Comparing Technical and Economic Efficiency among Organic and Conventional Italian Olive Farms

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Abstract

In many European states such as Spain and Italy there has been a significant growth of organic utilizable surface as a consequence of both a change in the model of agricultural production and also in order to satisfy arising demand of organic food. The purpose of this research was to investigate the level of technical, allocative and economic efficiency in Italian olive farms with two different system of farming as organic versus conventional using the dataset FADN (acronym of Farm Accountancy Data Network), which is a standardized database set up by the European Union to evaluate the impact of some actions correlated to the Common Agricultural Policy on farmers. The efficiency was investigated using a non parametric quantitative methodology called Data Envelopment Analysis or DEA. The results pointed out as organic olive farmers are more efficiently than conventional farmers even if allocative efficiency was lower in many of analyzed farms due to some pivotal variables such as land, agrarian capital and labor capital, which directly with the independent variable farm net income.

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1. Introduction

Since the early 1990s there has been a meaningful growth of organic surfaces and organic farms in all European states as a consequence of an increase of the customer's demand of healthy food able to protect the environment and also to improve the farmer's income. In Italy the demand of organic food is equal to 1.5% of annual expenditures (INEA, 2013; INEA, 2012). Nowadays, the buying process takes place in alternative commercial channels such as farmers' market, specialized shops, direct sales by e-commerce, groups of local buyers, called in Italy GAS or rather Gruppi di Acquisto Solidale. The GAS have generated a growth of social and ethic capital network rooted on rural areas, focused on a net of solidarity, sustainability and environment protection (Bertizzolo, 2013) fundamental to reduce in small rural communities their socio-economic marginalization (Galluzzo, 2010).

Even though recent analysis have underlined a drop in food consumption equal to 2% and 3.7% respectively in quantity and in value in two year time 2013-2012, in contrast for the organic olive oil the increase of demand has been equal to 7.9% in value and an incidence in percentage by 1.2% on the total organic Italian consumption in the first six month time in 2013 (ISMEA, 2014; INEA, 2013). According to the ISMEA's research findings on a sample of Italian families, carried out by annual Panel Famiglie GFK-Eurisko analysis, it seems as the organic food consumption has been able to generate a positive increase in family expenditures with a value of 7.3% on the total budget (SINAB, 2014; ISMEA, 2014) even if the conventional olive oil has underlined a decrease in value by 2.4% in the first semester 2013 (INEA, 2013).

In general, Italian consumption of organic food is equal to 1.5% of annual expenditures, with better performance of growth than the certified quality food, due to a significant development of alternative channels in order to buy these products directly without salesman such as farmers' market, farms specialized shops by organic farm gates in agro-tourisms equal to 2,795 enterprises located mostly in the north and south of Italy (Biobank, 2014). Direct sales by e-commerce, groups of local sellers and buyers have generated, in particular the former direct channel of sales, Italian rural districts and agro-industrial districts in small scale rural territories aimed at guaranteeing an endogenous and local development in agrarian areas at risk of marginalization with a share knowledge and skills among all the stakeholders and entrepreneurs (Galluzzo, 2009 a,b). Despite the development of new marketing strategies large retail chains are the most common channel to sell organic products in Italy with a level of price which is increased with lower levels than conventional ones (INEA, 2013). In

Italy there is a spatial distribution of organic food consumption; in fact, organic consumption is predominately concentrated in the centre and in the north eastern Italian regions (INEA, 2013). More than 60% of purchasing process in terms of organic food takes place in traditional shops specialized in selling organic food equal to more 820 units (Biobank, 2014).

Despite the economic crises, investments in organic farming have increased and in the same time there has been a growth of per capita demand of organic food in particular inside the European domestic market. In Italy every family spends more than 1.5% of annual own income buying organic foods and vegetables predominantly in informal channels such as directly buying process in farms or in formal market as mass markets even if the brand and specific labels seem to be the most influential aspect in the decision process of buying by consumers as a consequence of a high level of investments in communication (Torazza, 2010) which on the contrary a small farmer is not able to set up. Hence, small farmers prefer to use the direct sale channels in farm in order to implement their level of income and to fidelize customers.

The production of organic olive is doubled during the 10 year time of study; in fact, in 2003 harvested olives were equal to 282.000 tons and in 2012 harvested olives were equal to 584.000 tons (EUROSTAT, 2014). In Spain and in Italy there has been a significant increase of organic olive surfaces (Figure 1) where it is concentrated, according to data published in 2010, 1.46 million of hectares in Spain and 1.10 million of hectares in Italy (INEA, 2013; EUROSTAT, 2014) with a sharply enhancement of olive crop surfaces in conversion (Figure 2) with meaningful differences among European states about the per cent diffusion of organic surface out of the total arable land equal to 4% in Spain and 10% in Sweden (Latruffe and Nauges, 2014). At the end of 2012, 11.2 million hectares of organic crops were concentrated in Europe and they were managed organically by more than 320,000 farms whose two third belonging to the European Union with Spain, Italy, and Germany able to concentrate the largest organic agricultural producing a market size equal to 21 billion of euro (FIBL, 2014).

Over the time investigated in this research there has been an increase of organic cultivated surfaces in the world even if more than 60% are located in European countries hence, in 8 year time organic surfaces in Europe are doubled (Figure 1). In terms of olive cultivated surfaces in Italy and in Spain there has been the most significant increase of them even if in 2010 Spanish farmers have overtaken organic olive surface in Italy (Figure 2) although there is a more significant growth of areas in transition in Italy than in the world (Figure 3).

From 2009 to 2013 Italian organic food consumption has underlined a sharply growth of export and sales as well (Figure 4) with more than 30 euro per person of annual expenditure in order to buy organic products compared to 25 euro in 2009 (Figure 5).

The geographical analysis of Italian distribution in terms of organic crops has underlined as they are predominately located in the south of Italy where there is a higher diffusion of certified quality olive oil productions than other kind of crops such as forage and pasture cultivations (INEA, 2013). The level of income for organic farmers is lower than conventional ones due to specific techniques aimed at improving the quality of commodities and food instead of enhancing the quantity in terms of yield; hence, the first and foremost bottleneck of organic farming is tightly linked to a significant impact of these techniques on the management and technical efficiency of farms which are less productive than conventional ones because of they are more demanding and depending on subsides allocated in supporting organic crops (Kumbhakar et al., 2009). The selling price is inadequate to reduce the income gap between organic and conventional olive oil. In fact, the price of organic olive oil is higher than conventional one equal in 2011 to 7.94 €/kg and 4.42 €/kg (INEA, 2012). Anyway, comparing the average selling price of conventional olive oil in 2014 and the price of certified quality extra virgin olive oil findings have underlined as the extra virgin olive oil with a label of protected designation of origin (PDO), synonymous with high quality product, is greater than conventional one 6.00 €/kg and 3.56 €/kg (ISMEA, 2014) hence, the price of organic olive oil is higher than conventional and PDO ones but it is not enough to compensate different management strategies and yield in organic farms. The first purpose of this research was to investigate, over ten years, the level of technical and economic efficiency in olive Italian farms and secondly only during 5 years (2008-2012) the efficiency in olive oil productions, comparing organic and conventional farming systems and products in a sample of farms part of the Farm Accountancy Data Network (FADN) dataset. FADN is a standardized sample of farms detected by the European Union in order to assess the impact of some actions of Common Agricultural Policy. In literature only few Italian studies have investigated the efficiency using the FADN dataset comparing organic and conventional systems of farming (Cislino and Madau, 2007; Madau, 2006).

In general, one of the most important drivers in the decision process of farmers to convert their own agricultural productive specialization from a conventional model towards an organic one is the technical efficiency, the farm size and the level of farming intensity (Latruffe and Nauges, 2014). Lots of studies have underlined as the level of efficiency and productivity is tightly connected to the level in technology and investments that is typical of organic farms with pivotal consequences on the efficiency (Lansik et al., 2002). In contrast, because of a different level of inputs used in the process of production, few studies have also underlined an higher level of technical efficiency in organic olive farms than in conventional ones (Tzouvelekas et al., 2002). In literature the analysis about organic farming system and in conventional olive farms has concerned a sample of them analyzing the cost efficiency or technical and economic efficiency arguing as conventional farming is better than organic because of level of more background in technology, skill and knowledge (Bayramoglu and Gundogmus, 2008) compared to the organic olive farms, which have many issues tightly linked to the production level and to the quantity and quality of input (Artukoglu at al., 2010). This latter finding corroborates as efficiency is directly linked to productivity (Papadas, 1991) and to the variable farm size in terms of hectares of utilizable surface (Galluzzo, 2013).

In the second stage of this research, using a quantitative approach by a multiple regression model, one has estimated by the Ordinary Least Square (OLS) some main relationships among the dependent variable net income and other independent variables in terms of factors of production such as land capital, agrarian capital and subsides allocated by the European Union in order to stimulate rural development actions in the ten year time of study (2003-2012).

2. Materials and Methods

In order to study the efficiency there are two ways: a parametric or deterministic approach, which needs a knowledge and acquaintance of a specific production function and other parametric variables, and a non-parametric model or DEA (Data Envelopment Analysis) aimed at defining in function of the distance from the frontier of an hypothetical function of production an index of technical inefficiency (Bielik and Rajcaniova, 2004). In the non-parametric model some deviations from the frontier of function are caused by inefficiencies and they are not connected to errors thus, the technical efficiency is described as capabilities of farmers to maximize the output minimizing used inputs or vice versa (Bojnec and Latruffe, 2008). According to many authors (Farrel 1957; Battese 1992; Coelli 1996) in this paper the efficiency has been estimated by a non-parametric model applied to different specification assumptions such as a constant return to scale (CRS) and a variable return to scale (VRS) in an input oriented model using PIM-DEA software.

The goal of DEA linear programming model is to minimize in a multiple-output model the multiple-input in each farm that is a ratio of efficiency and in a mathematical model it can be written (Papadas, 1991):

$$\max h = \Sigma_r u_r y_{rjo} / \Sigma_i v_i x_{ijo} \quad (1)$$

s.t.

$$\Sigma_r u_r y_{rj} / \Sigma_i v_i x_{ij} \leq 1 \quad (2)$$

j= 0, 1, ...n (for all j)

$u_r, v_i \geq 0$

The efficiency is a ratio between obtained output and used inputs and it is a pivotal tool to define the capability of each Decision Making Units (DMU) to be efficient; in this case the farmer in order to produce a well-define quantity of output has to use a specific combination of input in different cross sections data over the time of investigation. In term of productivity if there are two DMUs such as A and B able to produce two levels of output such as y_a or y_b using a specific quantity of input x_a and x_b the productivity is a simple ratio y_a/x_a and y_b/x_b.

The non-parametric linear model throughout the Data Envelopment Analysis has been introduced for the first time in 1978 (Charnes et. al, 1978) and it is useful to estimate the relative efficiency in each Decision Making Units based on different level of input and output (Hadad et al, 2007) with the purpose, in an approach input oriented strategy used in this paper, to minimize the level of input (Doyle and Green, 1994) in olive crops and in the process of production of olive oil.

The goal of a non parametric input oriented model, such as in our research, or rather DEA linear programming, is to minimize in a multiple-output model the multiple-input in each farm that is a ratio of efficiency; hence, this model has many possible solutions and u_r* and v_i* are variables of the problem and the value of efficiency have to be greater to 0 or an other small but positive quantity thus, any input and output can be ignored in estimating the efficiency (Bhagavath, 2009; Papadas, 1991). If h is 100 there are not issues because this unit ($DMUh_1$) is more efficient compared to other $DMUh_n$, but whether h is above 100 there are lots of units more efficient than this unique unit ($DMUh_1$) then, every units is tightly linked to the level of input and output making each unit efficient (Bhagavath, 2009). To solve this negative aspect is fundamental to transform the model in a linear one by a linear programming methodology called CCR (Charnes and Cooper 1962; Bhagavath, 2009**)** written in this way:

$$\max h = \Sigma_r u_r y_{rjo} \quad (3)$$

s.t. dual variable

$\Sigma_i v_i x_{ijo} = 100\%$ Z_o

$\Sigma_r u_r y_{rjo} - \Sigma_i v_i x_{ijo} \leq 0$ with j = 0, 1, ...n (for all j) λ_j

$-v_i \leq -\varepsilon$ i = 0, 1,….m and ε is a positive value s_i^+
$u_r \leq -\varepsilon$ r = 0, 1, …t and ε is a positive value s_r^-

In the dual problem proposed by Charnes, Cooper and Rhodes in 1978 it is important to give a dual variable in each constraint in the primary model; this paper did not take into account in the dual model a constraint able to classify and to discriminate DMUs by the super efficiency called A&P model (Andersen and Petersen, 1993). In mathematical terms the solution of the dual model is written as:

$$\min 100\, Z_o - \varepsilon \ \Sigma_i s_i^+ - \varepsilon\, \Sigma_r s_r^- \quad (4)$$

s.t.

$\Sigma_j \lambda_j x_{ij} = x_{ijo} Zo - s_i^+$ i = 0, 1, …m

$\Sigma_j \lambda_j x_{rj} = y_{rj0} + s_r^-$ r = 0, 1,....t

$\lambda_{j,}\, s_i^+, s_r^- \geq 0$

λ_j are shadow prices able to reduce the efficiency in each unit lower than 1 and a positive value of λ_j is able to assess a peer group in some inefficient unit. If j is an organic farm inefficient the value of technical efficiency is lower than 1 (Charnes et al. 1978) even if in this paper the value of efficiency is in a percentage hence, 100% is the optimal value and values lower than 100% are many different inefficient solutions.

The next stage of the quantitative analysis has utilized a multiple regression model, estimating the parameters by Ordinary Least Square, with the purpose to investigate if some independent variables or rather factors of productive process such as land capital, agrarian capital, labor capital and financial supports allocated by the European Union in order to implement rural development are correlated to the dependent variable farm net income.

In order to estimate heteroscedasticity in error terms one has used the White's Test on the residuals using the basic assumptions quoted in literature about the multiple regression model (Verbeek, 2006). The estimation of the parameters has used the open source software GRETL 1.8.6. In its algebraic form of matrix, the multiple regression models can be so expressed (Verbeek, 2006):

$$\mathbf{y} = \mathbf{X}\beta + \varepsilon \quad (5)$$

Where **y** is a dependent variable and ε is the error but both are vectors with n-dimensions **X** is an independent variable which has dimension n x k.

In analytical terms, the model of multiple regression in its general formulation can be written in this way (Asteriou and Hall, 2011; Baltagi, 2011):

$$y = \alpha_0 + \alpha x_1 + \beta x_2 + \gamma\, x_3 + \delta x_4 + \varepsilon_{jt} \quad (6)$$

y is net farm income α_0 constant term

x_1, x_2, x_3, x_4 independent variables

α, β, γ, δ estimated parameters of the model

ε_{jt} term of statistic error.

Basis assumptions, to use a multiple regression model, are (Asteriou and Hall, 2011; Baltagi, 2011): statistic error ui has conditional average zero that is E (ui|Xi) = 0; (Xi, Yi), i = 1...n are extracted as distributed independently and identically from their combined distribution; Xi, ui have no fourth moment equal to zero. There is no correlation among regressors and random noise so that the value between β expected and β estimated is the same and to analyze if there is heteroskedasticity on standard errors, it has used White's Test on the error terms (Verbeek, 2006).

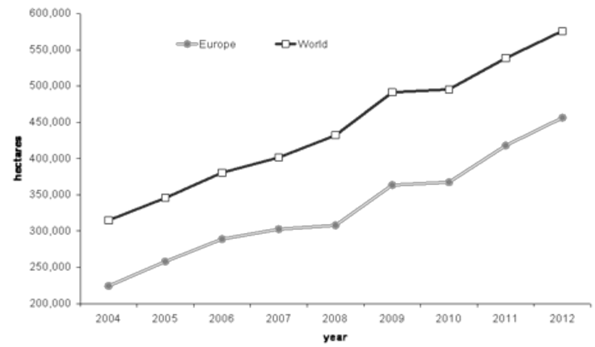

Figure 1. Evolution of organic cultivated surfaces in Europe and in the world (Source: or elaboration on data FIBL, 2014)

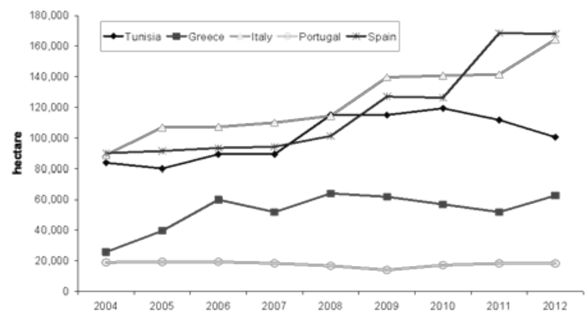

Figure 2. Evolution of olive organic surface in some European countries (Source: elaboration on data FIBL, 2014)

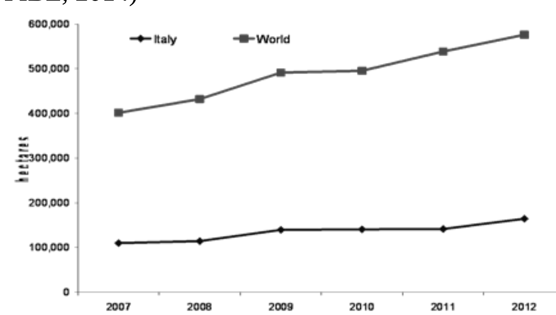

Figure 3. Evolution of olive organic surface in conversion in Italy and in the world over the most recent six year time (Source: elaboration on data FIBL, 2014)

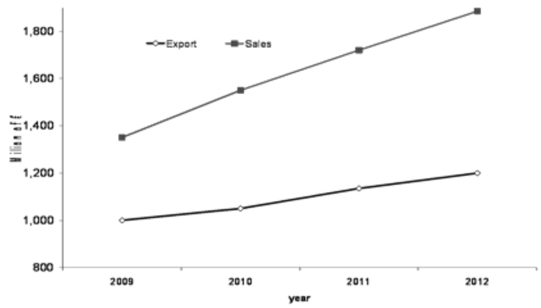

Figure 4. Export and sales of organic food in Italian market during six year time (Source: elaboration on data FIBL, 2014)

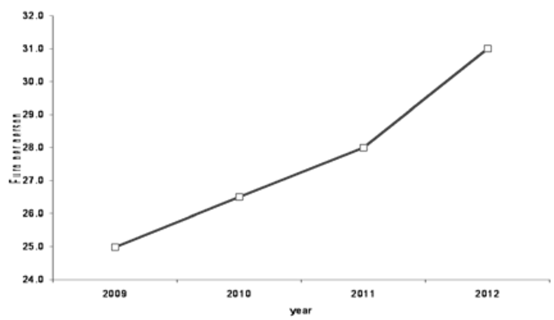

Figure 5. Per capita annual expenditures in the Italian organic market (Source: elaboration on data FIBL, 2014)

3. Results and Discussion

The analysis of the efficiency, comparing the organic olive crops to the conventional ones, has showed as the best overall findings are in favor of the conventional farming system than the organic one (Figures 6-7) using both the constant return to scale (CRS) and also the variable return to scale (VRS), even if in this latter approach the efficiency in organic olive crops is higher than in variable return to scale approach (Figure 7). Focusing the attention on the conventional olive cultivations the statistical data seems to underline as in 2012 and 2011 conventional olive crops have had a lower value than 100% both in terms of economic efficiency and also in terms of allocative efficiency (Table. 1) due to a meaningful reduction of olive yields because of adverse weather conditions. The organic olive crops, although have underlined a value of efficiency in some years lower than 100%, have pointed out also levels, both in CRS and also in VRS approach, of economic efficiency and allocative efficiency higher than those found in conventional olive crops, demonstrating as organic techniques can act on a drop in costs about the main capital or factors of production used in the cultivation processes getting olive organic crops more efficiently than conventional ones because of more efficient use of inputs (Table. 2).

The findings of the efficiency of organic and conventional olive productions have pointed out an optimal average value in organic productions compared to conventional ones in both CRS and VRS models (Table. 3-4). In 2012 there was the lowest level of efficiency in conventional olive oil productions. The variable return to scale has underlined a higher level of economic and allocative efficiency than constant return to scale approach in conventional and organic olive oil products as well. Conventional olive productions have stressed a higher value in terms of allocative efficiency both in CRS model and also in VRS one. It is important to emphasize as both the economic efficiency and the allocative efficiency are always above 100% in 4 years out of 5 using the CRS model but the situation is completely transformed using the VRS model hence, it implies a specific role of quantity of input level used to obtain better results in VRS approach.

The multiple regression model applied to the FADN time series showed as the model fits well on the dataset with a value of R^2 and adjusted R^2 equal to 0.62 and 0.51, hence more than 62% of the variance has been completed explained in the model, which has been able to emphasize a linear relationship between the dependent variable farm net income and independent variables in the model; furthermore, the absence of heteroscedasticity in error term, which is normally distributed without the presence of structural breaks. The multiple regression model has pointed out as the farm net income in the FADN time series sample is directly correlated with the independent variables of capital endowments in terms of land capital, agrarian capital and labor capital. This implies as ceteris paribus an increase in the production factor such as labor capital, in terms of workforce, could have a greater effect than an increase of land capital in olive farms. The funds and subsides allocated by the European Union throughout some actions in favor of organic methods of cultivations provided by the Common Agricultural Policy in the Rural Development Plan (RDP) seven year time 2000-2006 and in the further RDP period of time 2007-2013, is inversely correlated on the dependent variable farm net income.

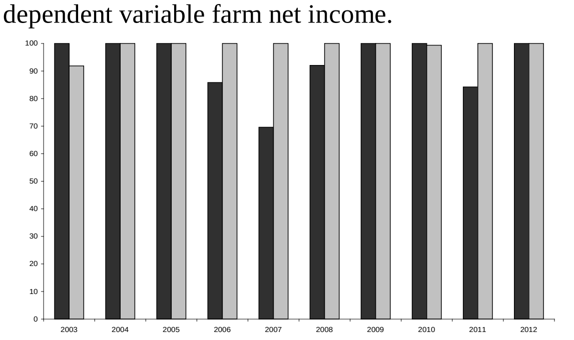

Figure 6. Main results comparing technical efficiency in organic and convention olive farms using constant return to scale.

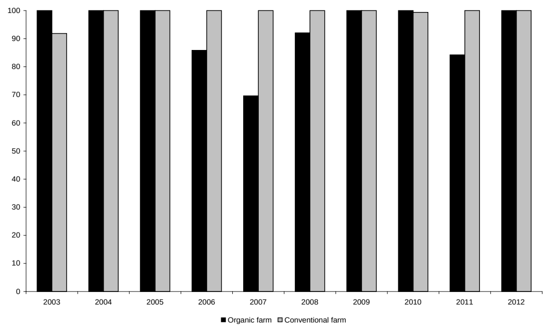

Figure 7 Main results comparing technical efficiency in organic and convention olive farms using Variable return to scale.

This latter aspect may be critical in particular in small Italian olive farms, which are sparsely spread on the countryside and are so common in the Italian rural space, whose low levels of profitability for farmer are a traditional characteristic of Italian olive farms; hence, it is pivotal to support them allocating financial subsides by the European Union in order to stimulate a new holistic rural development approach in areas at risk of socio-economic marginalization promoting organic crops and organic food consumption.

Table 1. Main results comparing organic and conventional olive farming systems using a constant return to scale (CRS) on an input based model

	Organic farming system		Conventional farming system	
Year	Cost Efficiency	Allocative Efficiency	Cost Efficiency	Allocative Efficiency
2003	76.49	76.49	44.76	48.73
2004	69.08	69.08	43.38	43.38
2005	65.38	65.38	49.78	49.78
2006	52.69	61.38	48.19	48.19
2007	39.78	57.14	41.85	41.85
2008	52.72	57.27	63.13	63.13
2009	42.87	42.87	48.79	48.79
2010	80.81	80.81	53.04	53.39
2011	58.55	69.51	49.92	49.92
2012	100.00	100.00	100.00	100.00
Average	63.84	67.99	54.28	54.72

Table 2. Main results in organic and conventional olive crops using a variable return to scale model.

	Organic farming system			Conventional farming system		
Year	Efficiency	Cost Efficiency	Allocative Efficiency	Efficiency	Cost Efficiency	Allocative Efficiency
2003	100.00	100.00	100.00	98.58	58.76	59.61
2004	100.00	90.20	90.20	100.00	59.39	59.39
2005	100.00	100.00	100.00	100.00	61.12	61.12
2006	100.00	64.29	64.29	100.00	67.37	67.37
2007	96.67	45.07	46.63	100.00	60.74	60.74
2008	100.00	54.37	54.37	100.00	69.15	69.15
2009	100.00	60.95	60.95	100.00	59.81	59.81
2010	100.00	93.82	93.82	100.00	59.72	59.72
2011	100.00	63.56	63.56	100.00	63.55	63.55
2012	100.00	100.00	100.00	100.00	100.00	100.00
Average	99.67	77.23	77.38	99.86	65.96	66.05

Table 3. Main results in organic and conventional olive oil productions using a constant return to scale model.

	Organic farming system			Conventional farming system		
year	Efficiency	Cost Efficiency	Allocative Efficiency	Efficiency	Cost Efficiency	Allocative Efficiency
2008	100.00	66.34	66.34	100.00	100.00	100.00
2009	100.00	74.31	74.31	100.00	82.09	82.09
2010	100.00	74.41	74.41	100.00	96.53	96.53
2011	100.00	80.51	80.51	100.00	78.14	78.14
2012	100.00	100.00	100.00	41.98	11.82	28.17
Average	100.00	79.11	79.11	88.40	73.72	76.99

Table 4. Main results in organic and conventional olive oil productions using a variable return to scale model.

	Organic farming system			Conventional farming system		
year	Efficiency	Cost Efficiency	Allocative Efficiency	Efficiency	Cost Efficiency	Allocative Efficiency
2008	100.00	76.99	76.99	100.00	100.00	100.00
2009	100.00	100.00	100.00	100.00	100.00	100.00
2010	100.00	92.65	92.65	100.00	100.00	100.00
2011	100.00	92.30	92.30	100.00	85.49	85.49
2012	100.00	100.00	100.00	100.00	100.00	100.00
Average	100.00	92.39	92.39	100.00	97.10	97.10

Table 5. Main relationships in the multiple regression model (Dependent variable is farm net income) .

Dependent variable	Regressor	Standard error	t ratio	p-value	
Constant	-5847,75	4985,65	-1.1729	0.25912	n.s.
Land capital	0.064301	0.0185719	3.4623	0.00348	***
Agrarian capital	0.104441	0.0290366	3.5969	0.00264	***
Labor capital	0.336439	0.117037	2.8746	0.01157	**
Financial rural support by the EU	-0.348276	0.0825811	-4.2174	0.00075	***

** denotes significance at 5%; *** denotes significance at 1%

4. Conclusions and Recommendations

The analysis has pointed out the fundamental role of subsides allocated by the European Union in order to stimulate in an inverse way the farm net income. Organic olive crops and the production of olive oil are as efficiently as conventional ones which are partially in contrast with findings of other authors regardless of the previous approach model based on constant or variable return to scale as argued by Bayramoglu and Gundogmus in 2008; even if in this case results are similar to findings proposed by other scholars (Artukoglu at al., 2010). The research has pointed out as there are not differences between the level of input used and obtained output both in input oriented model and also in output oriented one; therefore, it follows that the parameter able to discriminate acting on the level of efficiency is only between constant or variable return to scale.

A different level of input such as invested agrarian capital has implied an increase or a drop in terms of level of yield in olive farms.

For the future, organic olive crops seems to have a good prospective of growth towards Italian farmers hence, the European Union should implement actions to promote this kind of organic farming system among customers because there is not an homogeneous distribution and consumption in all European countries of organic food; furthermore the level of information and awareness about organic food is not so common, homogeneous and complete in different countries belonging to the European Union. Readdressing the buying and consumption patterns by a correct food education in the European consumers it could strengthen the role of organic olive farms; major efforts should concern making people understand that the selling price greater in organic food than in conventional ones is the result of a production choice which has decreased consumption of chemicals and or pesticides with consequent positive externalities in favor of sectors downstream of the farms.

To sum up, the next Rural Development Plan 2014-2020 in Italy may be a good milestone for farmers in order to reduce the overproduction of commodities converting them into organic crops and promoting them outside the domestic market by the financial and legal support of regional and other local public administrations.

The new proposals of the Rural Development Plan 2014-2020 should improve financial resources aimed at implementing organic olive crops in particular in less favoured areas where are scattered many olive farms, reducing, in the same time, bureaucratic aspects which have restricted the diffusion of organic cultivations. Furthermore, it is pivotal to stimulate a growth of farm dimension (land capital) by specific soft loans and also it is fundamental to give towards public administrations, such as local provincial authorities, more governance autonomy and power in order to help technically and agronomically organic olive farmers.

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