Climate change effects and Agriculture in Italy: a stochastic frontier analysis at regional level

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Abstract

Climate changes, associated to atmospheric accumulation of greenhouse gases, could alter level of temperature at the surface, rainfalls and regional water supplies. There are many areas of the Earth that will cope with a rapid increasing of warming at the surface and with an extremization of weather conditions. Although many economic sectors are influenced, agriculture is the most susceptible as weather heavily affects crop production trends, yield variability and reduction of areas suitable to be cultivated. Climate change effects represent a "*challenge*" that European agriculture has to face in the immediate future. The aim of our work is to analyze the economic impacts of climate change on agricultural sector in Italy at regional scale (NUTS2) in the light of mitigation policies undertaken by Italy in accordance with the commitments made by the EU Policy in the struggle against climate change. Using the stochastic frontier approach, we investigate on the Italian Regions efficiency in the period 2000-2010. Considering that inefficiency could be influenced by two main meteorological factors – rainfall and minimum temperature– we find that rainfall variable has a positive impact on efficiency while minimum temperature variable reduces the efficiency of harvested production.

JEL classification: Q10, Q54

Keywords: Climate change effects, agricultural sector, mitigation and adaptation, Italian Regions efficiency, stochastic frontier approach.

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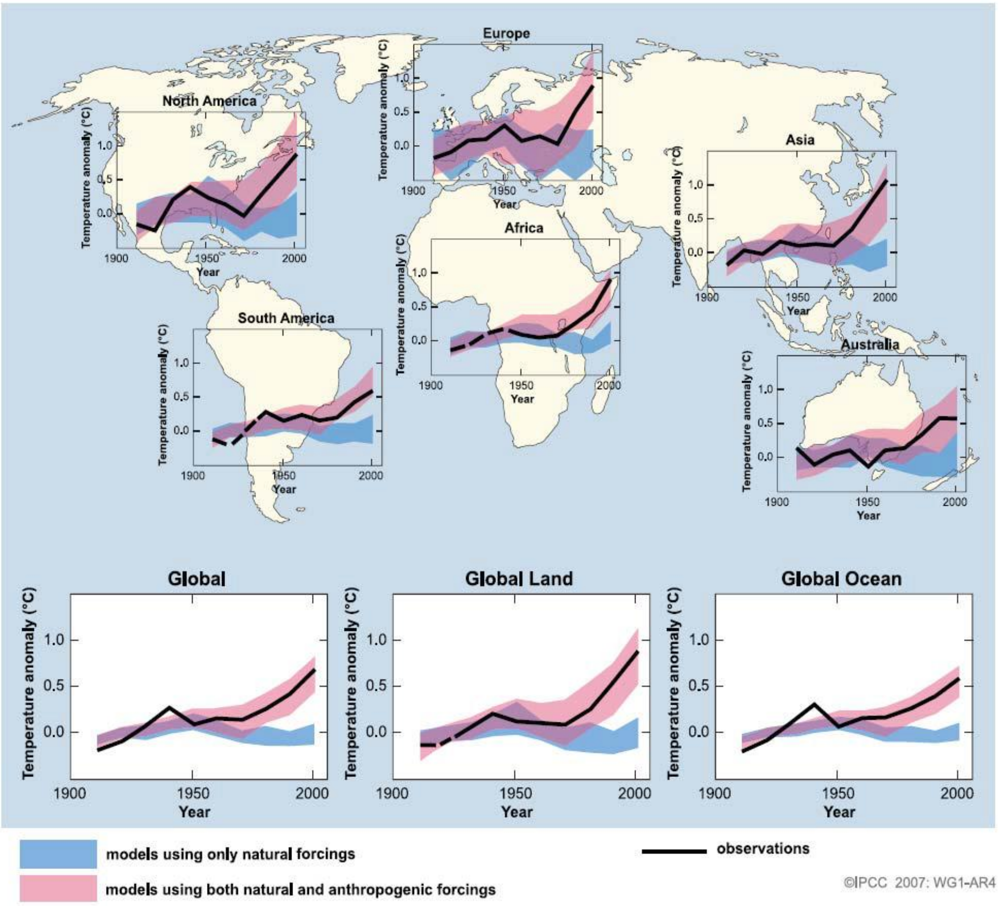
1. *Introduction*

Empirical evidences show changes in world's climate, principally caused by the growing concentration of greenhouse gases (GHG) in the atmosphere induced by socio-economic development and human activities over time. Concentrations of GHG, mainly carbon dioxide (CO2), increased by 70% since 1970. Climate changes, associated to atmospheric accumulation of greenhouse gases, could alter level of temperature at the surface, rainfalls and regional water supplies. Most of the heating occurred in the last fifty years (IPCC, 2007 and 2000) and several researchers have predicted and heralded further and more consistent climate changes in several areas all around the word. There are many areas of the Earth that will cope with a rapid increasing of warming at the surface and with an extremization of weather conditions.

Europe recorded a warming of about 1°C during the last century, faster than the global average. Although the impacts of climate change are detected through many climatic variables, specialized studies primarily consider changes in precipitation, temperature and higher variability degree of climatic conditions. In these recent years, the focus of researchers has primarily been the evaluation of the pathways of climate change impacts on economic activities and human health. Although many economic sectors are influenced, agriculture is the most susceptible as weather heavily affects crop production trends, yield variability and reduction of areas suitable to be cultivated. Climate change effects represent a "*challenge*" that European agriculture has to face in the immediate future being subject to relevant risks generated by new local meteorological conditions. In many countries, in fact, temperatures have become more extreme and economic losses due to extreme weather events and decreased water availability have risen considerably in the last decade. The intensity of rainfalls and snowfalls has increased with more frequent floods in Northern Europe, while in Southern areas rains have decreased substantially and drought periods are more frequent than in the past.

Figure 1. Temperature change on global and continental scale



Source: IPCC data

While a rising length of spring and summer periods, and the related increase of temperatures, could favor crops production at northern temperate latitude sites, conversely, higher temperatures could heavily reduce yields and threaten some crops in areas at southern latitude. In those areas in fact, as summer temperature is already high, water scarcity would make impossible to deal with this consequence of climate change. In this context, farmers have to deal with these risks in presence of more competitive global market conditions and modest policy support programs finalized to adaptation to climate change in European countries.

Many specialized studies have been conducted to estimate climate change impacts on agricultural sector in different areas of the world (Elbakidze, 2006, Easterling et al. 1993; Chang 2002; Peiris et al. 1996; Brown and Rosenberg 1999, Craigon et al. 2002; Jones and Thornton 2003, Shrestha et al. 2013). The literature underlines that the effects of climate change on crop yields are strongly related with the geographical location of the agricultural cultivation and shows that some regions of the Earth would benefit (Cuculeanu, Marcia and Simota 1999; Ghaffari, Cook and Lee 2002) while other regions would be damaged by the effects of new climatic conditions (Batts et al. 1997; Morison and Lawlor 1999; Jones and Thornton 2003; Parry et al. 2004).

The existing literature relating to climate change effects on agriculture focuses on the impacts in small restricted geographical areas or in particular regions (Sweeney et. al. 2003; Walker and Schulze 2008; Quiroga and Iglesias 2009).

The aim of our work is to analyze the economic impacts of climate change on agricultural sector in Italy at regional scale (NUTS2) in the light of mitigation policies undertaken by Italy in accordance with the commitments made by the EU Policy in the struggle against climate change. In particular we investigate on the Italian Regions efficiency during the period 2000 - 2010 when the negative effects of climate change has been increasing. Using the stochastic frontier approach to estimate the production functions of the Italian Regions, we are able to separate the effects of production inputs such as labor, physical and human capital from inefficiency meteorological factors described by the previous literature as the main causes of risk in agriculture.

A dataset of agriculture sector at regional level for the period 2000-2010 has been constructed by using official statistics for inputs and output of the production function and some proxies of climate change and water management. In particular we collected data on temperatures and rainfall, agricultural production, areas under cultivation, irrigation of land, days of work in the farm by employees and finally seeds and fertilizer used. We conclude our analysis ranking the Italian Regions on the basis of these estimated technical inefficiencies.

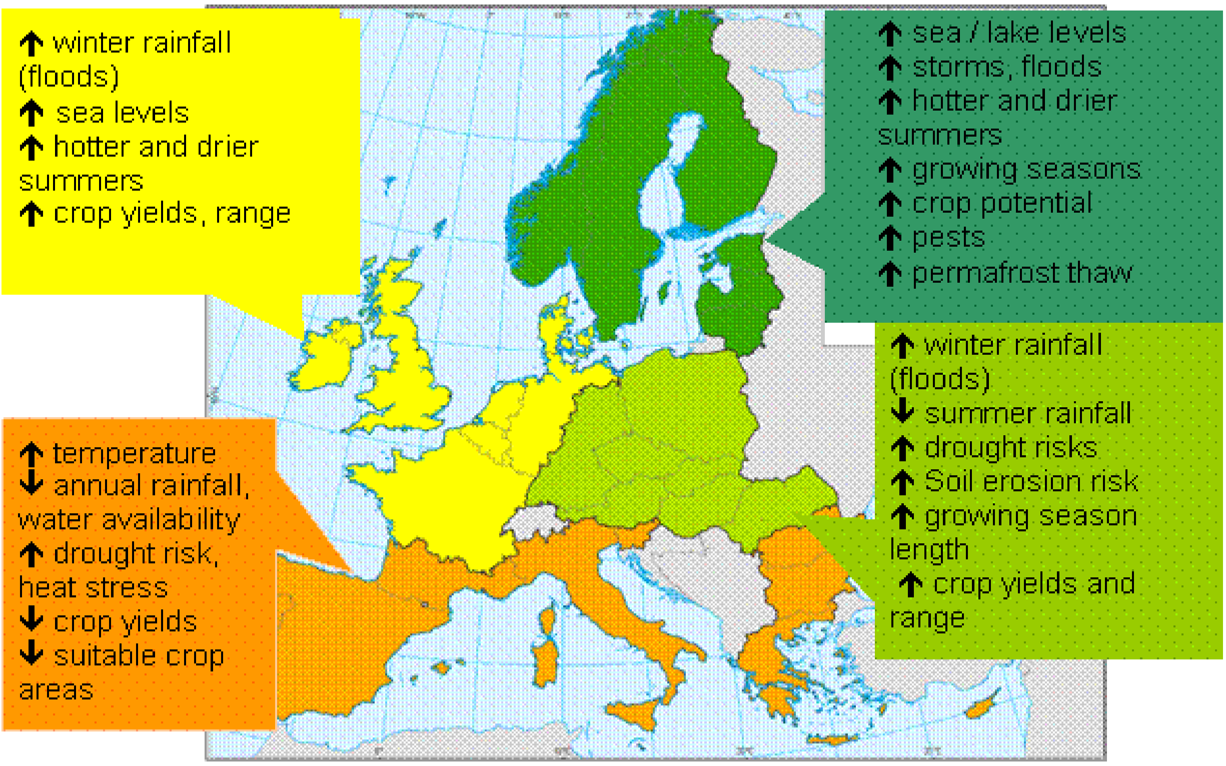
2. *Climate change impacts and agriculture in Europe.*

In Europe agricultural lands and forests cover about 90% of the territory. Weather experts claim that climate variability and extreme weather events are the major causes of alteration in production level, higher yield variability and reduction of cultivation areas in Europe, especially in regions with a lower latitude.

Many studies have evaluated the effects of climate change on agriculture in Europe taking into account important regional differences (Reidsma, Ewert and Lansink 2007, Olesen and Bindi 2002; Iglesias et al. 2009, Gornall et al. 2010). As a whole, in Europe a lengthening of growing season – defined as frost-free period – was observed in the last thirty year (Figure 1). While some of the envisaged consequences could be beneficial for agriculture in the Northern areas of Europe (lengthening of the growing season and improvements in agricultural production due to milder weather conditions) it is expected most of the consequences will be negative and will bring economic losses in the countries of the Mediterranean basin (EEA 2013b). In particular in Italy, Portugal, Greece, southern France and Ireland a significant reduction of cumulated values of rain during winter was recorded. Moreover Italy and southern France show a reduction of rain in summer time. The combined effect of significant increase in temperature and reduction in rainfalls has determined an increasing irrigation demand and has contribute to rise water deficit (Rosenzweig and Tubiello 1997). Water shortage represents the most important consequence of these meteorological phenomena on EU Southern countries agricultural production. For these reasons increased plant heat stress was recorded in Spain, Italy and in the Black Sea area like Turkey. In these countries agricultural sector absolutely must improve its water use efficiency to counter the costs associated with the increased use of this input.

On the other side, in Scandinavia, eastern EU, Balkans and Austria a significant increase of cumulated rain both during winter and summer was recorded. For this reason in Balkans, Austria, Czech Republic, The Netherlands, Denmark, southern Sweden and northern Poland a reduction of irrigation demand took place, mainly due to the increase of rain during the growing season.

Figure 1. Projected impacts from climate change in different EU regions



Even though understanding the nature and quantifying the magnitude of adaptations are critical issues, specialized studies show that in the long term the cultivation of different crops could shift to latitude further north. Moreover, in Europe regional differences will increase in terms of natural resource availability and agricultural productivity also because in this context, small farmers will be particularly affected as they have less capacity of adaptation (EEA 2013a, Cucuzza 2008).

Nowadays mitigation and adaptation represent the double challenge in response to climate change at international level. These two strategies for addressing climate change present some important differences relating to their objectives, the scale of benefits and the sectors involved. In particular mitigation is an intervention to reduce the *"causes"* of climate changes while adaptation addresses the "*impacts*". For this reason, mitigation is crucial to limit changes in the climate system by aiming to reduce the sources or enhance the sinks of greenhouse gases. On the other hand adaptation represents an adjustment in natural or human systems in response to actual or expected climatic changes or their effects, which moderates damage or exploits beneficial opportunities. Although climate change is a global issue, mitigation and adaptation measures to meet set targets also differ in terms of sectors, spatial and time scale. Mitigation is a priority in the energy, transportation, industry and waste management sectors and provides global benefits with a long-term effect on climatic system. Adaptation is a priority in the water and health sectors and provides benefits at the local scale that can have short-term effect on the reduction of vulnerability. Both mitigation and adaptation measures are relevant to the agriculture and forestry.

In the field of climate policy, in the last decades much attention has been paid to mitigation objectives by the European Union, underling that stabilizing global CO2 emissions can be mainly achieved by different strategies:

- the EU's Emission Trading System
- policies to promote the development and use of renewable energies
- measures to boost fuel economy and the use of biofuels in road transport
- initiatives designed to improve the energy performance of buildings
- the use of energy taxes to encourage investments in energy-saving measures
- initiatives to encourage moves towards less energy-intensive products

In April 2013 the European Commission adopted an EU Strategy on Adaptation to climate change that aims to make Europe more climate-resilient. The Commission will encourage all Member States to adopt comprehensive adaptation strategies to respond to the impacts of climate change and will provide funding to help them build up their adaptation capacities and make decisions at different governance levels especially about some vulnerable sectors such as agriculture and fisheries.

In the wake of the literature on climate change effects on the agricultural sector that focuses on the impacts in restricted geographical areas (Sweeney et. al. 2003; Walker and Schulze 2008; Quiroga and Iglesias 2009) and in the light of mitigation actions undertaken by Italy in accordance with the commitments made by the EU in the struggle against climate change, we analyze the economic impacts of climate change on agricultural sector in Italy at regional scale (NUTS2) in the period 1990-2010.

3. *What climate change effects and threats for Italian agriculture sector?*

Italy is strongly affected by the negative consequences of climate changes that could represent factors leading to inefficiency in the agricultural sector. This inefficiency is mainly due to Italian geographical location and to its sector structure which includes many small firms with a low capability to adapt themselves to a new situation, in term of temperatures and climate. Moreover, in this framework national institutions did not improve environmental management and governance on the agricultural sector to deal efficiently with climate change negative effects through time. In the last twenty years, a growing number of extreme weather events occurred and a rising shortage of water in several areas, traditionally suited to agriculture activities, threatened crops and areas suitable for cultivation with substantial losses. In particular, in some areas of South of Italy desertification has continued to increase since 1970 forcing the abandonment of local crops and the choice of new cultivations more resistant to the heat in the summer time.

Italy has a historic high agricultural vocation and is the second largest producer of "*fruit and vegetable*" in Europe - following Spain - offering a wide range of high quality products, a lot of typical Mediterranean products officially recognized as IGP and DOP are produced and sold.

The purpose of our work is to analyze the effects of climate changes on Italian agriculture by considering that the predominant production is represented by typical cultivations. These plants need more water and microclimatic conditions and could suffer for long drought periods and "*out of season*" meteorological events. This paper evaluates the economic effects an agriculture of Climate Change in terms of rainfall and maximum temperatures, which are considered the main components of climate (IPCC, 2007; Solomon et al., 2007). In particular, we want to consider the effects of climate change on the efficiency of agricultural crop harvested in terms of yields and the implications on the production efficiency at Italian regional level (NUTS2) in the period 1990-2010.

In the economic literature, many studies have investigated the economic effects of CC on agricultural sector (CEDEX, 2000; Christensen and Christensen, 2002; Giupponi and Shechter, 2003) based on long-term analyses at the aggregate level, i.e., continental or national scales (Xionget al., 2010). In contrast, few studies have performed short-term analyses at a sub-regional level (Dono and Mazzapicchio, 2010a and 2010b). In the case of agriculture and water management, models based on Discrete Stochastic Programming[3] (DSP) model have been used to forecast the effects on agriculture of changes in water availability due to CC (Dono and Mazzapicchio, 2010a and 2010b). A three-stage discrete stochastic programming model has been used to represent the choice process of the farmer based on the expectation of possible scenarios of rainfall and maximum temperatures for a specific irrigated area of Italy in the next future. These variables affect the availability of water for agriculture and the water requirements of irrigated crops (Dono et al. 2011).

Thus the importance of climate change implies that in our analysis we should consider the implications on irrigated areas of water needs and use and the impacts of changing on the use of agricultural land, on a regional production function using as inputs labor, physical and human capital and as output the level of production of the agricultural sector in all the Italian Regions.

In Italy, irrigated agriculture is the major water user accounting for more than 60% of total abstractions (OECD, 2006). In the South of Italy, the high water demand of agriculture and population is exacerbated by the limited natural availability of water resources and high climatic variability (MGWWG, 2005). Climate change is expected to intensify problems of water scarcity and irrigation requirements in all the Mediterranean region and in Italy in particular, as explained above (IPCC, 2007, Goubanova and Li, 2006; Rodriguez Diaz et al., 2007).

4. *Evaluating* Climate Change *economic effects on agriculture at regional level*: *a Stochastic Frontier Approach.*

For all the reasons mentioned above, we focus our attention on the Italian region efficiency during the period 1990 to 2010. In fact, in these last twenty years, the negative effects of CC has been increasing. Using the stochastic frontier approach to estimate the production functions of the Italian Regions, we are able to separate the effects of production inputs such as labor, physical and human capital from efficiency/inefficiency factors described by the previous literature as the main causes of desertification phenomenon. Moreover, we can disentangle distances from the efficient frontier dividing the error component in two aspects: the systematic and the noise component. Finally, we can rank the Italian Regions on the basis of these estimated technical inefficiency.

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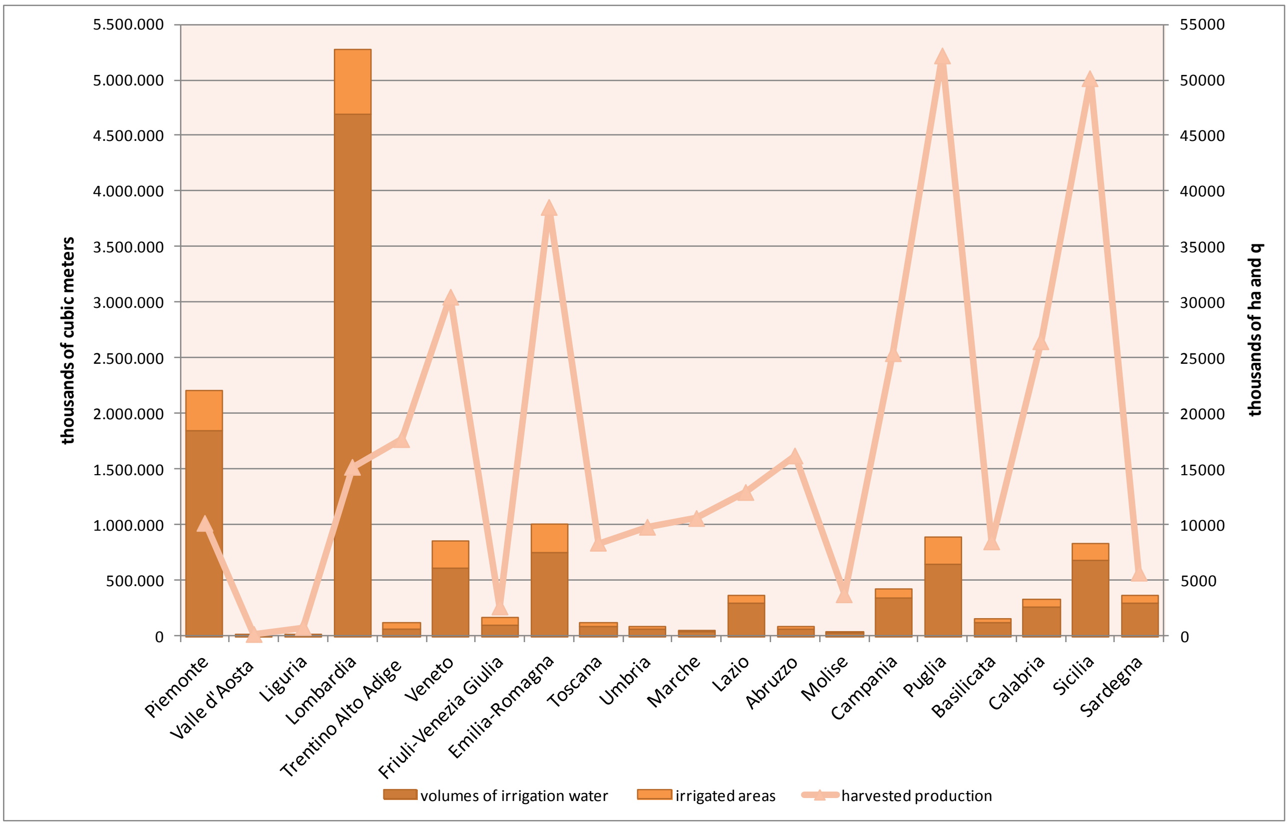
[3]DSP models allow the representation of a sequence of choices that are made under conditions of uncertainty (McCarl and Spreen, 1997). In particular, it allows the representation of decision-making concerned with production activities conducted at certain times (stages), which are influenced by certain conditions (states of nature) that are not known with certainty.

A dataset of agriculture sector at regional level for the period 1990-2010 has been constructed by using official statistics for inputs and output of the production function and some proxies of climate change and water management. In particular we collected data on temperatures and rainfall, agricultural production, areas under cultivation, irrigation water use, farming equipment, number of employees, seeds and fertilizer used. Data have been drawn from continuous and not continuous sample surveys and from V-VI Agricultural Census (sources: ISTAT, EUROSTAT, ISMEA, ISPRA, Aereonautica Militare). Temperatures and rainfall have been considered proxies of the CC. As official statistics on volumes of irrigation water used in Italian agriculture doesn't exist until Census 2010, we used the variable irrigated areas.

In order to consider the regional efficiency, we introduce in the error term not only the proxies of CC but even water management variables to verify if policy makers have taken into account the CC in these last years. Differently from the analysis of Dono et al. (2011), the agricultural sector would not seek to lower costs by modifying patterns of land use, and water use. Little attention has been paid to water management and the reduced availability of water in the future due to CC. The high temperatures instead increase the efficiency because of the largely offset of the increase in CO_2 levels, which boosts the yield of main crops of the irrigated zone. Therefore, availability and water management becomes a crucial factor to offset the increase of evapo-transpiration and of water stress resulting from the increase of temperature. However, the costs of CC are very high for some Regions, which suffer a large reduction in income.

Figure 2. Volumes of irrigation water, irrigated areas, harvested production Italian Regions, Year 2010 (cubic meter, hectar, hundred of Kg)



5. ***The SFA model: our empirical aims.***

As we have underlined before Italy, belonging to the Mediterranean area, could be influenced by the CC negative effects in the agricultural sector. In our empirical study, we apply the Stochastic Frontier Approach (SFA) to assess the efficiency of Italian regions on the harvest production.

According to the neoclassical paradigm, production is always efficient if several hypotheses are stringent. It is unrealistic that two regions – even if identical – can have a similar income with the same endowments. The difference between two regions can be explained through the analysis of efficiency and some unforeseen exogenous shocks (Desli et al., 2002). A simple OLS regression is not sufficient to estimate the relationship between output and inputs because it has several limits (e.g. does not discriminate between rent extraction and productive efficiency; does not simultaneously take into account distances from the efficient frontier for a given production function). To measure regional efficiency, we estimate individual production functions using the stochastic frontier approach developed mainly by Aigner et al., (1977); Meeusen and Van den Broeck (1977). The advantageous of this methodology could be summed up in to two aspects. First, production inputs and efficiency or inefficiency factors are separated in two distinct functions and second distances from the efficient frontier between those due to systematic components and those due to noise are disentangled. The main idea is that the maximum output frontier for a given input set, is assumed to be stochastic in order to capture exogenous shocks beyond the control of individuals. Since all individuals are not able to produce the same frontier output, an additional error term is introduced to represent technical inefficiency.

Using the stochastic frontier approach to estimate the production functions of Italian Regions, we are able to separate the effects of production inputs (labour and physical capital) from inefficiency factors described by the previous literature as the main causes of drought. We can disentangle distances from the efficient frontier dividing the error component in two aspects: the systematic and the noise component. Finally, we can rank the Italian Regions on the basis of these estimated technical inefficiency.

The Battese and Coelli (1995) specification is a SF in which individual effects are assumed to be distributed as truncated normal random variables:

(1) $\ln y = \ln f(x_i;\beta) + v_i - u_i$

where the unobserved random noise is divided into a first component v_{it} which are random variables following the assumption of normally distributed error terms [iid N(0, σ_V^2)], and a second independent component defined as u_{it} which are non-negative random variables. These variables are assumed to capture the effects of technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the N(mit, σU2) distribution with:

(2) $m_i = z_i\delta + \varepsilon_i$

Assuming that the two components are uncorrelated, the parameters can be estimated using the maximum likelihood estimator.

By assuming that the production function takes the constant returns-to-scale log-linear Cobb-Douglas form, we estimated the following two specifications of the stochastic frontier production model. The production function is:

(3) $$\begin{aligned}\ln(Y)_{it} &= \beta_0 + \beta_1 \ln(Kseed)_{it} + \beta_2 \ln(Kfert)_{it} + \\ &+ \beta_3 \ln(Kirrig\_area)_{it} + \beta_4 \ln(L)_i + v_{it} - u_{it}\end{aligned}$$

and the error function is:

(4) $$\begin{aligned}u_{it} &= \gamma_0 + \gamma_1 Rainfall_{it} + \gamma_2 Temp\_min_{it} + \gamma_3 North-west_{it} + \gamma_4 Noth-east_{it} + \\ &+ \gamma_5 Centre_{it} + \gamma_6 South_{it} + \varepsilon_{it}\end{aligned}$$

The description of the variables of the two functions is reported in the following tables.

Table 1. Variables used in specification (4) of the SFA model

VARIABLES	DEFINITION
Areas	Cultivated areas (ha) - source ISTAT: Annual Agricultural Crops Survey
Production harvested	Crops harvested (100 kg) - source ISTAT: Annual Agricultural Crops Survey
Y	Yields= Production harvested/cultivated areas (100 kg)
Kirrig_area	Irrigated areas (ha) - source ISTAT: V and VI Agricultural Censuses, Structure and Production of Agricultural Farms SPA sample Survey
Kfert	Fertilizers used (100 kg) - source ISTAT: Annual Census Survey on fertilizers allocation
Kseed	Seeds used (100 kg) - source ISTAT: Annual Census Survey on seeds allocation
L	Days of work in the farms - source ISTAT: V and VI Agricultural Censuses, Structure and Production of Agricultural Farms SPA sample Survey

Table 2. Variables used in specification (5) of the SFA model

VARIABLES	DEFINITION
Rainfall	Deviation of annual total rainfall average from 1971-2000 rainfall average value (mm) – source ISTAT: Survey of Seasonal climate-weather trend in Italy
Temp_min	Deviation of annual minimum temperature average from 1971-2000 minimum temperature average value (Celsius degree) – source ISTAT: Survey of Seasonal climate-weather trend in Italy
Dummy macro-areas	Italian macro-areas: North-west, North-east, Centre, South where islands is omitted for collinearity

The stochastic frontier estimation allows us to measure productive efficiency based on harvested production in Italian regions. The technical efficiency of the *i-th* region in the *t-th* time period is given by

(5) $TE_{it} = e^{(-u_{it})} = e^{(-z_{ti}\delta - \varepsilon_{ti})}$

The technical in/efficiency values will oscillate between 0 and 1, being the latter the most favourable case. Following Battese and Corra (1977), the simultaneous maximum likelihood estimation of the two-equation system is expressed in terms of the variance parameters $\sigma^2=\sigma^2_v+\sigma^2_u$ and $\gamma=\sigma^2_u/(\sigma^2_v+\sigma^2_u)$ to provide asymptotically efficient estimates[4]. Hence, it is clear that the test on the significance of the parameter γ is a test on the significance of the stochastic frontier specification. (The acceptance of the null hypothesis that the true value of the parameter equals zero implies that σ^2_u, the non-random component of the production function residual, is zero.)

6. *Empirical results*

The maximum-likelihood method is used in our analysis to estimate the parameters of the stochastic frontier of production and of the inefficiency model for 20 Italian regions in the period 2000-2010. We restrict our analysis to the period 2000-2010 for reaching more homogeneity within our sample. Results are presented in Table 3 where the Cobb-Douglas production function's estimated coefficients are reported and in Table 4 where the estimated coefficients are referred to the inefficiency equation.

Because, in all specifications, we reject the null hypothesis of the insignificance of the non-negative error component (γ), we conclude that the SFA is a good model to analyse the effect of local environmental spending on the regional economic performance. Moreover, the parameter (γ) also indicates the proportion of the total variance in the model that is accounted for by the inefficiency effects. This parameter, which is significant at the 1% level in all estimations, is 0.98 indicating that 98% of the variance is explained by the inefficiency effects, confirming that the inefficiency effects are important in explaining the total variance in the model.

In particular, we report the results of three estimations. The difference between the first and the second estimations consists in considering the Rainfal and Temp_min variables separately while in the last column the two variables are estimated jointly.

In all columns, the results indicate that production function performs relatively well because physical capital measured by fertilizer used (Kfert) and irrigated areas (Kirrig_area) shows always a positive and significant sign, while physical capital measured by seed used (Kseed) and human capital measured by days of work in the farms (L) have negative, albeit signs are insignificant for the first variable.

When we observe the signs of the inefficiency factors, we note that Rainfall variable shows a negative and significance sign, meaning that the more is the rain the more efficient is the agricultural production on area cultivated of Italian regions. This is in line with the common sense.

4 The log-likelihood function and the derivatives are presented in the appendix of Battese and Coelli (1993).

As concerned the minimum temperature variable, the sign is positive. Thus, the more is the minimum temperature the less efficient is the agricultural production on cultivated area of Italian regions. The geographical location of regions is not relevant, because all macro-areas have positive effects on efficiency.

Table 3. Results of the production function

Dependent variable: Prod/L	Model 1	Model 2	Model 3
Const	-1.21***	-1.15***	-1.17***
t	-2.87	-2.79	-2.80
Kseed	-0.02	-0.02	-0.02
t	-1.39	-1.08	-1.03
Kfert	0.27***	0.26***	0.26***
t	6.94	7.08	6.89
Kirrig_area	0.08*	0.09**	0.08*
t	1.94	2.21	1.83
L	-0.95***	-0.95***	-0.95***
t	-23.01	-22.79	-22.27

Table 4. Results of the inefficiency model

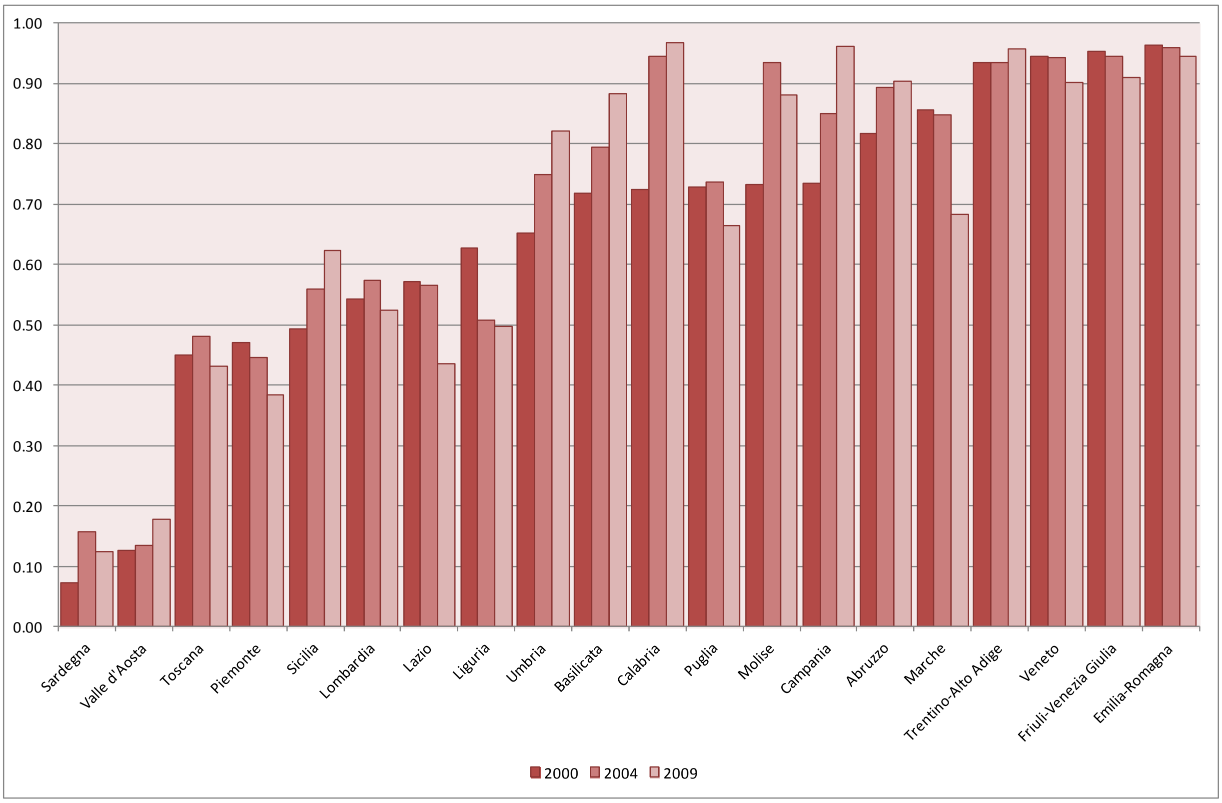
Dependent variable: Prod/Lo	Model 1	Model 2	Model 3
const	1.41***	1.29***	1.31***
t	8.44	7.27	7.02
Rainfall	-0.01*		-0.01*
t	-1.74		-1.78
Temp_min		0.19	0.21
t		1.10	1.12
Dummy macro-areas	Yes Neg. sign	Yes Neg. sign	Yes Neg. sign
Observations	200	200	200
sigma squared	0.44***	0.41***	0.41***
t	6.28	6.89	5.77
gamma	0.97***	0.97***	0.97***
t	160.87	139.77	119.73

, ** and * indicate significance at 10%, 5% and 1% levels*

To deepen our analysis, we have estimated technical inefficiencies for each region, using the model described in the third column. We report the technical inefficiencies of Italian regions for three separate years - 2000, 2004 and 2009 -which represent three non-missing data among regions. We then rank the Italian regions according to the level of inefficiency reached in 2000.

The results show that the inefficient regions are Sardinia and Valle d'Aosta as we expected because are these two regions are the less agricultural-sector-oriented. On the other extreme we find Veneto, Friuli-Venezia Giulia and Emilia Romagna, in which agriculture is relevant. Among the South regions, Sicily is the less efficient meaning that it should be more influenced by the negative effects of climate change.

Figure 2. Ranking of inefficiency effects among Italian Regions, Year 2000-2004-2009



7. *Conclusions*

In these last decades climate change effects, associated to atmospheric accumulation of greenhouse gases, have altered the level of temperature at the surface, rainfalls and regional water supplies. A rapid increasing of warming at the surface joined with an extremization of weather conditions have influenced agriculture production because it is the most susceptible to climate variability and extreme weather events.

While some of the envisaged consequences could be beneficial for agriculture in the Northern areas of Europe (lengthening of the growing season and improvements in agricultural production due to milder weather conditions) it is expected most of the consequences will be negative and will bring economic losses in the countries of the Mediterranean basin (EEA 2013b). In particular in Italy, a significant reduction of rainfall during winter has been documented. Moreover, Italy and southern France show a reduction of rain in summer. The combined effect of significant increase in temperature and reduction in rainfalls has determined an increasing irrigation demand and has contribute to rise water deficit.

For all these reasons, climate change effects represent a "*challenge*" that European agriculture has to face in the immediate future. The aim of our work is to analyze the economic impacts of climate change on agricultural sector in Italy at regional scale (NUTS2) in the light of mitigation policies undertaken by Italy in accordance with the commitments made by the EU Policy in the struggle against climate change. Using the stochastic frontier approach, we investigate on the Italian Regions efficiency in the period 2000-2010. Considering that inefficiency could be influenced by two main meteorological factors – rainfall and minimum temperature– we find that rainfall variable has a positive impact on efficiency while minimum temperature variable reduces the efficiency of harvested production. Thus we can confirm that the CC effects (expressed as rainfall intensity and minimum temperatures) contribute to increase inefficiency in agricultural crop yields in Italy and the Italian Regional production efficiency ranking shows a different impact of CC effects due to the low capability of adaptation.

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