_e S$. It is straightforward to show that the convexity of $C(\omega,e)$ in e guarantees the existence and uniqueness of the socially efficient level of effort e^* such that

$$p-\omega\psi'(e^*)=0. \quad \textbf{(1)}$$

Equation (1) corresponds to the common optimal conditions under which the marginal benefit of increasing effort (or care), p, equals the corresponding marginal social cost $\omega\psi'(e)$ (see, for example, Polinsky (1980). Assuming that the socially optimal level of welfare $S = R\text{-}pz(e^*)\text{-}C(\omega,e^*)$ is positive, it will be ex ante worthwhile to undertake the offset project.

Consider next the value of e that would be optimally implemented in the absence of any intervention to indemnify third party reversal losses. In this situation, the expected total surplus accruing to the project proponents would be $R\text{-}C(\omega,e)\text{-}K$. This indicates that while the project proponents enjoy the fruits of the project's success, neither internalizes the social costs (*i.e.*, the loss inflicted on the third party) of their project. With no reward being furnished for the expenditure of effort, the optimal contract would call for effort to be set equal to zero.

In this paper, we consider two alternative policy reactions to the problem of lack of effort. Both are in the nature of financial responsibility requirements. First, are the ex post liability rules. These rules require that the investor be held financially responsible for the losses inflicted upon the third party after-the-fact.

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[5] A linear formulation of this kind can be rigorously justified if the model is the reduced form of a dynamic one where the host controls a drift with a Brownian motion (Holström and Milgrom (1987). However, a preponderance of studies use linear schemes without invoking the dynamic model because the optimal linear strategies are easily computable (Bhattacharyya and Lafontaine, 1995).

Second, there are insurance rules. Under this regime, it is required that, prior to executing the offset project, the investor must purchase enough liability insurance to indemnify the third party for the reversal losses.

In the following two sections, we consider, in turn, the investor's private optimum under these two regimes. As is common in models of this kind, we assume that the contract design problem can be analyzed within a mechanism design framework. By the revelation principle, there is no loss in generality in focusing on a direct mechanism in which the investor provides the host with incentives that induce truthful behavior (*e.g.*, Fudenberg and Tirole, 1991; Laffont and Tirole, 1993). In a direct mechanism, the investor offers a standard screening contract $C = \{s(\hat{\omega}) : \hat{\omega} \in [\underline{\omega}, \overline{\omega}]$, prescribing a level of transfer $s(\hat{\omega})$ conditional upon the host's announcement $\hat{\omega}$. We assume that the investor can credibly commit not to renegotiate the contract.

The investor selects $s(\hat{\omega})$ to maximize her expected payoff. In so doing, he or she takes into account the response of the privately informed host. The optimal actions of the privately informed host gives rise to two kinds of constraints that the investor must take into account when designing the mechanism. The first kind ensures that the host reports his type ω truthfully. These constraints are called the *incentive compatibility* constraints (Myerson, 1979). The second type of constraints is called the *individual rationality* constraints. They require that the host, whatever his type, gets his reservation payoff, the payoff that the host would get by not participating in the project.

Using the revelation principle, we identify a Bayes Nash equilibrium. An equilibrium consists of a menu of transfers *s* and a vector of reports $\hat{\omega} \in [\underline{\omega}, \overline{\omega}]$ that implicitly determine the level of effort incentives.

The sequence of events is as follows: In the first stage, nature draws a type ω for the host from a set of feasible types $\omega \in [\underline{\omega}, \overline{\omega}]$. Only the host learns her ability. In the second stage, the investor and the host agree on a menu of contracts. The financial responsibility rule is publicly announced in the fourth stage. The host reports his type and then chooses a level of effort to supply given the compensation package and the financial responsibility rule. Final project output is observed and the transfers implied by the menu of contracts are implemented.

EX POST LIABILITY ALLOCATION

As alluded to earlier, liability rules are after-the-fact requirements: the financial damage or obligation is assessed only after the reversal loss has occurred. This implies that a reversal, in and of itself, need not automatically lead to cost internalization. Indeed, if a reversal does materialize, the third party must first bring an action against the investor before the court. The court must then weigh the evidence against what it deems to be appropriate standard of care. From the investor's perspective this process is subject to inherent uncertainty. For example, the investor may not be exactly sure about how the court will interpret the evidence in deciding whether the level of care was above or below the legal standard (see, for example, Craswell and Calfee, 1986; Fagart and Fluet, 2009). In sum, the investor exposure to tort risk is only probable, not a certainty.

To fix ideas, assume that if the third party suffers harm (*i.e.*, if there is a reversal) she always sues the investor under the doctrine of vicarious liability. We also take it that the host has no personal assets and therefore cannot satisfy any court judgment, *i.e.* he is judgment-proof. However, the investor has sufficient wealth to pay for this liability. Thus, the investor becomes liable for the harm only when the host is declared negligent. Let e^s be the legal standard of care. Thus, the investor is held liable if $e<e^s$. To capture this doctrine of negligence in the simplest way possible, we will assume that if the host chooses a level of effort e, then there is a probability $G(e) = \int_e^\infty g(e)de\, G(e)$, where $G'(e) \equiv -g(e)$ is the probability density function associated with the legal standard applied by the court, that the host will be found negligent. We assume that $G(e)$ is decreasing in e, so that liability is more likely to attach to the investor when the host chooses a lower level of care. The investor's expected liability can thus be written as $pG(e)z$.

Given a contract (κ,β,e), if the firm's cost parameter is ω, and if the firm reports ω truthfully, its expected utility is

$$U(\omega) = \kappa(\omega) - [1-p]z.\beta(\omega) - \omega\psi(e(\omega)) \quad \textbf{(2)}$$

If the firm were to misreport its type and report ω, when ω is its true productivity parameter, its expected utility would be

$$U(\hat{\omega},\omega) = \kappa(\hat{\omega}) - [1-p]z.\beta(\hat{\omega}) - \omega\psi(e(\hat{\omega}) \quad \textbf{(3)}$$

The revelation principle implies that an incentive-compatible contract under which the firm has no incentive to misrepresent its cost function is optimal. Thus, the search for an optimal contract can be restricted to the class of contracts that satisfies the incentive-compatibility constraints

$$U(\omega) \geq U(\hat{\omega},\omega), \quad \textbf{(4)}$$

where *U(ω)=U(ω,ω)*. In addition to submitting a cost report, the host is also assumed to have the right not to execute the project if the contract would result in a negative expected profit. Thus the optimal contract must also satisfy the individual-rationality conditions

$$U(\omega) \geq 0 \qquad \forall \omega \in \Theta \quad \textbf{(5)}$$

We say that a contract *(κ,β,e)* is feasible if it satisfies the incentive-compatibility and individual-rationality constraints (4) and (5) for all *Θ*. Thus, when the investor uses a feasible contract, the firm will be willing to truthfully reveal its cost realization and to operate whenever permitted. The investor's problem is to find a feasible contract that maximizes its objective function, which is obtained as:

$$\pi = R - \kappa(\omega) + [1-p]z.\beta(\omega) - pG(e)z \quad \textbf{(6)}$$

Ex ante, the investor does not know the host's cost function. His expected payoff is

$$E[\pi] = \int_{\Theta}\int_{Z}\left[R - \kappa(\omega) + [1-p]z.\beta(\omega) - pG(e)z\right]dzf(\omega)d\omega \quad \textbf{(7)}$$

Thus, the investor's problem can be stated as problem LA:

$$\max_{\beta(\omega),\kappa(\omega),e(\omega)} E[\pi] \quad \textbf{(7')}$$

subject to (4) and (5).

Characterizing the Optimal Solution. The main property of the solution to the investor's problem is recorded in Proposition 1 below. The intuition behind this result relies on a number of observations that are reported in the following two lemmas.

Lemma 1: A contract is feasible if and only if it satisfies the following conditions for all ω in Θ:

$$e'(\omega) \leq 0, \quad \textbf{(8)}$$

$$\beta'(\omega) \leq 0, \quad \textbf{(9)}$$

$$\frac{dU(\omega)}{d\omega} = -\psi(e(\omega)), \quad \textbf{(10)}$$

$U(\omega)$ is convex on Θ, and **(11)**

$$U(\omega) = U(\overline{\omega}) + \int_{\underline{\omega}}^{\overline{\omega}} \psi(e(\omega')d\omega' \quad \textbf{(12)}$$

Proof. From (4) for any ω and $\hat{\omega}$

$$U(\omega) \geq U^*(\hat{\omega},\omega) = U(\hat{\omega}) - \psi(e(\hat{\omega})).[\omega - \hat{\omega}], \quad \textbf{(13)}$$

using the definition of (2) and (3). Reversing the roles of ω and $\hat{\omega}$ in (13) we obtain

$$[U(\omega) - U(\hat{\omega})] \leq -\psi(e(\omega)).[\omega - \hat{\omega}]. \quad \textbf{(14)}$$

Now combining (13) and (14) yields

$$-\psi(e(\omega)).[\omega - \hat{\omega}] \geq [U(\omega) - U(\hat{\omega})] \geq -\psi(e(\hat{\omega})).[\omega - \hat{\omega}] \quad \textbf{(15)}$$

Thus, when $[\omega - \hat{\omega}] > 0$

$$-\psi(e(\omega)).[\omega - \hat{\omega}] \geq [U(\omega) - U(\hat{\omega})] \geq -\psi(e(\hat{\omega})).[\omega - \hat{\omega}]. \quad \textbf{(16)}$$

Dividing equation (16) by $[\omega - \hat{\omega}]$ and taking the limit as $[\hat{\omega} \to \omega$ ω→ω, we obtain equation (10) for a.e ω. Integrating (10) from $\underline{\omega}$ to ω implies that (12) must hold for any feasible contract. Next, note that if $\hat{\omega}$ is the best report of host *ω*, then necessarily, the following first-order condition holds,

$$\begin{aligned}&\kappa'(\hat{\omega}) + [1-p]e'(\omega).\beta(\hat{\omega}) - [1-p][\overline{z} + \varepsilon - e(\hat{\omega})]\beta'(\omega) \\ &-\omega\psi'(e(\hat{\omega}))e'(\hat{\omega}) = 0\end{aligned} \quad \textbf{(17)}$$

for all ω, together with the second-order condition,

$$\begin{aligned}&\kappa''(\hat{\omega}) + [1-p]e''(\omega).\beta(\hat{\omega}) + 2[1-p]e'(\omega).\beta'(\hat{\omega}) \\ &-[1-p][\overline{z} + \varepsilon - e(\hat{\omega})]\beta''(\omega) - \omega\psi''(e(\hat{\omega}))[e'(\hat{\omega})]^2 \\ &-\omega\psi'(e(\hat{\omega}))e''(\hat{\omega}) \leq 0.\end{aligned} \quad \textbf{(18)}$$

Using the fact that (17) holds identically and taking the second derivative of *κ* in (17) yield,

$$\begin{aligned}&\kappa''(\hat{\omega}) + [1-p]e''(\omega).\beta(\hat{\omega}) + 2[1-p]e'(\omega).\beta'(\hat{\omega}) \\ &-[1-p][\overline{z} + \varepsilon - e(\hat{\omega})]\beta''(\omega) - \omega\psi''(e(\hat{\omega}))[e'(\hat{\omega})]^2 \\ &-\omega\psi'(e(\hat{\omega}))e''(\hat{\omega}) - \psi'(e(\hat{\omega}))e'(\hat{\omega}) = 0.\end{aligned} \quad \textbf{(19)}$$

Substituting this relation in (18) yields

$$\psi'(e(\omega))e'(\omega) \leq 0. \quad \textbf{(20)}$$

Given that $\psi'>0$, $e'(\omega)\leq 0$, which is property (8). The sorting condition (9) is defined by condition

$$\frac{\partial}{\partial\omega}\left[\frac{\partial U / \partial\beta}{\partial U / \partial\kappa}\right] < 0. \quad \textbf{(21)}$$

Theorem 7.1 of Fudenberg and Tirole (1991) shows that a necessary condition for implementability of an indirect mechanism via a direct revelation mechanism is

$$\frac{\partial}{\partial\omega}\left[\frac{\partial U/\partial\beta}{\partial U/\partial\kappa}\right]\frac{d\beta}{d\omega} \geq 0. \qquad \textbf{(22)}$$

Hence, $\beta(\omega)$ is nonincreasing.

Equations (8) and (9) are the monotonicity conditions. The fact that $e(\omega)$ is nonincreasing is rather intuitive. The amount of care exerted by the host should decrease as it becomes more costly for her to expend effort. The fact that $\beta(\omega)$ is nonincreasing indicates that in (β, κ) space, indifference curves cross at most once. This parallels the single crossing property in standard screening models. The interpretation of this condition is that lower types (who are more efficient) prefer higher β while higher types prefer lower β. Thus, as the host's type increases, she is less willing to give up an increment in β in return for an increase in κ. This sorting condition establishes a monotonicity condition such that β is nonincreasing in type. Condition (10) follows from the envelope theorem applied to the host's objective function. To sum up, a direct revealing mechanism satisfies (8)-(10). It is also possible to check that these monotonicity conditions are sufficient for truthful revelation (this is a well-known result, see Guesnerie and Laffont, 1984). Note that together, (7), (10) and the fact that $\psi'>0$ imply that $U(.)$ is decreasing and convex in ω. This property follows from the fact that U is the maximum of a family of affine functions of ω as can be seen from (4).

Using Lemma 1 as a building block, we now proceed as follows: First, we replace the global incentive-compatibility constraints in (4) with a local incentive compatibility condition (10). Second, we reformulate problem LA by employing κ from the definition of U (equation 2):

$$\kappa(\omega) = U(\omega) + [1-p]z.\beta(\omega) + \omega\psi(e(\omega))$$

This is then substituted into equation (7'). The transformed problem is then stated as

$$E[\pi] = \int_{\Theta}\left[R - \omega\psi(e(\omega)) - U(\omega) - pG(e)z\right] dF(\omega) \qquad \textbf{(7'')}$$

subject to (5) and (10). The solution to the transformed problem can be obtained using control theoretic techniques. We take U as the state variable with trajectory determined by equation (10). The Lagrangian for the transformed optimal problem is

$$L = R - \omega\psi(e(\omega)) - U(\omega) - pG(e)z - \mu(\omega)\psi(e(\omega)) + \lambda(\omega)U(\omega),$$

where μ(ω) is the costate variable corresponding to the state equation (10) and λ(ω) is the multiplier corresponding to the individual-rationality constraints in (5). The costate variable μ(ω) is characterized in the following lemma.

Lemma 2: The costate variable μ(ω) satisfies

$$\mu(\omega) = F(\omega) - \int_{\underline{\omega}}^{\omega} \lambda(t)dt$$

and

$$\mu(\underline{\omega}) = 0; \qquad \mu(\overline{\omega})U(\overline{\omega}) = 0.$$

Proof. Differentiating the Lagrangian with respect to the costate variable yields

$$\frac{dL}{dU(\omega)} = -\mu'(\omega)) = -f(\omega) + \lambda(\omega).$$

Since U(ω)≥0, consider the choice of the boundary conditions $U(\underline{\omega}) = \underline{U}$ and $U(\bar{\omega}) = \bar{U}$. Calculation shows that

$$\frac{d\pi^*(\underline{U},\bar{U})}{d\underline{U}} = \mu(\underline{\omega}).$$

If $\underline{U} = 0$, then $\mu(\underline{\omega}) \leq 0$. Since U(ω)≥0

$$\left.\frac{dU(\omega)}{d\omega}\right|_{\omega=\underline{\omega}} \geq 0,$$

and from (10) this condition is satisfied only if ψ(e(ω))<0. From the Lagrangian, ψ(e(ω))<0 if and only if $-\omega - \mu(\underline{\omega}) < 0$. This condition, however, requires that $\mu(\underline{\omega}) > 0$, which contradicts the assumption that U=0. Therefore, $\underline{U} > 0$ and hence $\mu(\underline{\omega}) = 0$. A similar argument to the above establishes that

$$\frac{d\pi^*(\underline{U},\bar{U})}{d\bar{U}} = -\mu(\bar{\omega}).$$

Then, if $U(\bar{\omega}) > 0$, $\mu(\bar{\omega}) = 0$, which establishes that $\mu(\bar{\omega})U(\bar{\omega}) = 0$. Integrating μ′(ω) and using $\mu(\underline{\omega}) = 0$ yield

$$\mu(\omega) = F(\omega) - \int_{\underline{\omega}}^{\omega} \lambda(t)dt.$$

The adjoint variable can be interpreted as the marginal cost of satisfying the incentive-compatibility constraint. Note that the derivative in (10) is strictly negative, so by setting to zero the expected utility $U(\bar{\omega})$ for the highest value $\bar{\omega}$ of the cost parameter, the expected utility U(ω) is strictly positive for all $\omega \in [\underline{\omega}, \bar{\omega}]$, given an incentive compatibility contract. In this case, λ(ω)=0, *i.e.*, the individual-rationality constraint is not binding and *μ(ω)=F(ω)* for all $\omega \in [\underline{\omega}, \bar{\omega}]$.

Proposition 1 describes the solution to problem (7’).

Proposition 1. Suppose that the financial responsibility rule holds the investor strictly liable for reversal risk, the sorting condition holds and β(ω) is noninecreasing. Then the condition for optimal care $\breve{e}(\omega)$ is given by

$$\left\{G(\breve{e}(\omega)) + g(\breve{e}(\omega))z\right\} p - \omega\psi'(\breve{e}(\omega)) - \psi'(\breve{e}(\omega))\frac{F(\omega)}{f(\omega)} = 0. \tag{23}$$

Proof: Differentiating the Lagrangian with respect to e, we obtain the optimal level of care as

$$\left\{G(e(\omega)) + g(e(\omega))z\right\} p - \omega\psi'(e(\omega)) - \mu(\omega)\psi'(e(\omega)) = 0. \tag{24}$$

Substitute for λ(ω) and μ(ω) making use of the fact that λ(ω)=0 and *μ(ω)=F(ω)* yield the result of the proposition.

To understand the implication of condition (23), it is important to consider the implication of the combination of private contracting and adverse selection problem inherent in this model. In the absence of adverse selection, the first-best optimality would have required the maximization of (7) under constraint (5) only, which would have given the marginal condition

$$\left\{G(e(\omega)) + g(e(\omega))z\right\} p - \omega\psi'(e(\omega)) = 0. \tag{25}$$

The socially efficient level of effort is given by equation (1). Thus, comparing (23) with (25) and (1), we see that there are two sources of distortion under the private second-best optimum. The first source of distortion is represented by term $\psi'(e(\omega))F(\omega)/f(\omega)$. This term shows that the second-best effort function is obtained by replacing the individual's type with a distorted, or virtual type $\omega+F(\omega)/f(\omega)$, which is typically higher than ω. Thus, the term $\psi'(e(\omega))F(\omega)/f(\omega)$ in (23) derives from the host's private information; it can be interpreted as the marginal cost of dealing with the informational asymmetry resulting from the host's private information. Observe that the term $\psi'(e(\omega))F(\omega)/f(\omega)$ is equal to zero for $\omega = \underline{\omega}$ since $F(\underline{\omega}) = 0$. For all host types above the lower end point, $\omega > \underline{\omega}$, however, $F(\omega)>0$, and it is evident that the last term in equation (23) is strictly positive.

The second source of distortion in effort is captured by the term $\{G(e)+g(e)z\}$ and can be readily attributed to the effects of uncertainty in the judicial process. An increase in *e* decreases the loss from reversal if it ever materializes at all. The marginal reduction in loss from reversal is unity; its magnitude is weighted by the chance $G(e)$ that the investor will be found liable and therefore will benefit from reducing the reversal loss. Thus, the product $G(e)p$ represents the saving to the investor from the application of greater effort because expected reversal costs are reduced. The second term $g(e)z$ represents a reinforcing effect. An increase in *e* reduces the probability of being held liable at all, and this creates an incentive to induce more effort. The marginal change in the likelihood of being held liable is $g(e)$; its is multiplied by *z* the magnitude of the loss. Thus, $g(e)z$ represents a saving to the investor from the application of greater effort because, even if a reversal occurs, it is now less likely that he will be found liable.

In general, the information asymmetry exacerbates the agency problem. As for the judicial process, whether or not it worsens the agency problem will crucially depend on the magnitude of $G(e)+g(e)z$. If $[G(e)+g(e)z]<1$, then a comparison of (25) and (1) reveals that the judicial process will negatively impact the agency problem. Conversely, if $[G(e)+g(e)z]>1$, the opposite will hold true.

REVERSAL INSURANCE

To see why liability insurance may have a particular appeal, recall from the discussion above that ex post liability rules lead to cost internalization only in theory. In practice, liability requirements, and indeed any other after-the-fact penalties or obligations, suffer from an important weakness: since the financial damages or obligations arise only after a reversal has occurred, any loss that is incurred by the third party may not be compensated, either in full or in part. One can identify a number of reasons for this unpleasant outcome. First, a potentially responsible party (*i.e.*, the investor or host) can escape liability (and hence cost internalization) via prior dissolution or bankruptcy. Second, the allocation of liability may itself be the outcome of a judicial process that is subject to error. For example, a court may find in favour of the project's proponents, even when they were in fact negligent. Insurance rules counter this weakness. In concrete terms, insurance requirements ensure that the expected costs of reversal risks appear on an investor's balance sheets and in its business calculations. If an investment in a carbon reduction project implies possible future liability costs, insurance requirement increases the relevance of these costs to the project's decision-making.

We assume that the insurance requirement is imposed on the investor, who is required to provide assurance that he will able to indemnify z in future liability costs. Confronted with this commitment, the investor can either self-insure or purchase an insurance policy from a third party. Obviously, self-insurance requires that the investor possess demonstrable wealth and financial stability. An investor with fewer resources will find that it cannot self-insure and must therefore acquire rights to financial assets from third parties, such as banks and insurers. To abstract from the effect of the investor's wealth on the optimal contract, we will assume that the investor purchases an insurance policy that provide coverage in the amount *z* from a perfectly competitive insurance market. Moreover, we will assume that the insurance industry faces no administrative costs, so that premiums are actuarially fair. Since a reversal occurs with probability *p* causing damage *z* and the amount of care is observable, the insurance company will charge a premium of $p.z$. Thus, the investor's objective is

$$\pi^I = R - \kappa(\omega) + [1-p]z.\beta(\omega) - pz. \tag{26}$$

By virtue of the fact that the host faces no sanctions from the reversal risk, it's expected payoff is unchanged from the previous section. The screening problem in this setting, denoted by RI, is as follows:

$$\max_{e(\omega)} E[\pi^I] = \int_\Theta \left[R - \omega\psi(e(\omega)) - U(\omega) - pz\right] dF(\omega) \tag{27}$$

subject to (4) and (5).The solution to problem (27) is described in the following proposition. The proof is similar to the proof of Proposition 1 and is therefore omitted.

Proposition 2. Suppose that the financial responsibility rule requires the investor to take full liability insurance z at an actuarially fair premium. Then the condition for optimal care $\tilde{e}(\omega)$ is given by

$$p - \omega\psi'(\breve{e}(\omega)) - \psi'(\breve{e}(\omega))\frac{F(\omega)}{f(\omega)} = 0. \tag{28}$$

Compared with (1), equation (28) shows that the optimal level of care is distorted away from its socially efficient level. The distortion principally stems from the host's private information and is given by the term *ψ'(e(ω))F(ω/f(ω*. From the sorting condition and the fact that *0≤F(ω)≤1*, it is evident that this term takes on a positive value for all host types above the lower endpoint $\omega > \underline{\omega}$. This is because the incentive compatibility constraints are `upward-binding,' in this screening model (lower host type mimic higher host types). To induce truthtelling, the linear compensation scheme lowers the level of care below its socially efficient level for all host types above the lower endpoint, $\omega > \underline{\omega}$. Only for type $\underline{\omega}$, for whom $F(\underline{\omega})$=0, is the socially efficient outcome achieved.

COMPARING INCENTIVES

We are concerned here with how the optimal level of care under liability rules $\breve{e}(\omega)$ compares with the level of care under reversal insurance rule $\tilde{e}(\omega)$. That is, does the format of financial responsibility affect the magnitude of distortions in effort incentives that are optimally implemented by the investor? Is the level of effort, $\breve{e}(\omega)$, optimally chosen by the host under liability rule greater than, less than or equal to the level of effort, $\tilde{e}(\omega)$, chosen under an insurance framework?

As a preliminary step to answering this question, rewrite equations (23) and (28) in the following useful form:

$$\psi'(\breve{e}(\omega)) = \frac{p}{\omega + \dfrac{F(\omega)}{f(\omega)}}\left\{G(\breve{e}(\omega)) + g(\breve{e}(\omega))z\right\} \tag{29}$$

$$\psi'(\tilde{e}(\omega)) = \frac{p}{\omega + \dfrac{F(\omega)}{f(\omega)}}. \tag{30}$$

The fact that $\psi'(\breve{e}(\omega))>0$ and $\psi'(\tilde{e}(\omega))>0$ along with equations (29) and (30) indicate that an evaluation of the relationship between $\breve{e}(\omega)$ and $\tilde{e}(\omega)$ can be made by evaluating the difference between $\psi'(\tilde{e}(\omega))$and $\psi'(\breve{e}(\omega))$. More precisely, since ψ is strictly convex, $\tilde{e}(\omega) > \breve{e}(\omega)$ for $\psi'(\tilde{e}(\omega)) > \psi'(\breve{e}(\omega))$ and $\tilde{e}(\omega) < \breve{e}(\omega)$ for $\psi'(\tilde{e}(\omega)) < \psi'(\breve{e}(\omega))$. By virtue of the fact that $\left\{G(\breve{e}(\omega)) + g(\breve{e}(\omega))z\right\}$>0, $\psi'(\tilde{e}(\omega)) > \psi'(\breve{e}(\omega))$ and $\tilde{e}(\omega)$ > $\breve{e}(\omega)$ if $\left\{G(\breve{e}(\omega)) + g(\breve{e}(\omega))z\right\}$<1; $\psi'(\tilde{e}(\omega)) < \psi'(\breve{e}(\omega))$ and $\tilde{e}(\omega) < \breve{e}(\omega)$ if $\left\{G(\breve{e}(\omega)) + g(\breve{e}(\omega))z\right\}$>1. Thus, the sign of the difference $\psi'(\tilde{e}(\omega)) - \psi'(\breve{e}(\omega))$ is indeterminate and the relationship between $\tilde{e}(\omega)$ and $\breve{e}(\omega)$ cannot be uncovered without knowledge of the magnitude of the term $\left\{G(\breve{e}(\omega)) + g(\breve{e}(\omega))z\right\}$.

To shine some light on the make-up of the term in question, observe $g(\breve{e}(\omega))$ can be interpreted as the distribution of the variance of e^s. Put somewhat differently, $g(\breve{e}(\omega))$ reflects the extent of uncertainty with respect to the legal standard. As the level of uncertainty grows larger, the value $g(\breve{e}(\omega))$ should get smaller in the conventional sense of stochastic dominance. Conversely, as the extent of uncertainty regarding the legal standard diminishes, the value $g(\breve{e}(\omega))$ should increase.

Going back to equations (29) and (30), and invoking the preceding arguments, we can conjecture that the inequality $\{G(\breve{e}(\omega))+g(\breve{e}(\omega))z\}>1$ is likely to hold if uncertainty regarding the legal standard is sufficiently small. Conversely, the inequality $\{G(\breve{e}(\omega))+g(\breve{e}(\omega))z\}<1$ will hold if the uncertainty with regard the legal standard is sufficiently small. These observations now lead to the following proposition:

Proposition 3. Under the assumptions of propositions 1 and 2: if uncertainty regarding the legal standard is sufficiently large, then the optimal level of effort will be more pronounced under insurance rules than under liability rule; if the uncertainty regarding the legal standard is sufficiently small, then the converse will be true.

The gist of Proposition 3 is that uncertainty is sufficient to lead to the dominance of liability rules over insurance rules and vice versa. Under insurance rules, the investor faces a certain upper limit on the marginal benefit of supplying effort so that inducing the host to exceed this limit provides no further reward. With liability rules, however, exceeding the legal standard not only reduces the magnitude of third-party losses. It also reduces the likelihood that the investor will be found liable at all and hence the expected liability costs. When there is very little uncertainty in the determination of the legal standard, there is a strong incentive to exceeding the legal standard because exceeding this limit results in only slightly higher expenditure of effort, but a highly reduced likelihood of being held liable, and therefore paying for the third party's losses. When there is a great deal of uncertainty in the determination of the legal standard, however, the incentive to be diligent is particularly muted because supplying effort below the legal standard greatly reduces the disutility of effort while only slightly increasing the expected reversal losses.

CONCLUSIONS

This paper developed a simple model to rank alternative concepts of financial responsibility. In particular, we examined how two notions of financial responsibility--namely, liability rules and insurance requirements--can affect the nature of contractual agreement between an investor and a host, and the induced level of effort under asymmetric information. Our model demonstrates that whether liability rules dominate insurance rules or vice versa crucially depends on the extent of uncertainty regarding the legal standard. More precisely, if uncertainty regarding the legal standard is sufficiently large, then the optimal level of effort is more pronounced under insurance rules than under liability rule; if the uncertainty regarding the legal standard is sufficiently small, then the converse holds true.

The reason for this is that, relative to insurance rules, liability rules essentially expands the range of channels through which effort can be rewarded. Herein, exerting effort not only reduces the amount of third party losses that must be paid in the event of a reversal, it also reduces the likelihood of being held liable. The magnitude of these effects is inversely related to the extent of uncertainty regarding the legal standard.

The implication of this result depends upon the interpretation applied to the phrase "uncertainty regarding the legal standard." Suppose the unpredictability of the legal standard varies across different jurisdictions due to culture, customs, institutions, *etc.* Then the result presented here suggests that a responsive financial responsibility policy would call for the adoption of liability rules in jurisdictions where the judicial process is not prone to uncertainty and the employment of insurance requirements in jurisdictions where the judicial process is characterized by a great deal of uncertainty.

This study could be extended in a variety of ways. Our model assumes that both the investor and the host are risk neutral. Risk neutrality for the investor is questionable in this context, however, because individual investor's seeking low-cost carbon mitigation options are unlikely to possess a diversified portfolio. The same can be said of the host's risk preferences. Thus, a deeper exploration of the impact of liability allocation might involve an examination of the effects of risk preferences. Second, we assumed throughout that the host's effort is observable. Most often, however, effort may be unobservable and therefore not contractible. The model could thus be modified to incorporate moral hazard. Third, our model assumes that the scheme of liability is based on negligence. A possible extension might admit strict liability. These lines of thought are beyond the scope of this study and are left for further research.

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CHAPTER 9

A Choice Experiments Application in Transport Infrastructure: A Case Study on Travel Time Savings, Accidents and Pollution Reduction

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Abstract: This paper presents the results of a Choice Experiment (CE) conducted to estimate the values derived from a highway construction project in Greece. To account for preference heterogeneity conditional logit with interactions and random parameter logit models are estimated. The results indicate that individuals have significant values for travel time savings, percentage decrease in traffic accidents, percentage decrease in traffic related emissions and landscape modifications. Models where the attributes are interacted with socioeconomic variables perform better and produce lower welfare estimates compared to models without interactions with important implications for cost benefit analysis.

Keywords: Economic valuation, choice experiment, transport infrastructure, travel time savings, accidents and pollution reduction.

INTRODUCTION AND MOTIVATION

Performing accurate cost-benefit analysis is a challenging task for policy making especially for the evaluation of public infrastructure projects. Such projects involve use and non-use values resulting from many alternative motivations. Due to market failures or the outright lack of markets and market prices many of the values cannot be estimated using revealed preference data. Without accurate and efficient estimates for the entirety of the generated values there is a risk of underestimating the benefits accrued to the public by the project hence under-providing the public good.

Especially when estimating the benefits from new highway construction, important values enter the scope of the analysis. These values relate to individual well-being, environmental conditions as well as impacts on the landscape. Specifically, there exist benefits generated from the decrease in the number of serious traffic accidents in the locality of the new highway. Additional values can also result from environmental improvements due to reduced emissions from vehicles. Furthermore, any construction involves landscape modification that should be fully accounted for in the cost benefit analysis. For the purpose of cost benefit analysis, values generated form decreased accident rates are often approximated using the human capital approach according to which the value of an accident foregone is given by the present value of the expected income flow had the accident not happened. While this approximation may accommodate the marginal value of one less accident at the macro level, it fails to recognize values accruing to the individual that emerge from altruistic motives, thus excluding them from the analysis. Benefits from reduction in traffic related emissions are similarly evaluated using monetary estimates on the environmental damage caused by emissions without accounting for non-use, bequest and altruistic values. This approach is inappropriate from the economist's point of view, according to which values should be derived from individual preferences.

In order to estimate the values involved in public construction projects accurately, it is important to evaluate all non-use benefits and explicitly account for them in cost benefit analysis. Hence, it is necessary to circumvent the lack of prices for non-marketed characteristics like travel time savings, percentage accident and emissions reduction and landscape impacts by applying non market valuation methods that are based on the creation of hypothetical markets using stated preference data.

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Recent literature on the estimation of benefits from the reduction of accident rates includes Iragüen and Dios Ortuzar (2004) who apply a CE to estimate the Willingness-to-Pay (WTP) for reducing fatal accident risk in urban areas. Regarding the valuation of travel time savings Hensher (2001) estimates the value from decreased travel times in New Zealand using mixed logit models. A CE approach is also followed in the valuation of travel time by Amador *et al.* (2005) who explicitly account for preference heterogeneity for when evaluating the benefits accruing to the public from travel time savings. On the effects of policy measures Garrod *et al.* (2002) estimate the effects of traffic calming to the UK population.

In this paper we present the results of a CE aiming to value different characteristics relating to the construction of a public highway in Greece. To inform policy making, valuations for travel time savings, landscape impacts, as well as percentage decreases in accidents and emissions are estimated. Next section introduces the case study. Third section presents the CE method and the theoretical grounding of the models estimated, while section four discusses the survey design and implementation. Section five presents the results and last section concludes the paper.

The Case Study

This paper draws on data from a case study regarding the construction of a new highway under consideration that will connect mainland Greece with the island of Evia. The island of Evia is located to the east of mainland Greece and the distance between them at some points is less than 500 meters. This has led to efforts to connect the two land masses to facilitate quick transport with land transportation means. At the moment there are three alternative ways to reach Evia form mainland Greece: the “old” and “new” bridges connecting mainland Greece and Chalkida the capital of the island and ferry services traveling between mainland Greece and Evia.

The proximity of Chalkida to Athens, the largest city in Greece which lies 80km to the south, is an important factor that necessitates the improvement of the local road network. Traffic in the surrounding areas has increased in recent years as the numbers of commuters living in Evia and working in Athens and vice versa increased. In addition, Evia is a popular holiday and weekend destination for residents of Athens. The overall increase in traffic results in severe congestion in Chalkida, the main entry point to the island. The state of the local road network is not sufficient for current needs and is deteriorating. These effects have lead policy makers to explore alternative measures to decongest Chalkida and replace sections of the existing aging infrastructure. The solution proposed is the development of a new highway connecting mainland Greece and Evia that will be completed by 2013.

The highway is planned to connect Schimatari in mainland Greece with Aghios Nickolaos in Evia. The new highway will be located to the south of the existing bridges and will facilitate traffic towards southern and northern Evia bypassing the city of Chalkida, and circumventing sections of the existing network thus reducing travel times and accident rates. The main beneficiaries from the development are expected to be local residents as well as the recreational and business travelers to Evia.

The Choice Experiment Method

CEs have been widely applied during the past decade in the fields of environmental, resource, health and transportation economics (see for example, Hanley *et al.*, 2002; Birol *et al.*, 2006; Garrod *et al.*, 2002) for the estimation of public goods’ use and non use values. The theoretical foundations of the CE method lie on Lancaster’s characteristics theory of value according to which individuals derive utility from the characteristics composing the good instead from the good as a whole (Lancaster, 1966). The theoretical basis for incorporating stated behavior with economic valuation is provided by the random utility theory (McFadden, 1974).

The most popular econometric specification for the analysis of CE data to date continues to be the Conditional Logit Model (CLM) (McFadden, 1974). In the random utility framework the utility of respondent i from choosing alternative j is given by:

$$U_{ij} = V_{ij}(Z_{ij}) + e_{ij} \tag{1}$$

where for any household i is the respondent, (Z) the alternative, V is the deterministic component of utility, e is the non-systemic component of utility and Z are the attributes of the good to be valued. The deterministic component of utility represents the impacts on utility that the researcher can observe while the random component corresponds to all effects unobserved by the researcher. Assuming that the relationship between utility and attributes is linear in the parameters and variables function, and that the error terms are identically and independently distributed with a Type 1 extreme value distribution, the probability of any particular alternative j being chosen can be expressed in terms of a logistic distribution. Equation (1) can be estimated with a conditional logit model (McFadden, 1974; Greene, 2000), which takes the general form:

$$P_{ij} = \frac{\exp(V(Z_{ij}))}{\sum_{h=1}^{C} \exp(V(Z_{ih}))} \quad \textbf{(2)}$$

where the conditional indirect utility function generally estimated is:

$$V_{ij} = \beta_1 Z_1 + \beta_2 Z_2 + \ldots\ldots + \beta_n Z_n \quad \textbf{(3)}$$

Where *n* is the number of attributes considered, and the vectors of coefficients β_1 to β_n are attached to the vector of attributes (Z) .

In recent years however there has been increasing dissatisfaction with the CLM, since in effect it imposes homogeneous preferences across individuals, unless these can be adequately represented using interactions with observable socio-economic characteristics. Furthermore, the CLM does not allow for error correlation across respondents' choices. This can lead to biased estimation of the WTP. As Hensher (2001) notes the CLM can result in the underestimation of the value of travel time savings. This shortcoming of the conditional logit model has seen the development of alternative models relaxing the preference heterogeneity restriction such as the Random Parameter Logit model (RPL) (Train, 1998).

In the RPL model preference heterogeneity is considered to affect the systematic component of utility at the individual level. Then, heterogeneity is accounted for by assuming that the attribute coefficients in the estimated model are distributed across respondents. The estimated coefficients represent the mean of the parameter distributions. Specifically, the utility derived by individual i from alternative j is given by

$$U_{ij} = \beta X_{ij} + \psi_i X_{ij} + \varepsilon_{ij} \quad \textbf{(4)}$$

where X_{ij} is the vector of attributes and β is the vector of coefficients associated with the attributes. The derivation of different parameters for each individual is made possible by the inclusion of the vector of deviation parameters ψ_i . Assuming that the error term ε_{ij} is iid with Type 1 extreme value distribution, the probability that individual i chooses alternative j is given by calculating the integral

$$\Pr_{ij} = \int \frac{\exp(\beta_i X_{ij})}{\sum_{n=1}^{N} \exp(\beta_i X_{in})} f(\beta_i \mid \theta) \mathrm{d}(\beta_i) \quad \textbf{(5)}$$

with N being the number of alternatives in each choice set and θ the distribution parameters. The integral in equation 5 does not have a closed form solution and should be calculated with simulation methods.

Survey Design and Administration

To design a CE survey it is essential to identify the good to be valued and express it in terms of a finite number of characteristics. The public good to be valued in this case was the new highway. The attributes and their levels were chosen with the consultation of engineers developing the project and focus groups with the general public. Furthermore, the attributes were selected to reflect the effects of the highway in the population of Evia and the surrounding areas as well as satisfy the guidelines of the Greek ministry of Environment and Public Works for cost-benefit analysis. We opted for a small scale experimental design since initial testing and focus groups revealed that respondents were extremely adverse to longer questionnaires. The attributes and their corresponding levels are presented in Table **1**.

Table 1: Attributes and their Levels.

Attribute	**Levels**	**Status Quo**
Time Saving	5 minutes, 10 minutes	No time saving
Percentage Decrease in Accidents	30 % reduction, 60 % reduction	No change
Percentage Decrease in Emissions	30 % reduction, 70% reduction	No change
Type of Crossing	Bridge, Tunnel	No crossing
Toll	€0.5, €1, €1.2, €1.5	€0

The attributes relate to the expected impacts of the new highway to the general public as a result of decreased traveling distances bypass of hazardous locations of the existing road network. The travel time saving attribute refers to the average time required for individuals to reach the national road network from any of the locations that will be served from the highway. It was estimated by the engineers involved in the construction that depending on its exact layout, the highway could save travelers 5 or 10 minutes for reaching the national road network. The new highway is expected to decrease the number of serious accidents, defined as those resulting to injury or death. Depending on the layout of the road it is expected that accidents will decrease by 30 % or by 60 %. The new layout will decrease emissions from cars in the area by 30 % or 70 %. The type of crossing attribute refers to the mode of the axis while crossing the sea between mainland Greece and the island of Evia. For the length of 600 meters the crossing can cross over the sea on a bridge or below the sea in a tunnel. This attribute was chosen to explore the public's preferences with regards to the effects of the construction on the landscape. A tunnel construction was perceived to minimize the interference to the landscape. The monetary attribute was defined as the toll rate per crossing, a charge that would be levied to all users of the highway. This choice was motivated by its familiarity with the respondents and its credibility among them. The levels of the toll rate attribute where selected to emulate 2007 charges in the Greek national and local road network with the purpose of improving the credibility of the constructed scenarios.

Based on these attributes and their levels a number of scenarios can be constructed. Following an orthogonalization procedure (Louviere *et al.*, 2000), thirty two unique profiles were developed. These were randomly paired in choice sets. In particular, a foldover with random pairing approach was followed. Providing all sixty four scenarios in a single task was not feasible and hence the number of scenarios was reduced to sixteen by designing one version based on the orthogonal main effects plan. Then, a second statistically equivalent version constructed from the ''foldover'' of the first version resulted in the final thirty two scenarios that were considered adequate to allow estimation of all the parameters of interest. It should be noted that same approach has been also applied in Coast *et al.* (2008) and Hjelmgren and Anell (2007). The choice sets were assigned to four different versions consisting of four choice sets each. Each choice set was complemented with an additional profile describing the status quo expressed by the attributes at their current levels. The inclusion of the status quo is necessary for the welfare interpretation of the WTP estimates (Bateman *et al.*, 2003). Table **2** presents an example of a choice set.

The survey instrument started by introducing the organizations participating in the construction project and guaranteeing the anonymity and confidentiality of the responses. Subsequently respondents were presented with details regarding the new highway. These included an accurate description of the attributes and the levels used in the CE design as well as a map visualizing in broad lines the proposed layout of the new highway. Before posing any question to the respondents, they were reminded of the substitute goods and were asked to keep in mind payments their household makes for similar goods and services.

Table 2: Example of a Choice Set.

Please tell us which of the layouts presented below you prefer.						
		Layout 1		**Layout 2**		**No New Road**
Time Saving		10 minutes		10 minutes		No time saving
Car Accidents Reduction		30 %		30 %		No reduction
Noise and Pollution Reduction		70 %		30 %		No change
Type of Crossing		Bridge		Bridge		No crossing
Toll		€1.2		€1		No toll

Once the details regarding the project were explained, the respondents were guided through the four choice sets and where asked to state their preferences among the two alternative layouts and the status quo. Follow-up questions were asked to those selecting the status quo alternative in order to identify protestors. Further questions collected information on car ownership, number of cars owned and whether there was a professional driver in the respondent's household. Questions that assessed the driving habits of the respondents and their expectations regarding their usage of the new highway were also asked. Finally, the survey concluded with the collection of socioeconomic data, such as age, household size education level and income.

The CE survey was implemented using face to face interviews of randomly intercepted individuals in various locations in the island Evia and in Athens in June 2007. These locations were chosen in order to approach a sample of the population that is interested in traveling to Evia and may also derive use and non-use values from the project's construction. In total 150 in-person interviews were completed with a response rate of approximately 78 %. Among the respondents four protestors were identified and removed from the sample.

Results

Table **3** presents the descriptive statistics of the sample.

Table 3: Descriptive Statistics.

Variable	**Mean**	**Std Dev**
Driver (1=yes, 0=no)	0.868	0.339
Car owner in household (1=yes, 0=no)	0.980	0.243
Professional driver in household (1=yes, 0=no)	0.204	0.404
Live (0=Evia,1=Elsewhere)	0.414	0.494
Work(0=Evia,1=Elsewhere)	0.517	0.501
Employment (1=in full employment, 0=other)	0.743	0.438
Education (1=university education and above, 0=less that university education)	0.356	0.480
Gender (1=male,0=female)	0.72	0.451
Age	40.068	13.901
Car number in household	2.099	1.254
Household monthly income (€)	2439.85	1240.933
Household size	3.738	1.407

Approximately 87 % of the individuals interviewed are registered drivers while 20 % of the respondents live in households with professional drivers. Over 98 % of the respondents live in a car owing household while the average car ownership is 2 cars per household. 74 % of the sample is in full time employment while 35 % have completed or are in the process of completing their university education. Regarding the residence and workplace of the respondents, 41 % and 51 % of the sample reside and work outside of Evia respectively.

For the econometric analysis the impacts of the highway construction on travel time savings, percentage accident reduction, percentage pollution reduction and toll rate entered the analysis as continuous variables while two dummy variables indicated the type of crossing using no crossing as the baseline level. To test for preference heterogeneity we carried out a Hausman (1978) test. Table **4** presents the results of the test for the IIA property. The test was carried out by removing one of the three alternative choices from the respondents' choice sets. The IIA assumption is rejected for the first case while the Hausman statistic cannot be calculated for the second and third case as a result of the existence of non-positive definite matrix. Greene (2002) notes that it is possible when you drop one or more alternatives some attribute to be constant among the remaining choices leading to singularities. The rejection of the IIA assumption implies that applying the usual conditional logit model could lead to misleading results and alternative, less restrictive models should be applied (Birol *et al.*, 2006; Hanley *et al.*, 2006). To take into account of the potential preference heterogeneity in addition to the standard CLM we present the results of the CLM with interactions and the RPL model with and without interactions.

Table 4: Results of the Hausman Test for IIA.

Excluded Choice	Statistic	Significance level
Scenario A	25.531	0.0003
Scenario B	Could not be carried out	
Scenario C	Could not be carried out	

Conditional Logit Model

The results of the CLM are presented in the first column of Table **5**. The estimated parameters on all attributes included in the model are statistically significant, thus affecting individual scenario choice. All parameters have the expected signs. The coefficient on travel time savings is positive implying that individuals are more likely to choose alternatives with higher travel time savings. This is also the case for the coefficient on percentage pollution reduction: the probability of selecting an alternative increases with the percentage decrease in pollution. The positive parameter on the percentage accident decrease attribute indicates that respondents prefer scenarios with lower accident rates. The coefficients on the two crossing dummy variables are also positive indicating that building some type of crossing is more desirable that no crossing at all. Furthermore, the magnitude of the two coefficients is almost identical. Consequently, respondents in general do not have a distinct preference for either one of the two proposed crossings and can be considered to be indifferent between the two. Finally the coefficient on the monetary payment attribute is negative conforming to economic theory since higher toll rates decrease the probability that an alternative is selected.

The highest effect on utility results from the accident reduction attribute, followed by bridge and tunnel construction. Pollution decrease has the third highest magnitude while the smallest impact on utility comes from travel time savings.

Conditional Logit Model with Interactions

To capture possible preference heterogeneity that is attributed to observable socioeconomic factors for different highway construction we estimate a conditional logit model including some of the respondent's socioeconomic characteristics as interaction terms with the highway construction attributes. After extensive testing among interaction terms, we found the best fitting model to be the one including the following interactions: a dummy variable indicating whether the respondent resides away from Evia interacted with the percentage decrease in accidents and the tunnel attributes, the number of cars belonging to the respondent's household interacted with the accident reduction and the toll rate and finally a dummy variable indicating whether the respondent is in full-time employment interacted with the toll rate. The results of the CLM with interactions are reported in the second column of Table **5**.

Regarding the attribute coefficients, they remain significant and maintain the same signs as in the original CLM specification. Nevertheless, the coefficients are now of slightly different magnitude. Respondents that reside away from Evia are more likely to select alternatives with higher decrease in accidents relative to those that reside in the vicinity. This could be attributed to individuals not living in the area overestimating the numbers of serious accidents, even though this information was conveyed in the survey. Furthermore respondents that do not live in Evia are more likely to select the tunnel construction. This implies that the local population is relatively more adverse to the least intrusive method of construction. The justification for this effect could be found in the previous experience of local residents with the already existing bridges. These bridges have developed to landmarks for the wider area and locals may foresee additional values from the creation of a new landmark. Non-residents on the other hand derive values relating to the conservation of the local environment as well as from recreation in the area. This could justify their preference for minimal visual intervention. Respondents are more likely to choose alternatives with higher toll rates the larger the number of cars their household owns. This effect appears counterintuitive at first sight since it implies that household expenditure may increase. On the other hand, this may be an indication of the intention of respondents to internalize environmental externalities relating to car use. The interaction of the toll rate with a dummy variable indicating whether the respondent is full time employment though not statistically significant is of the expected positive sign indicating that respondents with certain and presumably higher income are willing to pay higher amounts.

To examine whether the model with interactions is an improvement to the standard conditional logit model we perform a Swait-Louviere log likelihood ratio test. The test indicates that there is significant increase to model fit form the CLM with interactions comparing to the original CLM at 1 % significance level.

Random Parameter Logit Model

For the RPL model specification we assume that preferences are heterogeneous for the travel time saving and pollution attributes. Their parameters are assumed to be normally distributed across the population. Heterogeneity of preferences over travel time savings is motivated from the cross section of individuals that are likely to benefit form the highway that includes leisure travelers, local residents, commuters and others that are likely to have different preferences on travel time. Regarding pollution reduction, preference heterogeneity was considered after focus groups indicated that residents and non-residents of the affected areas had different perceptions about the acceptable levels of emissions in the area. Table **5** presents the results of the best fitting random parameter logit model.

Table 5: RPL and CL models estimation

Variable	**Conditional Logit Model**	**Conditional Logit Model with Interactions**		**Random Parameter Logit**	**Random Parameter Logit with Interactions**
	Coefficient	Coefficient		Coefficient	Coefficient
Travel Time Savings	0.063** (0.028)	0.059** (0.028)		0.107** (0.051)	0.102** (0.053)
Percentage Decrease in Accidents	2.030*** (0.440)	2.436*** (0.913)		2.545 *** (0.633)	2.967*** (1.247)
Percentage Decrease in Pollution	0.995*** (0.294)	1.062*** (0.300)		1.696** (0.667)	1.671*** (0.633)

Table 5: cont….

Bridge	1.929*** (0.450)	2.002*** (0.448)		4.296*** (1.483)	4.424*** (1.644)
Tunnel	1.878 *** (0.441)	1.798*** (0.463)		4.220*** (1.458)	4.134*** (1.584)
Toll	-0.455*** (0.171)	-1.209*** (0.409)		-0.594*** (0.216)	-1.578*** (0.563)
Percentage Decrease in Accidents*Live away from Evia		1.283* (0.768)			1.765 (1.121)
Tunnel*Live away from Evia		0.375* (0.211)			0.498* (0.299)
Percentage Decrease in Accidents*Car number		-0.409 (0.305)			-0.522 (0.411)
Toll*Car number		0.244** (0.125)			0.296* (0.161)
Toll*In full time employment		0.265 (0.321)			0.425 (0.433)
			Derived Standard deviations		
			Travel Time Savings	0.211* (0.127)	0.229* (0.141)
			Percentage Pollution Decrease	4.922 ** (2.015)	4.505** (1.937)
Standard errors in parenthesis.					
R^2	0.35599	0.365		0.361	0.369
Log-likelihood	-413.192	-407.635		-410.062	-404.523
Restricted Log-likelihood	-641.589	-641.589		-641.589	-641.589

*indicates significance at 10 %, **indicates significance at 5 %, ***indicates significance at 1 %

The estimated parameters on all attributes included in the model are statistically significant, thus affecting individual scenario choice. Furthermore, all estimated coefficients carry the expected sign as was the case for the CLM, suggesting that the respondent is more likely to select an alternative the higher the level of travel time savings, percentage of accidents and pollution reduction. On the other hand respondents are less likely to select alternatives with higher toll rates. Comparing to the CLM model, the estimated coefficients of the RPL model are of noticeably higher magnitude. Indicatively the coefficients on the type of construction dummies are of twice the magnitude of the same coefficients under the CLM.

The significant derived standard deviation of the travel time savings and percentage reduction in pollution attributes suggests that there exists heterogeneity in preferences for these attributes. The magnitude of the derived standard deviation in both cases is such that it implies that there exist respondents with negative preferences for travel time savings and percentage decrease in pollution. Specifically, 30.63 % of the respondents have negative preferences for travel time savings while 36.52 % are more likely to select alternatives with lower percentage pollution decrease.

Among the attributes valued in the study, the dummy variables indicate the type of crossing have the strongest effect on utility. This illustrates the desire of the respondents to move away from the status quo of no crossing between Athens and Evia in this particular area. The next highest effect on utility is derived from percentage decrease in accidents. This suggests that respondents have significant values that are based on self preservation and altruistic motives. Percentage reduction in pollution also has substantial impact on the likelihood of an alternative's choice. Among the positive impacts on utility travel time savings have the smallest impact on alternative choice.

Random Parameter Logit with Interactions

The results of the RPL model with interactions are presented in the fourth column of Table **5**. As in the CL model with interactions we observe a minor change in the magnitude of the coefficients on attributes. The coefficients of the interaction terms maintain the signs of the CL with interactions models. Nevertheless now the interaction of accident decrease with the dummy indicating residence location is no longer significant. The derived standard deviations are still significant and imply that 32.8 % of the respondents have negative preference for travel time savings while 35.5 % of the respondents are more likely to choose alternatives with lower pollution reduction. Similarly to the CLM case, the Swait-Louviere log-likelihood test reveals that model fit is significantly improved when adding the interaction terms in the model.

Willingness to Pay Estimates

To derive the marginal WTP for changes in attributes for the CL and the RPL models we apply the formula 6 adjusting it accordingly:

$$WTP = -1\left(\frac{\hat{\beta}_{attribute}}{\hat{\beta}_{payment}}\right) \quad \textbf{(6)}$$

In particular, this formula is employed in the case of a CL model with no interaction terms as well as of an RPL with no interaction terms and no-random variables (type of crossing and percentage decrease in accidents). When interaction terms are also included formula 7 is applied:

$$WTP_{attribute} = -1\left(\frac{\hat{\beta}_{attribute} + \hat{\beta}_{socdem.\mathrm{var}.\cdot attribute} \cdot Socdem.Var}{\hat{\beta}_{\mathrm{payment}} + \hat{\beta}_{\mathrm{socdem.var.\cdot payment}} \cdot Socdem.Var}\right) \quad \textbf{(7)}$$

In particular, we obtain the numerator of WTP by deriving utility with respect to the attributes, that is, generally, $\hat{\beta}_{attribute} + \hat{\beta}_{socdem.\mathrm{var}.\cdot attribute} \cdot Socdem.Var$ which depends on a specific value of the socioeconomic variable. Similarly, the denominator of WTP is obtained by deriving utility with respect to payment, as $\hat{\beta}_{\mathrm{payment}} + \hat{\beta}_{\mathrm{socdem.var.\cdot payment}}$. Similar expressions were obtained by Galilea and Ortúzar (2005) and Hoyos *et al.* (2009). In the presence of an RPL model specification WTP estimates need to take into account as well the randomness of the identified random parameters (time saving and percentage decrease in emissions parameters). Hence, considering formula 6 but with $\hat{\beta}_{attribute,i}$ and specifying the cost parameter as non-random allows easy derivation of the distribution of WTP for each attribute, since it is distributed in the same way as the attribute's parameter (Revelt and Train, 2000). As a result, simulated distributions of WTP are obtained. This approach was also adopted in Westerberg *et al.* (2010).

Table **6** reports the WTP estimates for the attributes under the CLM, the RPL and their corresponding versions with interactions, for the average respondent.

It should be noted that while for the models without interactions the all WTP estimates are positive. This is not true for the WTP of the average respondent in the models with interactions. Indicatively, while the WTP for travel time savings in positive for the CLM and RPL models while it becomes negative for the average respondent.

Table **6** illustrates the importance of model selection in our CE application. The differences in the valuation estimates indicate that the results of cost benefit analysis may vary depending on the model selected to describe preferences. Relying on the models without interactions will produce higher benefits regarding the project in question. However, as reported earlier, the models with interactions perform significantly better compared to their counterparts that contain no interactions. As a result, ignoring possible socioeconomic factors that may influence individual valuation may eventually lead to the overestimation of the benefits and ultimately to false conclusions to the cost-benefit analysis.

Table 6: WTP Estimates.

Attribute	Conditional Logit	Random Parameter Logit	Conditional Logit with Interactions - Average Profile	Random Parameter Logit with Interactions- Average Profile
Travel time savings	0.139 (0.091)	0.180** (0.106)	-0.660* (0.379)	-0.873* (0.509)
Percentage Accident Reduction	4.459** (1.789)	4.288** (1.700)	-4.386*** (1.333)	-5.331*** (1.729)
Percentage Pollution Reduction	2.185** (0.915)	2.857** (1.300)	0.169 (0.687)	0.121 (0.860)
Tunnel	4.125*** (1.486)	7.109** (2.878)	-2.379*** (0.628)	-4.942*** (1.780)
Bridge	4.237*** (1.534)		0.946 (0.939)	1.866 (1.451)

*indicates significance at 10 %, **indicates significance at 5 %, ***indicates significance at 1 %

CONCLUSIONS

In this paper we presented the results of a CE designed to provide estimates of the value for alternative characteristics of highway construction in Greece. The values identified to be significant in such a construction related to the effects on environment, individual and general well being, landscape and travel time. With this motivation the attributes chosen for the purposes of the analysis related to the decrease in travel time, the expected decrease in accident rates and emissions as well as the type of the construction in terms of its effects on the visual amenity of the area. Some preference heterogeneity was identified and accounted for with including socioeconomic factors in the models as well as by estimating random parameter models. The results indicate that respondents derive significant values from all attributes we employ in this study, under all estimated models. However there are noticeable differences in the estimated values under the alternative models estimated.

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