Institut de Sostenibilitat

RESEARCH PLAN

TECHNICAL, ENVIRONMENTAL & SOCIAL EFFICIENCY OF SPANISH AGRICULTURE

By

AMER AIT SIDHOUM

Under the supervision of

Thesis director: Dr. TERESA SERRA DEVESA

Tutor: Dr. JOSÉ MARÍA GIL

PhD Program: Sustainability

Main Subject: Agricultural Economics

TABLE OF CONTENTS

ABSTRACT

Firm-level efficiency measures have important implications for the assessment of their economic viability and sustainability. The evaluation of a firm's performance requires the use of an adequate methodological approach to derive efficiency estimates. Given the increasing importance of the environmental issue, several conventional efficiency analyses have been extended to allow deriving combined environmental and technical efficiency measures. More recently some studies have considered the role that production risk can play in assessment of the agricultural efficiencies.

While the literature has highlighted that the social sustainability is an issue of increasing concern to policymakers at national and international levels. And a number of studies have assessed firm's performance by including the social dimension; however the impact of social factors on the farms' efficiency has not been investigated so far. Our thesis will make a relevant contribution to the literature by assessing technical, environmental and social efficiency of Spanish farms. Furthermore, in our doctoral project we will consider the stochastic environment in which production takes place while measuring efficiencies. State-contingent techniques will be used as the theoretical and empirical tool to allow for risk issues.

To achieve our objectives, our study will be based on a survey to collect the necessary data. Information regarding economic, environmental and social data will be collected from 180 Catalan farms specialized in the production of cereal, oilseed and protein (COP) crops. Our research results will be useful to farm managers, policy makers and society at large.

1. MOTIVATION:

During the last century, agricultural production has increased significantly and this trend will continue. Since, according to a study (Tilman et al, 2001), which extrapolated into the future in terms of linear trends for the years 1960-2000 , has concluded that it will needs about one billion hectares of land more by 2050 to meet the increasing demand. However, if agriculture can be made more efficient, the amount of additional land and other inputs required could be much smaller. The increase in agricultural and food production has led to social benefits but also costs for farmers, societies and the environment too. These negative consequences can no longer be supported.

These adverse impacts have raised a lot of interest especially for the environment, where the impact of intensive agriculture can be quite deep, including emissions to air and water, the quality and the quantity of water surface and groundwater, soil erosion, pollution due to the widespread use of pesticides, and the loss of biodiversity and habitats.

In response to these concerns, governments and scientists have tried to address these concerns, the first ones by policies aimed at the introduction of alternative forms of agriculture (organic) and a shift in sustainable agriculture, is the case of the recent reforms of the CAP, which place special emphasis on the quality of agricultural products and food security (McSharry reform), and extended its political context to meet the growing demands of citizens, protect the environment (sustainable agriculture) and ensure product quality and food safety with the Fischler reforms in 2003.

On their side, the scientific community has tried to assess the external costs of this contemporary agriculture, but due to the heterogeneity of methods and data, it is not easy to drive conclusions. These costs mainly concerns the environmental aspect in particular damage caused by the application of pesticides, where runoff of agricultural pesticides from farm presents a significant source of drinking water pollution and involves costs for human health and causes damage to wildlife and ecosystem balance and biodiversity.

Sustainable agriculture does not depend only on the economic and environmental aspect; we should as well consider the social dimension. However, a feeling of oblivion and negligence turns around social sustainability, since it is the least developed compared

to the economic and environmental pillars ((Kunz, 2006; Littig and Griessler, 2005; Partridge, 2005 Cuthill, 2010).

Technical efficiency is directly related to the economic efficiency and traditional measures of efficiency at the firm-level analyze the various conventional inputs and outputs and tend to assess the ability of a company to maximize its production by fixing a set of inputs (Farrell, 1957). Recently, and due to the growing interest for the environment, and in order to improve the assessment of the overall performance of the firms, some of them have extended the approach of efficiency analysis by introducing the environment pollution in their assessment process.

It is important to note that many of the studies that deal with the evaluation of sustainability define their indicators at a global level, which can be quite useful for politicians to make agricultural and environmental policy, but are unhelpful when it comes to assessing unit management decisions. And many of those studies that assess firms performance including the three pillars of sustainability but only at an aggregate level, however none study has considered the three pillars of sustainability (Economic, Environmental and Social) at the microeconomic level. And none of them has explicitly considered the role that risk can play in the assessment of the efficiency. Considering everything that has been mentioned, the following general and specific objectives are proposed:

2. OBJECTIVES

The main objective of this project is to assess combined environmental, technical and social efficiency of Spanish farms by explicitly allowing for the stochastic nature of production. More specifically, this thesis aims at pursuing the following specific objectives:

1. Build a data set based on a survey at the firm that evaluates farm-level environmental, technical and social performance of Spanish farms. The survey will collect technical, environmental and social information and will be crucial for the achievement of our Ph.D. thesis project.

2. Assessing jointly the technical, environmental and social efficiency of Spanish farms. Efficiency measures will be derived for each farm in the sample. The interest to derive these measures lies in the fact that, contrary to global sustainability indicators, they are specifically related to farm management decisions.

3. On the basis on efficiency measurements, make recommendations regarding the possibility of reducing the environmental impact of agricultural activities.

4. Assist in the design of economic proposals to reduce pollution in the agricultural sector by estimating the private cost of damage abatement.

5. Contribute to the still incipient literature on efficiency by explicitly allowing for the stochastic conditions in which agricultural production takes place. While a number of articles on the issue of farm-level efficiency have been published, very few of them has allowed for the environmental impacts to depend on production risk and none one of them has included the social aspect in the assessment of efficiency. This latter objective will involve extension of previously defined technical, environmental and potentially social efficiency measures to allow for state-contingent techniques.

3. STATE OF THE ART

In the current situation of the global economy, where some countries are going through a rather difficult economic conditions marked by declining growth, more unemployment ... etc. A sustainable economy is emerging as the strategic solution for the sustainable development of the countries. It is in these circumstances that the competitiveness and efficiency analysis of organizations should be used as a means to improve the well-being of the societies. This applies also to the microeconomic level, where efficiency is associated with the concept of sustainability, where the entities are trying to use their economic resources in order to maximize production and profit while minimizing costs.

The assessment of firms' efficiency is a matter of greater research not only at the global level, even at the microeconomic level. Its important to note that in the last 30 years, many studies have investigated this topic in several fields. The investigation behind inefficient enterprises is essential to detect deficiencies and move toward a more efficient production.

In light of this problem, literature suggests to use frontiers instead of traditional analyzes that are based on the production functions. A production frontier shows the maximum attainable output given different input bundles and a technology (Kumbhakar and Lovell, 2000). Those firms operating on the frontier are considered as technically efficient, while those operating below the frontier are labeled as inefficient. From an economic perspective, technical efficiency as a combination of input–output, where it is not possible to increase any output (decrease input) without simultaneously increasing the input use (or decreasing another output), (Koopmans, 1951).

Distance and Directional distance functions have become increasingly popular as a measure of technical efficiency that simultaneously includes multiple outputs produced and multiple inputs used. Both concepts assess quantitatively the distance between the firm and the efficient frontier. The most common distance function used is Shephard's (1970) input (output) distance function, which measures the maximum amount of a firm input (output) vector that can be contracted (expanded) by setting an output (input) vector constant.

The Stochastic Frontier Analysis (SFA) is a parametric approach which was originally and independently proposed by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977) as pointed out by Battese and Coelli (1988). Efficiency measurement in SFA is based on the choice of a specific parametric functional form for the production frontier, as well as the specific distributional assumptions of the random noise and inefficiency error components. SFA empirical results are quite sensitive to parametric assumptions, modeling biases and a possibility of incorrect inferences.

In contrast to SFA, Data Envelopment Analysis (DEA) techniques, allow overcoming many of the SFA limitations. DEA was developed by Charnes et al. (1978) based on the work of Farrell (1957). This method has been used to estimate the efficiency in the organizational units in several areas (Cooper 1999). DEA is a non-parametric method to estimate efficiency, DEA permits to compares all firms to benchmark performance frontier, DEA does not impose any assumptions about functional form characterizing the underlying technology; hence avoids misspecification problems. DEA does not consider the statistical noise, and the efficiency estimates may be biased if the technology is largely characterized by stochastic elements, which means that all deviations from the frontier are assigned to inefficiency.

On the basis of the work of Luenberger (1992), Chung et al. (1997) defined the foundation to be able to present the joint production of desirable (Good) and undesirable (bad) outputs by extending the Shephard's output distance function (Shephard, 1970) to the directional output distance function. A directional output distance function expands (contracts) good (bad) outputs along a path that varies according to the direction vector adopted. Furthermore, the directional technology distance function recently introduced by Robert Chambers and his coauthors (Chambers et al, 1996a, 1996b and 1998) completely generalizes the Shephard's input and output distance functions providing an adequate tool to approach economic and environmental performance issues in an integrated fashion. The flexibility of this representation of the technology is a remarkable feature that enhances its usefulness in policy-oriented applications. (Picazo-Tadeo et al, 2005).

As the majority of the economic activities, the agricultural sector affects not only the environment but also the social life of the farmers. Basically, the environment is affected by the use of natural resources, some of which are non-renewable in order to

have good and bad outputs (pollution). A large number of studies in different regions and using different methodology have tried to assess the external costs (environmental) of agricultural sector (Pimentel et al., 1992 and 1995, Steiner et al., 1995, Fleischer and Waibel, 1998, Bailey et al., 1999, Stoate et al, 2001, Tegtmeier and Duffy, 2004, Pretty et al., 2005, Dale et al., 2007, Praneetvatakul et al., 2013). While the assessment of the social external costs of agriculture are quite rare, because the meaning and objectives of the social aspect within sustainability remains quite abstract (Dempsey et al, 2011;. & Casula Vifell Soneryd, 2012). Thin (2000) describe the social aspect as the most conceptually elusive pillar within sustainability. In addition the social dimensions of sustainability has not drained the same enthusiasm as the other two pillars (Cuthill, 2009; Vavik & Keitsch, 2010) and there is no agreement on what issues should be addressed (Dixon & Colantonio, 2008, Murphy, 2012).

Financial benefits have often been associated with an increase in technical efficiency, but what about the effect of the environmental and social efficiency on the firm's performance? Porter and Van Der Linde (1995) emphasize that environmental interests can stimulate innovation and efficiency and thus improve the competitiveness of firms. Which could encourage the implementation of a cleaner technologies, the hypothesis of Porter and Van Der Linde (1995) is supported by the empirical work of Murty and Kumar (2003), van der Vlist et al (2007) and Tamini et al. (2012). In contrast with this hypothesis, Palmer, Oates and Portney (1995) indicated that the imposition of stricter environmental regulations has no significant impact on competitiveness. Regarding the effect of the social aspect on firm's performance, some studies indicate that firms that invest in stakeholder engagement and management have a positive image in the community, enabling them to recruit and retain high quality employees. (Lado and Wilson, 1994 , Crook et al., 2011, Waddock, & Graves, 1997, Maditinos etal., 2011, Cerin and Reynisson, 2010, Humphrey et al., 2012). However Galema et al, (2008) and Soana (2011) find no statistically significant link that indicates any positive or negative relationship between Corporate Social Performance and Corporate Financial Performance.

The existing literature classifies the environmental efficiency into two groups; the first group consists of those measurements using deterministic methods, while the second group takes into account the stochastic nature of the environment where production takes place.

By including pollution as an undesirable output, Färe et al. (1989) attempted to assess environmental efficiency using conventional nonparametric data envelopment (DEA) methods. The strong disposability is verified when the undesirable outputs (heavy metals, CO_2) are freely disposable. While the weak disposability is verified when a reduction of pollution forces a lower production of desirable outputs, i.e. the production process is congested and abatement costs are positive. Färe et al. (1989) develop a hyperbolic efficiency measure that considers both outputs asymmetrically by expanding the desirable outputs while reducing the undesirable outputs. This "enhanced" efficiency measure is compared with the conventional efficiency where, setting the inputs constant, one expands desirable outputs and ignores pollution. The comparison of these two approaches shows that ignoring bad outputs involves misrepresentation of the efficiency magnitude. Using data from U.S. fossil-fuel-fired electric utilities Färe et al. (1996) decompose the overall factor productivity into a pollution index and an input-output efficiency index. They show that ignoring pollution leads to significant divergence in the rankings of the electric utilities. Along the same lines Färe et al. (2001) found that ignoring bad outputs leads to underestimate the annual productivity growth of US manufacturing sectors for the 1974-1986 period (on average, 1.7% vs. 3.6%). A number of studies has also focused on the agricultural sector, A literature review is presented below.

Piot-Lepetit and Vermersch (1998) measure technical and environmental efficiency of the French pig sector by considering organic nitrogen pollution as weakly disposable output. Also, by using duality, a shadow price of nitrogen pollution is derived. Using DEA techniques, The results indicate a limited ability to reduce nitrogen pollution for given output levels.

De Koeijer et al., (2002) present a conceptual model for quantifying sustainability on the basis of efficiency theory. The conceptual model is implemented using DEA approach where pollution is considered as an input. Polluting inputs are assumed to be strongly disposable, which implies that environmental improvement can be achieved without private costs. Sustainability is measured for a sample of Dutch sugar beet growers. The results show that the average technical efficiency was only 50%, which leads to a considerable margin of progress of the sustainability and that without new technology and by avoiding the conflict between the economic and environmental objectives.

Asmild and Hougaard (2006) suggest a two-step DEA analysis to estimate both the technical and environmental efficiency of a sample of Danish pig farms. They propose to disaggregate nutrient surpluses into in-flows and out-flows, which means that the environmental factors can be incorporated in DEA as inputs and outputs. . The main empirical findings are considerable inefficiencies; especially at the environmental level. The authors indicate that, it would be pertinent to focus in particular on the environmental aspect, seeing that, half of the farms are inefficient with average efficiency scores of 34–56%.

Coelli et al, (2007) propose a new method of measuring the environmental efficiency of firms that involves the incorporation of the materials balance concept into the production model, this leads to a new environmental efficiency measure that can be decomposed into technical and allocative components. The approach is examined with the case of phosphorus emission on Belgian pig-finishing farms, using data envelopment analysis (DEA) methods. The results show that an important part of the nutrient pollution in these farms can be abated in a cost reducing manner.

Vlontzos et al., (2014) attempted to evaluate the energy and environmental efficiency of the agricultural sector of the EU member state countries a non-radial Data Envelopment Analysis (DEA) during the period 2001-2008. The results show that countries like Germany, Sweden, and Austria, with strong environmental standards, seem to be less energy and environmentally efficient compared to countries such as Denmark, Belgium, Spain, France and Ireland.

Aldanondo-Ochoa et al., (2014) applied the environmental efficiency model to the analysis of different technologies and calculated productivity and efficiency with and without environmental impacts. Using Data Envelopment Analysis (DEA) and bootstrap techniques to detect and measure differences between organic and conventional agriculture aggregate efficiency and productivity in a sample of vineyard farms operating in semiarid, non-irrigated conditions in Navarre (Spain), taking into account the indicators; farms' nitrogen surplus and pesticide toxicity. The results suggest that organic production systems are environmentally more efficient than conventional systems by achieving higher output for the same degree of environmental impact and quantity of inputs.

Toma et al., (2013) attempted to compare the environmental efficiency of 2 divergent strains of Holstein-Friesian cows across 2 contrasting dairy management

systems (grazing and nongrazing). Using two DEA models: the undesirable outputoriented model (UO) and the normalized undesirable output-oriented (NUO) model. Each model type had 2 versions, one with 2 types of pollutants (greenhouse gas emissions, nitrogen surplus) and the other 3 (greenhouse gas emissions, nitrogen surplus, and phosphorus surplus). The results show significant differences between efficiency scores among the two systems. They also indicate that inputs have an important role in the measurement of environmental efficiency of dairy systems.

Applying some approaches based on the non-parametric Data Envelopment Analysis (DEA) method, Shortall et al., (2013) analyzed the link between the technical and environmental efficiency of dairy farms in Scotland with regarding the greenhouse gas emissions. They find that the bigger farms which are more technically efficient, are more efficient in their emissions of GHG emissions.

Regarding the social efficiency, and /or the involvement of social factors in efficiency measures at the farm-level has not been investigated so far. Actually the requirement is more for the development of a better understanding of the social aspects of sustainability, which has received much less interest than the other two pillars of sustainability (Cuthill, 2009; Vavik & Keitsch, 2010) and to highlight the most relevant indicators for the assessment of the social efficiency.

Several studies have aimed to develop social indicators at farm-level (Weber et al. 2012). A common characteristic to these analyses is that each one has developed its own indicators which depend on the specific issues of the study (Omann and Spangenberg, 2002). While a generalization is difficult to make. Three main types of social sustainability indicators can be distinguished. First, some scientists assess social sustainability through measures of farm labor health, demography or income. Others consider qualitative parameters such as wellbeing perceived, cultural vitality and democratic decision-making. A third group of indicators includes social power, political-economic structure and inequality. Below, we will present a few studies that have attempted to bring out some social sustainability indicators at the farm level.

Shreck et al, 2006, assess the social sustainability of organic farmers in California. The used questionnaire includes questions about farming activities, the process of hiring and employment, the farmers view on sustainability, and their demographic characteristics. A Likert scale (agree / disagree) is used to measure the responses of farmers. The results claim that to have a social justice while empowering

12

workers and by creating favorable production conditions, it is imperative to think about a change in the food system as a whole. Allen et al., 1991 also had results along the same lines.

Gafsi et al, 2006 investigated the effectiveness of the Territorial Farming Contract (TFC) (derived from the Farming Orientation Law of July 1999) for the implementation of sustainable agriculture in France. A combination of two approaches have been used, quantitative and qualitative. The first one is an analysis of more than 3000 TFC signed at the Midi-Pyrenees region, the rate of signed contracts, the characteristics of farmers and their farms are among the parameters that were taken into account in the assessment of TFC. An analysis of the effects of the TFC was done using a qualitative approach on a sample of 66 farms. The social aspect of sustainability is measured by considering two types of indicators. Inside the farm indicators: work and well-being and health of farmers and their families. Outside the farm: the farm's commitment to local relationships and local social networks. TFC aims to address the first level, but the effect is more in maintaining jobs and improving labor conditions, whereas there there's been virtually no job creation. The second level of the social aspect has not received.

Agricultural workers face numerous risks, in the existing literature; pesticide exposure appears to be the most relevant hazard. While consumers deal more with chemical residues of pesticides, agricultural workers are directly exposed to the pesticide hazards during the application. (Ridley, 2010). Even though, some procedures have been implemented to reduce the risk on farm workers health such as the US Environmental Protection Agency's Worker Protection Standard for Agricultural Pesticides (EPA, 1992), more studies are needed to ensure sustainable social development for agricultural workers (Notarnicola et al, 2012).

In a study that assesses the economic, environmental and socio-institutional aspect of the major cropping systems in the North China Plain, Zhen et al, 2005 indicated that about 20% of farmers reported headache problems, dizziness, nausea , upset stomach, rash and fatigue caused in particular by the use of pesticides. This increases the frequency of visits to the doctor during farming seasons, relative to non-farming seasons.

Strochlic et al, 2008, evaluate the working conditions in organic farms in California. While organic farmers do not suffer from the impact of synthetic pesticides, the toxicity related to organic pesticides should not be ignored. Strochlic et al, 2008 also identified other types of hazards that are often ignored by the literature, ie, musculoskeletal injuries associated with repetitive stress, stoop labor and heavy lifting, and injuries from vehicles, heavy machinery, or falls from ladders. Dependence on manual weeding in organic farming may also increase the risk of musculoskeletal injuries related to the stoop labor. Their findings suggest low rates of accidents and injuries when farms apply certain occupational safety and health (OSH) practices.

Myers_et_al, 2009 focused on fatal and non-fatal injuries suffered by US farmers and farm workers. They indicate that older farmers and farm workers have a risk of harm below the risk faced by workers less than 55 years of age, however fatalities rates for older farmers and farm workers were over 2.5 times that of the younger age group.

Fielke and Bardsley, 2014 assess the relevancy of education in the agricultural sector in the South of Australia as a tool to maximize the beneficial outcomes. Using a Likert scale of 5, they cross the variable level of education with some items belonging to the following concepts: agricultural land use priorities, perceptions of personal and community future outcomes, perceptions of future risks to their agri-business. The results suggest the positive role of formal education, especially university education in the progress of sustainability. They also find that a higher level of education leads farmers to prioritize the socio-environmental outcomes in their agricultural practices.

Regarding the involvement of social factors in efficiency measures, Urdiales et al., (2015) constitute the unique exception. Urdiales et al., (2015) used data envelopment analysis to assess the eco-efficiency for a sample of dairy farms in northern Spain. Noteworthy that the OECD defined eco-efficiency as " the efficiency with which ecological resources are used to meet human needs" (OECD 1998). The authors used information on nutrients balances and greenhouse gas emissions to calculate environmental pollution. They found that dairy farms are highly eco-inefficient. While, some of the results suggest that farmers that are younger, that plan to continue in operation in the foreseeable future and that participate more in training programs are found to be more eco-efficient.

The literature review presented above provides evidence that further research needs to be done regarding the extension of conventional technical efficiency measures to a consideration of environmental issues and particularly social matters. It is also evident that studies focusing on the efficiency analysis of Spanish farms are very scarce, which offers scope for further research.

The impact of the uncertainty in agricultural production decisions has been addressed widely in the literature in both proposing theoretical modeling and empirical assessments and investigations. As a result of unpredictable weather conditions, pest infestations, unstable markets, etc., stochastic effects have been of special interest in agriculture (Chavas and Holt, 1996; Moschini and Hennessy, 2001). A range of different techniques have been developed to model risk and risk preferences. A priori probability assessments have usually served as risk assessment tools, which are known to lead to potentially serious biases (Camerer, 1995). Risk preferences have been generally measured within the expected utility model (Saha et al., 1994) which has also been questioned as a useful tool to adequately represent economic agents' risk attitudes (see Rabin, 2000; Just and Peterson, 2003). Pope and Chavas (1994) demonstrate that cost minimization cannot be adequately characterized by expected output alone under risk aversion, because the role of risk management in input use can be relevant.

Chambers and Quiggin (1998 and 2000) propose an alternative for the modeling of preference selection under uncertainty by representing the stochastic technology using a state-contingent input correspondence and they show that under a state-contingent approach a standard cost minimization problem applies irrespective of risk preferences.

The state-contingent approach proposed by Chambers and Quiggin (1998 and 2000) and built upon the theory developed by Debreu (1959) and Arrow (1965), is based on the assumption that production under uncertainty can be represented by differentiating outputs and potentially inputs according to the state of nature in which they are realized. The advantage of this technique compared to other methods is the fact that it was developed for a deterministic assessment and could be applied to decision-making under uncertainty. Chambers and Quiggin (2000) show that the duality methods of modern production theory are fully applicable to state-contingent production and conclude that "the state-contingent approach provides the best way to think about all

15

problems involving uncertainty, including problems of consumer choice, the theory of the firm, and principal-agent relationships"

However, empirical application of state-contingent approach in a production theory is not obvious to perform, as the efforts focus more on the collection of ex-post production data while the ex-ante measures are usually unavailable.

This problem is present in most of the methods that address modeling of stochastic production and is described by O'Donnell, Chambers, and Quiggin (2010) as an output-cubical technology. Where, when the producers choose a scalar input level, along with a stochastic act of nature, determines output in every state of nature. Therefore, the observation of an output that results from an identifiable state of the nature is sufficient to determine the selected input and output that would have been realized in any other state of nature. However, if the restrictive assumption is not satisfied, it has been shown that this technique potentially leads to important biases in efficiency estimates(O'Donnell et al., 2010). In our work, we will apply the state-contingent approach fairly easily since our survey enables us to collect information on ex-ante state- contingent outputs.

Despite the relevance of this technique in stochastic production modeling, the state-contingent technology has seen few empirical applications. For example, Chavas (2008) develops an approach to specify and estimate cost-minimizing input decisions under a state-contingent technology. O'Donnell and Griffiths (2006) use a Bayesian finite mixtures approach to estimate a state-contingent production frontier. Their results for Philippine rice farmers demonstrate that different technical efficiency estimates are obtained if a state-contingent framework is used instead of a standard estimation approaches. These results go along the same lines with O'Donnell et al. (2010) who show that the application of standard methods of efficiency analysis to data arising from production under uncertainty may produce inaccurate efficiency measure. Based on the theoretical approach of O'Donnell et al. (2010), Nauges et al. (2011) analyse production under uncertainty and inefficiency without considering the nature of producer risk preferences using Finnish farm data. Uncertainty is characterized by three states of nature, defined in terms of climatic conditions: favorable states for wheat, barley and oats. They found that technical efficiency achieves 0.63 and the efficiency level drops when conditions are less favorable. Recently, Serra et al. (2014) propose state-contingent approach to measure technical and environmental efficiency for a sample of

Catalan arable crop farms. They found that technical efficiency has a tendency to slightly decrease in the case of the bad nature condition, while nitrogen pollution can decrease significantly under good growing conditions.

Farmers decisions making affect directly the efficiency of their farms, but these decisions may have an impact beyond the farm, it is for this reason that governments may be interested in what happens inside the farm. In addition to the economic influences and the environmental interests, literature has highlighted the importance of the social dimension in the decisions-making of farmers in their agricultural activities. As noted above, except Urdiales et al., 2015 who attempted to explain the score of eco-efficiency according to certain socioeconomic characteristics and some farmers' attitudes by considering some Spanish dairy farms. However, the impact of the social dimension in the agricultural efficiency has not been investigated so far.

In addition to the measurement of technical and environmental efficiency in a state-contingent framework, this work will assess the social efficiency by considering several social factors; socio-demographic characteristic of the farmers, farmers' perceptions of the impact of farming activities on their mental and physical health, structure of the farm business and social externalities of agricultural activities.

4. METHODOLOGY

Ignoring the effect of uncertainty in the agricultural sector may lead to biased estimates of efficiency ((e.g., Chen and Van Dalen 2010), to avoid this, recently the traditional measures of efficiency have integrated stochastic effect in the assessment of the agricultural efficiency.

As already indicated above, our work consists in the assessment of technical, environmental and social efficiency, using State-contingent approach by allowing the effect of uncertainty in the production following the works of Chambers and Quiggin (1996, 1997 and 2000).

Consider a firm that uses a vector of inputs $x = (x_1, \dots, x_n) \in \mathbb{R}_+^N$ to produce an (y) output. Uncertainty is represented by a set of states of nature $\Omega = \{1, 2, \dots, S\}$, hence , there exists a state-contingent output set that gives the range of output values once

$x = (x_1, \ldots, x_n) \in \mathbb{R}_+^N$ is committed. By considering the state-contingent framework, production activities thus take place over two periods of time: in period 0 the producer chooses the quantity of non-stochastic input to use; in period 1 Nature chooses a particular state of Nature that determines the realized output. If Nature picks a state S , then the realized output can be denoted by (y_s) . The state-contingent framework is flexible in that it allows for perfect substitution between stochastic outputs, no substitution and intermediate substitution possibilities.

The feasible production set under the state-contingent approach T, can be derived as follows

$$T = \{(\boldsymbol{x}, \boldsymbol{y}) : \boldsymbol{x} \text{ can produce } (\boldsymbol{y}); \ \boldsymbol{x} \in \mathbb{R}_+^N, \boldsymbol{y} \in \mathbb{R}_+^S \quad (1)$$

where $y = (y_1, \ldots, y_s) \in \mathbb{R}_+^S$ is a vector of state-contingent output levels, y_s being the quantity of output realized under the sth state of nature. T is interpreted as an ex-ante technology.

Increasing the output vector size under the state-contingent framework may indicate problems of dimensionality which is especially relevant for the SFA approach, in addition to this, the number of parameters to estimate increases substantially. Further, as shown by Chavas (2008), the use of state-contingent techniques jointly with parametric efficiency estimation methods can be problematic as ex-ante state-contingent outputs tend to be highly correlated with each other, which leads to potential multicollinearity issues that become particularly relevant in econometric model estimation when the number of state-dependent variables is larger than 2.

In contrast to SFA, Data Envelopment Analysis (DEA) techniques, which allows for efficiency measurement of multiple inputs and outputs without assigning weights and specifying any function form, which reduces the risk of misspecification issues that may lead to biased efficiency estimates.

Following Färe et al. (1994), the DEA linear programming model to assess input-oriented version can be expressed as:

$$\min_{\lambda, \theta} \theta$$

$$s.t.$$

$$-\boldsymbol{y}_i + \boldsymbol{Y}\lambda \geq 0$$

$$\theta \boldsymbol{x}_i - \boldsymbol{X}\lambda \geq 0$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

Where N represents the number of farms. The constraint $N1'\lambda = 1$ is included to allow for variable returns to scale.

4.1 DATA

Our analysis will be based on cross sectional, farm-level data collected from a sample of 180 Spanish holdings specialized in the production of cereal, oilseed and protein (COP) crops. As will be explained with more detail below, the analysis will focus on the COP sector given the important use that this sector makes of Spanish arable land.

The information will be collected in two stages; first, we will collect detailed information from each farm on planned input use, in addition to information's on physical, structural, economic, environmental and social data of the farms will also be collected. Special care will be taken when collecting data on ex-ante outputs for three alternative states of nature: bad, normal and ideal growing conditions $y = (y_1, y_2, y_3)$. This stage started during the planting season (Octobre 2015). Secondly, ex-post data on production will be collected during the harvesting season (summer 2016).

Our analysis will focus on farms specialized in cereal, oilseed and protein (COP) crops. COP crops, that are mainly devoted to human consumption and animal feed, can be cultivated on the same type of land and require similar equipment. In the year 2013, the COP sector with a production value of nearly 5 billion euros which represents almost 20% of the total vegetable production in Spain (Spanish Ministry of Agriculture, Food and Environment, magrama, 2014).

The cop sector represents more than 120,000 farm holdings which represents 13% of total Spanish agricultural holdings (INE, 2009). The cereal, oilseed and protein crops represent the highest proportion of the utilized agricultural area (UAA) in Spain. UAA

in Spain totaled 23.3 million hectares in 2013 (INE, 2013) of which 32% were being devoted to COP crops.

According to EU's FADN (2010) database, Spanish COP farms cultivated, on average, 74.2 hectares in 2007, which substantially above the Spanish average farm size of 29.2 hectares. Labor use was 0.96 annual working units (AWU) per COP farm, being the average for the Spanish agricultural sector equal to 1.36 AWUs. COP farm's total output (gross farm income) was 44,094 (39,186) euros, being the sector average 42,846 (30,852) euros.

Our questionnaire (See Appendix 1) allows us to focus on the estimation of nitrogen pollution, two main methods are identified; the farm-gate balance and the soil surface balance. Due to the financial constraints of the second approach, in our study we opt for the farm-gate balance, which allow us to consider the nutrients imported through inputs and the nutrients exported. Under this method, two input sources are considered: nitrogen applied through fertilizers and seeds. The nitrogen output source is crop-nitrogen removal. The estimation of nitrogen content will be based on coefficients facilitated by some research conducted by the Spanish Ministry of Agriculture (2005) and Mercadé, Delgado, and Gil (2012).

The questionnaire also allows us focus on pesticide emissions since it includes very detailed questions on the application of herbicides, fungicides and insecticides, including the chemical formula and the applied doses. This allows us to estimate of the quantity of the active substance used during the phytosanitary application. Since the different active ingredients do not have the same environmental effects, a weighting procedure based on Acceptable Daily Intake (ADI) will be used to approximate contamination caused by pesticides.

The last part of the questionnaire will allow us to examine the social dimension within the farm, in addition to the farmers' socio-economic factors, the questionnaire also includes; working hours per year, the number of vacation days and the number of accidents linked to agricultural activities. The survey will also allow us to investigate the perception of farmers who will judge forty statements on a Likert scale of 4. These statements are related to; working conditions in the farm, the impact of faming activities on the farmers' health and social externalities associated with farming activities.

5. WORK PLAN

The thesis will be carried out in 36 months and the tasks that will be developed during this period are described below:

First year:

1. Literature review. During this first year a thorough review of the literature was conducted, both on theoretical and econometric approach related to the analysis of technical, environmental and social efficiency. This review has allowed me to become more familiar with the innovative literature in this field, but also was a basis for the second stage of this first year, which is the questionnaire design.

2. Survey design and data collection. During this first year we are collecting farm-level data which will be the basis to achieve my Ph.D. thesis objectives. The field work was launched in October 2015 during the planting seasons. Data collection will take around four months.

Second year:

1. Survey data will be recorded in electronic format.

2. Data inconsistency check. The data will be checked for inconsistencies and in case inconsistencies and errors are detected, farmers will be contacted again to avoid losing observations.

3. Descriptive analysis. A descriptive analysis of the data will be carried out which will guide us through the remaining tasks of the project.

4. Definition and specification of the theoretical and empirical efficiency models to estimate.

Third year:

1. Estimation of the efficiency models.

2. Derivation of implications for farm managers, policy makers and society.

3. Writing up of research results.

Overview of the Work plan																																				
Task description	Months																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Literature review	■	■	■	■	■	■	■	■	■	■	■	■																								
Survey design and data collection	■	■	■	■	■	■	■	■	■	■	■	■	▨																							
Introduction of data in electronic records													■	■	■	■	■	■																		
Data inconsistency check																	■	■	■	■																
Descriptive analysis																			■	■	■	■														
Model specification																							■	■	■											
Model estimation																										■	■	■	■	■	■					
Derivation of policy implications																																■	■	■	■	■
Research results write up																																■	■	■	■	■

6. EXPECTED CONTRIBUTIONS

Since our research will be based upon survey data, the first results will not be obtained until the second half of the second year, where a descriptive analysis of collected data will be elaborated. The most relevant results, however, will not be obtained until the third year.

Regarding scientific paper production, we expect to elaborate three articles:

First scientific paper. This paper will focus on assessing the difference between efficiency measures derived by using conventional efficiency DEA analyses and the implementation of DEA techniques within a state-contingent framework.

Second scientific paper. This paper will be elaborated in parallel with the first one and its aim will be to compare the efficiency estimators derived through the stochastic frontier analysis with or without the use of state-contingent techniques.

Third scientific paper. This paper will focus on the derivation of the combined technical, environmental and social efficiency measures for the sample farms.

We expect that with this thesis we will make the following contributions:

- Contributions to the development of the efficiency measures at farm-level which has not received much attention.

- Development of social sustainability indicators at the farm level.

- Identification of social reasons for the technical and environmental inefficiency.

- Our project will help designing mechanisms to reduce the environmental impact of agricultural production.

- Identification of the inefficiencies in the use of environmentally detrimental inputs.

- Contribution to the design of environmental policies, especially those based on economic incentives

- Improve the understanding on how a change in production risk levels may affect the variation of the pollution levels.

- Participation in national and international seminars and congress.

- The articles will be submitted to indexed journals.

REFERENCES

Aigner, D., Lovell, C. K., and Schmidt, P., 1977. Formulation and estimation of stochastic frontier production function models. journal of Econometrics, 6: 21-37.

Aldanondo-Ochoa, A. M., Casasnovas-Oliva, V. L., and Arandia-Miura, A., 2014. Environmental efficiency and the impact of regulation in dryland organic vine production. Land Use Policy, 36: 275-284.

Allen, P., D. Van Dusen, Lundy, J. and Gliessman, S., 1991. Integrating social, environmental, and economic issues in sustainable agriculture.'' American Journal of Alternative Agriculture, 6: 34–39.

Arrow, K., 1965. Aspects of the Theory of Risk Bearing. Helsinki: Yrjo Jahnsson Saatio.

Asmild, M., and Hougaard, J. L., 2006. Economic versus environmental improvement potentials of Danish pig farms. Agricultural Economics, 35: 171-181.

Bailey, A. P., Rehman, T., Park, J., Keatinge, J. D. H., and Tranter, R. B., 1999. Towards a method for the economic evaluation of environmental indicators for UK integrated arable farming systems. Agriculture, ecosystems & environment,72: 145-158.

Battese, G. E., and Coelli, T. J., 1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. Journal of econometrics, 38: 387-399.

Camerer, C., 1995. Individual decision making. In J. H. Hagel and A. E. Roth (eds.), The Handbook of Experimental Economics. Princeton, NJ: Princeton University Press, 587-703.

Casula Vifell, A. and Soneryd, L., 2012. Organizing matters: how "the social dimension" gets lost in sustainability projects. Sustainable Development 20:18–27.

Chambers, R. G., and Quiggin, J., 1996. Nonpoint-source pollution control as a multi-task principal-agent problem. Journal of Public Economics 59: 95-116.

Chambers, R. G., and Quiggin, J., 1997. Separation and hedging results with state-contingent production. Economica 64: 187-209.

Chambers, R. G., and Quiggin, J., 1998. Cost functions and duality for stochastic technologies. American Journal of Agricultural Economics 80: 288-295.

Chambers, R. G., and Quiggin, J., 2000. Uncertainty, Production, Choice, and Agency. Cambridge: Cambridge University Press.

Chambers, R.G., Chung, Y., and Färe, R., 1996a. Benefit and distance functions. Journal of Economic Theory 70: 407-419.

Chambers, R.G., Chung, Y., and Färe, R., 1998. Profit, directional distance functions, and nerlovian efficiency. Journal of Optimization Theory and Applications 98(2): 351-364.

Chambers, R.g., Färe, R., and Grosskopf, S., 1996b. Productivity growth in APEC countries. Pacific Economic Review 1:3, 181-190.

Charnes, A., Cooper, W. W., and Rhodes, E., 1978. Measuring the efficiency of decision making units. European journal of operational research, 2: 429-444.

Chavas, J. P., 2008. A cost approach to economic analysis under state-contingent production uncertainty. American Journal of Agricultural Economics 90: 435-446.

Chavas, J. P., and Holt, M. T., 1996. Economic behavior under uncertainty: A joint analysis of risk preferences and technology. The Review of Economics and Statistics 78: 329-335.

Chen, C.-M. and Van Dalen, J., 2010. Measuring efficiency in dynamic production: theories and an integrated methodology. European Journal of Operational Research 203: 749–760.

Chung, Y. H., Färe, R., and Grosskopf, S. (1997). Productivity and undesirable outputs: a directional distance function approach. journal of Environmental Management, 51: 229-240.

Coelli, T., Lauwers, L., and Van Huylenbroeck, G., 2007. Environmental efficiency measurement and the materials balance condition. Journal of Productivity Analysis, 28: 3-12.

Cooper, W. W., 1999. Operational research/management science: Where it's been. Where it should be going?. Journal of the Operational Research Society, 3-11.

Cuthill M., 2009. Strengthening the social in sustainable development: developing a conceptual framework for social sustainability in a rapid urban growth region in Australia. Sustainable Development 18: 362–373

Cuthill, M., 2010. Strengthening the 'social'in sustainable development: Developing a conceptual framework for social sustainability in a rapid urban growth region in Australia. Sustainable Development, 18: 362-373.

Dale, V. H., and Polasky, S., 2007. Measures of the effects of agricultural practices on ecosystem services. Ecological economics, 64: 286-296.

De Koeijer, T. J., Wossink, G. A. A., Struik, P. C., and Renkema, J. A., 2002. Measuring agricultural sustainability in terms of efficiency: the case of Dutch sugar beet growers. Journal of environmental management, 66: 9-17.

Debreu, G. 1959. Theory of Value. Cowles Foundation Monograph 17. New Haven, CT: Yale University Press.

Dempsey, N., Bramley, G., Powers, S., and Brown, C. 2011. The social dimension of sustainable development: defining urban social sustainability. Sustainable Development 19: 289– 300.

Dixon, T. and Colantonio, A. 2008. Submission to EIB Consultation on the Draft EIB Statement of Environmental and Social Principles and Standards. Oxford: Oxford Institute for Sustainable Development.

EPA, 1992. Worker Protection Standard (WPS). Part 156e170. Federal Register, 40 CFR. US Environmental Protection Agency.

FADN, 2010. Farm Accountancy Data Network. Public Database. http://ec.europa.eu/agriculture/rica/database/report_en.cfm

Färe, R., Grosskopf, S. and Lovell, C.A.K., 1994. Production frontiers. New York, NY: Cambridge University Press.

Färe, R., Grosskopf, S., and Pasurka Jr, C. A., 2001. Accounting for air pollution emissions in measures of state manufacturing productivity growth. Journal of Regional Science, 41: 381-409.

Färe, R., Grosskopf, S., and Tyteca, D., 1996. An activity analysis model of the environmental performance of firms—application to fossil-fuel-fired electric utilities. Ecological economics, 18: 161-175.

Farrell, M.J., 1957. The measurement of productive efficiency. Journal of the Royal Statistical Society, Series A, CXX, Part 3: 253-290.

Fielke, S., J. and Bardsley D., K. 2014. The importance of farmer education in South Australia. Land Use Policy, 39: 301–312.

Fleischer, G., and Waibel, H., 1998. Externalities by pesticide use in Germany. InExpert Meeting.

Gafsi, M., Legagneux, B., Nguyen, G., and Robin, P., 2006. Towards sustainable farming systems: Effectiveness and deficiency of the French procedure of sustainable agriculture. Agricultural Systems, 90: 226–242.

Grassini, P., Eskridge, K. M., and Cassman, K. G., 2013. Distinguishing between yield advances and yield plateaus in historical crop production trends. Nature Communications, 4.

INE, 2009. Censo Agrario 2009. http://www.ine.es/CA/Inicio.do

INE, 2013. Encuesta sobre la estructura de las explotaciones agrícolas 2013. http://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254 736176854&menu=ultiDatos&idp=1254735727106

Just, D. R., and Peterson, H. H., 2003. Diminishing marginal utility of wealth and calibration of risk in agriculture. American Journal of Agricultural Economics 85: 1234-1241.

Koopmans, T.C. 1951. An analysis of production as an efficient combination of activities. In: T.C. Koopmand, ed., Activity analysis of Production and Allocation. Cowles Commission for Research in Economics Monograph no 13. New York: Wiley.

Kumbhakar, S.C., and Lovell, C. A. 2000. Stochastic Frontier Analysis. Cambridge: Cambridge University Press

Kunz J. 2006. Social Sustainability and Community Involvement in Urban Planning. University of Tampere: Tampere, Finland.

Littig B, and Grießler E. 2005. Social sustainability: a catchword between political pragmatism and social theory. International Journal of Sustainable Development 8: 65–79.

Luenberger, D. G., 1992. Benefit functions and duality. Journal of mathematical economics, 21:461-481.

Meeusen, W., and Van den Broeck, J., 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. International economic review, 435-444.

Mercadé, L., Delgado, M., and Gil, J. M., 2012. Pràctiques de fertilització a Catalunya. Enquesta 2010. Generalitat de Catalunya: Departament d'Agricultura, Alimentació i Acció Rural. http://agricultura.gencat.cat/web/.content/de_departament/de02_estadistiques_ob servatoris/24_estudis_i_documents/03_documents_de_treball/arxius_estatics/dt0 13_2011.pdf

Moschini, G., and Hennessy, D., 2001. Uncertainty, risk aversion, and risk management for agricultural producers. In B. L. Gardner and C. G. Rausser (eds.), Handbook of Agricultural Economics, volume 1A. Amsterdam: Elsevier, 88-153

Murphy, K., 2012. The social pillar of sustainable development: a literature review and framework for policy analysis. Sustainability: Science, Practice, & Policy, 8(1), 15-29.

Murty, M. N. and Kumar, S., 2003. Win-win Opportunity and Environmental Regulation: Testing of Porter Hypothesis for Indian Manufacturing Industries. Journal of Environmental Management 67: 139-144.

Myers, J. R., Layne, L. A., and Marsh, S. M., 2009. Injuries and fatalities to US farmers and farm workers 55 years and older. American journal of industrial medicine, 52: 185-194.

Nauges, C., O'Donnell, C. J., and Quiggin, J., 2011. Uncertainty and technical efficiency in Finnish agriculture: a state-contingent approach. European Review of Agricultural Economics, jbr014.

Notarnicola, B., Hayashi K., Curran, M., A., and Huisingh, D., 2012. Progress in working towards a more sustainable agri-food industry. Journal of Cleaner Production, 28, 1-8.

O'Donell, C.J., Chambers, R.G., and Quiggin, J., 2010. Efficiency analysis in the presence of uncertainty. Journal of Productivity Analysis 33:1-17.

O'Donnell, C. J., and Griffiths, W. E., 2006. Estimating state-contingent production frontiers. American Journal of Agricultural Economics 88: 249-266.

OECD, 1998. Eco-Efficiency. Organization for Economic Co-operation and Development, OECD, Paris

Omann, I. and Spangenberg, J. 2002. Assessing Social Sustainability: The Social Dimension of Sustainability in a Socio-Economic Scenario. Seventh Biennial Conference of the International Society for Ecological Economics. March 6–9, Sousse, Tunisia.

Palmer, K., Oates, W.E., and Portney, P.R., 1995. Tightening Environmental Standards: The Benefit-Cost or no Cost Paradigm. Journal of Economic Perspective 9: 119-132.

Partridge E., 2005. Social Sustainability: a Useful Theoretical Framework, paper presented to the Australasian Political Science Association Annual Conference, Dunedin, New Zealand.

Picazo-Tadeo, A. J., Reig-Martinez, E., and Hernandez-Sancho, F., 2005. Directional distance functions and environmental regulation. Resource and Energy Economics, 27: 131-142.

Pimentel, D., Acquay, H., Biltonen, M., Rice, P., Silva, M., Nelson, J., and D'amore, M., 1992. Environmental and economic costs of pesticide use.BioScience, 750-760.

Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., and Blair, R., 1995. Environmental and economic costs of soil erosion and conservation benefits. Science-AAAS-Weekly Paper Edition, 267: 1117-1122.

Piot-Lepetit, I., and Vermersch, D., 1998. Pricing organic nitrogen under the weak disposability assumption: an application to the French pig sector. Journal of Agricultural Economics, 49: 85-99.

Pope, R. D. and Chavas, J. P., 1994. Cost functions under production uncertainty. American Journal of Agricultural Economics 76: 114-127.

Porter, M. and Van der Linde, C., 1995. Green and Competitive: Ending the stalemate. Harvard Business Review 73: 120-137.

Praneetvatakul, S., Schreinemachers, P., Pananurak, P., and Tipraqsa, P., 2013. Pesticides, external costs and policy options for Thai agriculture.Environmental Science & Policy, 27, 103-113.

Pretty, J. N., Ball, A. S., Lang, T., and Morison, J. I., 2005. Farm costs and food miles: An assessment of the full cost of the UK weekly food basket. Food Policy, 30: 1-19.

Rabin, M., 2000. Diminishing marginal utility of wealth cannot expain risk aversion. In D. Kahneman and A. Tversky (eds.), Choices, Values, and Frames. New York, NY: Cambridge University Press, 202-208.

Ridley, K., 2010. Farm Workers Suffer the Most from Pesticide Exposure. Sustainable Food. Published on-line June 24, 2010.

Saha, A., Shumway, C. R., and Talpaz, H., 1994. Joint estimation of risk preference structure and technology using expo-power utility. American Journal of Agricultural Economics 76: 173-184.

Serra, T., Chambers, R. G., and Lansink, A. O., 2014. Measuring technical and environmental efficiency in a state-contingent technology. European Journal of Operational Research, 236: 706-717.

Shephard. R.W., 1970. Theory of Cost and Production Functions. Princeton University Press, Princeton (1970)

Shortall, O. K., and Barnes, A. P., 2013. Greenhouse gas emissions and the technical efficiency of dairy farmers. Ecological Indicators, 29: 478-488.

Shreck, A., Getz, C. and Feenstra, G., 2006. Social sustainability, farm labor, and organic agriculture: Findings from an exploratory analysis. Agriculture and Human Values, 23:439–449.

Spanish Ministry of Agriculture, Food and Environment, magrama, 2005. Balance del nitrógeno en la agricultura española. http://www.ruena.csic.es/pdf/Metodologia%20balance%20N.pdf

Spanish Ministry of Agriculture, Food and Environment, magrama, 2014. http://www.magrama.gob.es/es/estadistica/temas/estadisticas-agrarias/agricultura/default.aspx

Steiner, R. A., McLaughlin, L., Faeth, P., Janke, R. R., Barnett, V., Payne, R., and Steiner, R., 1995. Incorporating externality costs into productivity measures: a case study using US agriculture. Agricultural sustainability: economic, environmental and statistical considerations., 209-230.

Stoate, C., Boatman, N. D., Borralho, R. J., Carvalho, C. R., De Snoo, G. R., and Eden, P., 2001. Ecological impacts of arable intensification in Europe. Journal of environmental management, 63: 337-365.

Strochlic, R., Wirth, C., Besada, A. F., and Getz, C., 2008. Farm labor conditions on organic farms in California. California Institute for Rural Studies (June 2008).

Tamini, L. D., Larue, B., and West, G. 2012. Technical and environmental efficiencies and best management practices in agriculture. Applied Economics 44, 1659-1672.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., ... and Swackhamer, D., 2001. Forecasting agriculturally driven global environmental change. Science, 292: 281-284.

Tegtmeier, E. M., and Duffy, M. D., 2004. External costs of agricultural production in the United States. International Journal of agricultural sustainability, 2: 1-20.

Thin, N. 2002. Social Progress and Sustainable Development. London: ITDG Publishing.

Toma, L., March, M., Stott, A. W., and Roberts, D. J., 2013. Environmental efficiency of alternative dairy systems: A productive efficiency approach. Journal of dairy science, 96: 7014-7031.

Urdiales, M. P., Lansink, A. O., and Wall, A., 2015. Eco-efficiency Among Dairy Farmers: The Importance of Socio-economic Characteristics and Farmer Attitudes. Environmental and Resource Economics, 1-16.

Van der Vlist, A.J; Withagen, C. amd Folmer, H., 2007. Technical Efficiency under Alternative Environmental Regulatory regimes: The Case of Dutch Horticulture. Ecological Economics 63: 165-173.

Vavik, T. and Keitsch, M. 2010. Exploring relationships between universal design and social sustainable development: some methodological aspects to the debate on the sciences of sustainability. Sustainable Development 18:295–305.

Vlontzos, G., Niavis, S., and Manos, B., 2014. A DEA approach for estimating the agricultural energy and environmental efficiency of EU countries.Renewable and Sustainable Energy Reviews, 40: 91-96.

Weber, M., N. Krogman, and T. Antoniuk. 2012. Cumulative effects assessment: linking social, ecological, and governance dimensions. Ecology and Society, 17: 22.

Zhen, L., Routray, J., K., Zoebisch, M., A., Chen, G., Xie, G., and Cheng, S., 2005. Three dimensions of sustainability of farming practices in the North China Plain. A case study from Ningjin County of Shandong Province, PR China. Agriculture, Ecosystems and Environment, 105; 507–522.

CREDA
CENTRE DE RECERCA EN ECONOMIA
I DESENVOLUPAMENT AGROALIMENTARI

«Date»: ----------------- «Address»: -----------------------------

«Province»:-------------------- «City»:--------------------

«Phone»: -----------------

A.   FARMER

1. Demographic information

Characteristic		Measure
Birth year		
Number of family members	Under 12 years old	
	Between 12 and 65 years old	
	Above 65 years old	
Gender (tick one)	Male	
	Female	
Education level (tick one)	Illiterate	
	Primary education	
	Secondary education	
	University education	
	PhD	
Annual non-farm income	€ per year	
Number of groups or organizations, networks, associations to which you belong. These could be formally organized groups or just groups of people who meet regularly to do an activity or talk about things.		

B.   AGRICULTURAL HOLDING AND COP (CEREAL, OILSEED AND PROTEIN CROPS) PRODUCTION

2. Land distribution

Land distribution	Hectares	Tenure regime of land	Hectares
Utilized agricultural area (UAA)		Ownership	
UAA planted to COP		Rented	
Set-aside compulsory		Sharecropping	
Set-aside voluntary			

3. Inventory of the assets related to COP production

Asset		
Harvesting machinery	**Age**	**Replacement value**
1er		
2^{on}		
3er		
Other machinery except tractors	**Age**	**Replacement value**
Motor vehicles	**Age**	**Replacement value**
1er		
2^{on}		
3er		
4^{rt}		

Tractors	<55CV		55-81CV		82-135CV		>135CV	
	Age	Replacement value	Age	Replacement value.	Age	Replacement value	Age	Replacement value
1er								
2^{on}								
3er								
4^{rt}								
5^{e}								

Buildings	**Square meters**	**Age**	**Replacement value**
1er			
2^{on}			
3er			
4^{rt}			
5^{e}			

Note: the inventory should include rented machinery devoted to COP production. It should also include assets that are shared with other agricultural holdings. In this latter case, please indicate the asset share held by the farm.

35

C. NEXT PRODUCTION CYCLE

3. Intended land use in this next production cycle

Details on intended land use	Irrigated land				Non-irrigated land				Prices
		What kind of yield do you think you would get if GROWING CONDITIONS were:				What kind of yield do you think you would get if GROWING CONDITIONS were:			Price per kg if MARKET CONDITIONS were:
	Land quantity	bad	normal	ideal	Land quantity	bad	normal	ideal	normal
Cereals	ha	kg/ha	kg/ha	kg/ha	ha	kg/ha	kg/ha	kg/ha	€/kg
Wheat									
Barley									
Oats									
Rye									
Corn									
Triticale									
Sorghum									
Other cereals									
Protein crops	ha	kg/ha	kg/ha	kg/ha	ha	kg/ha	kg/ha	kg/ha	€/kg
Chick peas									
Dry beans									
Dry broad beans									
Dry peas									
Lentils									
Other protein crops									
Industrial crops	ha	kg/ha	kg/ha	kg/ha	ha	kg/ha	kg/ha	kg/ha	€/kg
Sunflower									
Rape									
Other industrial crops									
Other crops	ha	kg/ha	kg/ha	kg/ha	ha	kg/ha	kg/ha	kg/ha	€/kg
Forage crops									

Note: normal growing conditions are those that would lead to yields similar to the last 10-year average yield

4. Intended input use in this next production cycle:

SEEDS

	Home grown seeds			Purchased seeds - R2 type			Purchased seeds - R1 type		
	SEEDS – NON-IRRIGATED LAND								
	Quantity of land	Seed quantity	Seed price	Quantity of land	Seed quantity	Seed price	Quantity of land	Seed quantity	Seed price
	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Cereals									
Wheat									
Barley									
Oats									
Rye									
Corn									
Triticale									
Sorghum									
Other cereals									
Protein crops	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Chick peas									
Dry beans									
Dry broad beans									
Dry peas									
Lentils									
Other protein crops									
Industrial crops	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Sunflower									
Rape									
Other industrial crops									
Other crops	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Forage crops									

	SEEDS – IRRIGATED LAND								
	Home grown seeds			Purchased seeds - R2 type			Purchased seeds - R1 type		
	Quantity of land	Seed quantity	Seed price	Quantity of land	Seed quantity	Seed price	Quantity of land	Seed quantity	Seed price
	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Cereals									
Wheat									
Barley									
Oats									
Rye									
Corn									
Triticale									
Sorghum									
Other cereals									
Protein crops	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Chick peas									
Dry beans									
Dry broad beans									
Dry peas									
Lentils									
Other protein crops									
Industrial crops	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Sunflower									
Rape									
Other industrial crops									
Other crops	ha	kg/ha	€/kg	ha	kg/ha	€/kg	ha	kg/ha	€/kg
Forage crops									

5. Intended input use in this next production cycle:

PHYTOSANITARY PRODUCTS (herbicides, fungicides, insecticides)

	PHYTOSANITARY PRODUCTS - NON-IRRIGATED					
Crop	**Commercial name** **Ex:** CHALLENGE-N	**Formula** **Ex:**ACLONIFEN 60% [SC] P/V	**Dose of concentrated product**	**Price of concentrated product**	**ha**	**Number of applications during the production cycle**
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		
			☐l/ha -	☐€/l -		

Note: if the frequency of application is lower than annual (ex. every 2 years):

- **Provide details of this frequency in the cell 'Number of applications during the next production cycle'**
- **Fill in the proportional annual dose in the cell 'Dose'**

| Crop | PHYTOSANITARY PRODUCTS – IRRIGATED (herbicides, fungicides, insecticides) | | | | | |
	Commercial name Ex: CHALLENGE-N	Formula Ex:ACLONIFEN 60% [SC] P/V	Dose of concentrated product	Price of concentrated product	ha	Number of applications during the production cycle
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		
			□l/ha -	□€/l -		

Note: if the frequency of application is lower than annual (ex. every 2 years):

- **Provide details of this frequency in the cell 'Number of applications during the next production cycle'**
- **Fill in the proportional annual dose in the cell 'Dose'**

6. **Intended input use in this next production cycle:**

FERTILIZERS

FERTILIZERS – NON-IRRIGATED LAND

MINERAL FERTILIZERS

Crop	Commercial name	Formula			Dose	Price	ha	Number of applications during the production cycle
		% N-nitrogen	**%P$_2$O$_5$-phosphorus**	**%K$_2$O-potassium**				
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		

ORGANIC FERTILIZERS

Crop	Type	Dose	Price	ha	Number of applications during the production cycle
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		

Note: if the frequency of application is lower than annual (ex. every 2 years):

- **Provide details of this frequency in the cell 'Number of applications during the next production cycle'**
- **Fill in the proportional annual dose in the cell 'Dose'**

FERTILIZERS – IRRIGATED LAND

MINERAL FERTILIZERS

Crop	Commercial name	Formula			Dose	Price	ha	Number of applications during the production cycle
		% N-nitrogen	%P_2O_5-phosphorus	%K_2O-potassium				
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		
					□l/ha -	□€/l -		

ORGANIC FERTILIZERS

Crop	Type	Dose	Price	ha	Number of applications during the production cycle
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		
	□ Porcine □ Bovine □ Avian □ Ovine □ Equine	□l/ha -	□€/l -		

Note: if the frequency of application is lower than annual (ex. every 2 years):

- **Provide details of this frequency in the cell 'Number of applications during the next production cycle'**
- **Fill in the proportional annual dose in the cell 'Dose'**

8. Intended input use in this next production cycle:

OTHER INPUTS

Other inputs	Irrigated	Non-irrigated		Total cost
Irrigation water Is the price paid a fixed annual amount independent of the water actually consumed? No ☐ Yes ☐ fixed amount_____€/year	m3/ha	m3/ha	€/m3	€
Water used for pesticide application	l/ha	l/ha	€/l	€
Fuels (including fuels for irrigation, vehicle operation and heating systems)	liters/ha	liters/ha	€/liter	€
Lubricants	liters/ha	liters/ha	€/liter	€
Electricity	kwh/ha	kwh/ha	€/kwh	€
Upkeep of machinery (and purchase of minor equipment), car expenses, upkeep of buildings and land improvements (major repairs are not considered here)	€/ha	€/ha		€
Machinery and building insurance	€/ha	€/ha		€
Contract work	€/ha	€/ha		€
Land hiring costs (includes sharecropper payments to landlord	€/ rented ha	€/ rented ha		€
Crop insurance	€/ha	€/ha		€
Work	**Irrigated**	**Non-irrigated**		**Total cost**
Non-paid work	hours/ha	hours/ha		
Paid work	hours/ha	hours/ha	€/hours	€
Other (specify)	€/ha	€/ha		€

9. CAP payments

Subsidy type	ha	Euros/ha	Total euros
CAP payments			
Value of non-COP agricultural production in the next production cycle			

10. Could you tell me the average net income of the farm over the last ten years?

…………………………………Euros

11. Workers planned to use in the next production cycle

List all workers in the farm	Family Relationship with the Manager						Gender		Birth year	Marital Status				Education Level				Type of Education		Planned Labor Force Education Spending €/year	Work			
	Spouse	Son, daughter, step-son, step-daughter	Father, mother, stepfather, stepmother	Brother, sister, brother-in-law	Other parent	Unrelated	Male	Female		Single	Married	Divorced	Widow	None	Primary	Secondary	University	Agri	Non-Agri		Working (Hours per Year)	Holidays (Days per year)	Experience in the agricultural sector	Experience Working in this Farm (Year)
Manager																								

12. Working Conditions

Could you please tell me if you agree or disagree with the following? statements:	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
My work requires that I learn new things at least every 3 years	4	3	2	1
My job involves a lot of repetitive work	4	3	2	1
In my work, I have to be creative	4	3	2	1
My work requires high level of skills	4	3	2	1
I get to do a variety of different things in my job	4	3	2	1
At work, I have the opportunity to develop my own abilities	4	3	2	1
My job allows me to take a lot of decisions on my own	4	3	2	1
I have very little freedom to decide how I do my work	4	3	2	1
My opinions influence the management of the agricultural holding	4	3	2	1
My work requires working very fast	4	3	2	1
My work requires working very hard	4	3	2	1
I do not need to do an excessive amount of work	4	3	2	1
I have enough time to get the job done	4	3	2	1
I am free from conflicting demands that others make	4	3	2	1
In the farm, work schedules are flexible	4	3	2	1
the number of holidays that I have is enough	4	3	2	1
I find my job to be motivating	4	3	2	1
I am satisfied with work and working conditions in the farm	4	3	2	1

13. **Health**

	DEATH	SERIOUS INJURY	MINORS INJURY
1. Could you tell me how many accidents have taken place on the farm in the last 5 years?			

2. Could you tell me how often the following occurred on your farm?	VERY OFTEN	OFTEN	SELDOM	NEVER
Being struck by a moving vehicle	4	3	2	1
Being injured by contact with electricity	4	3	2	1
Being injured by farm machinery	4	3	2	1
Being injured by an animal	4	3	2	1
Suffer from muscular pain due to farm work	4	3	2	1
Suffer from headache due to farm work	4	3	2	1
My work entails painful postures	4	3	2	1
My work is physically demanding	4	3	2	1
I am exposed to annoying noise in my work place	4	3	2	1
The temperatures under which I work are tough	4	3	2	1
In my work, I need to manipulate or breathe noxious or toxic substances	4	3	2	1
Rate the risk of disease at the farm	4	3	2	1
Rate the risk of accidents at the farm	4	3	2	1

3. Now tell me if you agree or disagree with the following sentence:	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
My work is healthy	4	3	2	1

47

14. Social externalities

Now tell me if you agree or disagree with the following sentence:	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
Agricultural activities of my farm contribute positively to the landscape quality	4	3	2	1
Our farm products are safe for the health of the consumers	4	3	2	1
Products from the farm contribute to food security in the region	4	3	2	1
Our farm contributes positively to the local economy	4	3	2	1
Our agricultural activities contribute to the diversification and/or preservation of fauna and flora	4	3	2	1
Our farm contributes to the social fabric of rural communities	4	3	2	1
Our farm contributes to maintain basic services (schools, health facilities, etc ...) in rural areas	4	3	2	1
Our farm helps to reduce the local unemployment	4	3	2	1