A Comparative Analysis of Organic and Conventional Farming trough the Italian FADN

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Abstract. This paper presents some results from a wider research on economic and environmental sustainability of organic farming. It aims to compare organic and conventional farming in order to identify some of the main differences between those groups of farms that participated in the official Farm Accountancy Data Network (FADN) - 2003. The study is organized in two sections. The first part, after a brief literature review of the most recent statistical methodologies applied to identify the two similar groups of farms, presents some key economic variables (production, costs and revenues) and the most widely-used structural, economic and balance sheet indexes. The second part describes findings from a case study on the Italian fruit-growing sector. A non-parametric input-oriented frontier analysis (Data Envelopment Analysis, DEA) was used to evaluate which technique makes better use of their disposable productive inputs. Findings show that organic farmers can (partially) overcome the productivity gap (with respect to conventional ones) by more efficient use of their inputs (with respect to their own frontier).

Keywords: Comparative Analysis, FADN Sampling, Organic Farming, Efficiency Analysis

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1. Introduction

The increasing spread of organic farming in Europe over the last decade has stimulated the interest of many economists, both in terms of trades dynamics with its related market strategies, and in terms of farm production and revenue performances. Indeed, in the medium and long-term, organic farming cannot disregard the fact that farms can achieve acceptable profit and efficiency levels (Offermann and Nieberg, 2000). The most common approach in the literature is based on a comparison of organic and conventional farms. Following this branch of research, analysis of the two different production systems can offer important information in terms of both the micro–economic point of view (for instance, evaluating the economic chance to convert) and macro-economic results (for instance, evaluating specific addressed policies) (Scardera and Zanoli, 2002).

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Comparative analysis introduces some problems related to methodological issues. Some researchers argue about the effective reasonableness of the comparison itself, because it is done on two systems with: a) very different production techniques; b) different technical-productive patterns, admitted that it is possible to define a specific one for each group; c) heterogeneity within groups, mostly because conventional farming is a mix of agronomic techniques, some quite similar to the organic ones.

With respect to this last issue, conventional farming can be considered as the most widespread agricultural system in a given territory or, *vice-versa*, it could been seen as everything but organic techniques and methods (Offermann and Nieberg, 2000). Even if the objective is a comparison, the risk of taking non-homogenous systems into account is very high, either from the technological or management point of view. On the other hand, it should be emphasized that, as with every comparison analysis, the results, and their implications, are strictly connected to the methods applied to the comparison. What emerges is the deep complexity in identifying an analytical approach that can "explain" differences and similarities.

This study presents some results from a wider research on the economic and environmental sustainability of organic farming. It aims to compare organic and conventional farming in order to identify some of the main differences between those groups of farms from the economic and technical points of view.

Specifically, a "distance analysis" has been carried out on a sample of Italian farms that participated in the official Farm Accountancy Data Network (FADN) during 2003.

The study is organized in two sections. The first part presents a brief literature review of the most recent statistical methodologies applied to address differences (if any) in production technology, costs and revenues between organic and conventional farms. A selection procedure finalized at the comparison of *similar* organic and conventional farms was applied to the Italian FADN sample. The investigation tries to provide evidence of heterogeneity or homogeneity between organic and conventional farms through the analysis of some key economic variables.

The second part shows some findings of a case study on the Italian fruit-growing sector. The purpose is to estimate differences in technical efficiency (TE), productivity (φ) and scale efficiency (SE) between organic and conventional fruit-growers.

The analysis is based on the comparison of two groups of organic and conventional farms. It demonstrates that productivity in the organic process is generally lower than in the conventional farming (Offermann and Nieberg, 2000). It is clear that inadequate efficiency and productivity levels could be a disincentive for farmers to convert to organic farming[1]. As a consequence - leaving aside the environmental and health externalities generated by this practice – the development of organic farming could be invalidated if individual farms do not reach adequate efficiency levels. This implies that organic farms must try to achieve both productive and economic efficiency.

2. Comparing Organic and Conventional Farms: Methodologies and Selection Criteria

An approach used for the comparison between the two productive systems, through FADN data, defines conventional farms as an approximation, that means *how an organic farm should be if it were conventional*. The similarity between the two kinds of

[1] Several studies have found that financial subsidies and not profitability represent the main incentive for farmers to switch to organic farming (Pietola and Oude Lansink, 2001).

enterprise, which should operate in the same context, is founded on the same levels of potential production, and on the same level of available resources. So the hypothesis is that there is technological homogeneity between the two production systems. This approach, however, introduces many problems. The more important are (Offermann and Lampkin, 2005):

- the selected variables' submission to the system/context: how much variables depend on organic or conventional farming?
- business management: the more innovative farms often show greater conversion inclination
- the *self-selection* bias: if all farms had the same information to maximise profits, then there would be no reason for the comparison, because every farm would adopt the most rewarding production technique.

As far as the organic and conventional FADN sub-samples are concerned, the best solution would be to consider a constant sample[2] of farms, that is a *panel* to be analysed during a specified temporal lag. Following this approach it would be possible to evaluate the conversion period looking at some of the most important impacts on farm economic performance and market behaviour. A temporal analysis, in fact, is considered as the preferable one (where possible) because it allows both a *within* and *between* farms' analysis to be done (Santucci, 2002). This is one of our purposes for further analysis. Other recent studies developed using FADN data have, instead, favoured the application of a *spatial approach*, analysing farms' structural and economic characteristics. This would not take into account the possible effects coming from a change in business management, as well as those necessary to evaluate the effective advantage of converting (evaluation of cost-opportunity).

Some studies match groups of farms ensuring only that group averages are similar, while others select a group of comparable farms for each organic farm. Furthermore, some studies use an aggregated measure of similarity which allows to rank conventional farms and then select a number of the most similar farms (Offermann, 2004). These differences make comparison across countries difficult, so proposed guidelines for harmonisation have been developed (EU-CEEOFP). The comparison analysis that could have been adopted can be summarized as follows:

- comparison between groups of similar farms: averages within groups are similar;
- comparison between two farms considered as the most representative of their farm type;
- comparison between organic and conventional farms classified as similar thanks to a weighting system of selection;
- comparison between farms based on "minimum similar criterion", where the conventional farms selected have specific minimum requirements;
- comparison between two groups of farms with similar characteristics in terms of production system, size and location.

The debate on farms' selection process *for* comparison is still open, however, some of the main guidelines shown in recent studies and seminars have been followed (Nieberg

[2] FADN sample has a variable quota of farms: every year some farms are dropped from the survey and new ones are included – at least since 2003.

et al. 2005; EISFOM, 2005). According to these researchers, organic and conventional farms to be compared have to meet the following requirements:

- similar environmental conditions (land fertility, climate…);
- same localization (Region);
- same equipment of production factors;
- same business typology (farm type)

The selection of the comparison groups of farms has been done by selecting those that fall within a set of criteria (indicators) that fill the requirement of independence from the production system, following the main guidelines for harmonization. As a result, a group of 799 conventional farms have been selected. However, the two FADN sub-samples have the same number of farms, as the most similar one has been selected for each organic farm.

The first step in the selection procedure was the identification of the organic group of FADN farms and the second one the implementation of the specific database with all the information needed to apply the comparison analysis. In order to reach this second goal some indexes have been identified. The most important ones take into account the following factors: land/cattle, labour force and technological issues. Furthermore specific indexes have been selected as independent variables:

- ALT (Altimetry);
- CA/TA (Cultivated Area/Total area);
- GCU (Grown Cattle Unit);
- FLF/TLF (Family Labour Force/Total Labour Force);
- CV TOT (Machine Power);
- SGM (Standard Gross Margin)

The farms were selected using a stratified sampling method based on *geographical location*, *technical and economic orientation* and *economic dimension unit*. The variables used for stratification are:

- TF[3]: the classification used for selection is based on 67 principal Type of Farming categories.
- ESU[4]: the classification used for selection is based on 7 farm size categories.
- Region[5]: the classification for selection is based on 21 Italian Regions and 3 district areas (North, Centre, South and Islands).

Every cell containing a specific number of organic farms has been filled up with the conventional farms that show the best requirements. The choice of variables for the selection of comparable conventional farms has been restricted to *non-system dependent* factors. Some indicators have been considered to select conventional farms that could be defined similar to the organic ones in terms of production potential, resources endowment, land area, farm type. In particular, the *selection procedure* has been carried out in three steps: 1) evaluation of the selection variables using FADN data (available in the Italian FADN database); 2) setting-up of the selection indicators for the submission

[3] TF stands for Type of Farming.
[4] ESU stands for *European Size Unit*.
[5] FADN Regions (NUTS).

of conventional farms; 3) data processing for the effective conventional farms' selection.

The territorial distribution of the FADN sample is presented in table 1 and refers to the following groups:

- Total Sample (N = 14,811)
- Organic group (n_1 = 799)
- Comparison Conventional farms (which correspond to the organic ones) (n_2 = 799)
- Non-comparison Conventional farms ($n_3 = 13213 = N- n_1 - n_2$).

Table 1 *- Organic farms by Type of Farming and District - %*

	N. FARMS / DISTRICT							
TYPE OF FARMING	**North**	%	**Centre**	%	**South and Isl.**	%	**Total**	%
Specialist field crops	18	2.3	59	7.4	47	5.9	124	15.5
Specialist horticulture	3	0.4	2	0.3	4	0.5	9	1.1
Specialist permanent crops	47	5.9	58	7.3	195	24.4	300	37.5
Specialist grazing livestock	63	7.9	43	5.4	80	10.0	186	23.3
Specialist granivore	2	0.3	4	0.5	3	0.4	9	1.1
Mixed cropping	17	2.1	26	3.3	34	4.3	77	9.6
Mixed livestock	1	0.1	8	1.0	5	0.6	14	1.8
Mixed crops-livestock	11	1.4	37	4.6	32	4.0	80	10.0
Total	**162**	**20.3**	**237**	**29.7**	**400**	**50.1**	**799**	**100.0**

Source: Own data processing on FADN data (2003).

The second step turned out to be particularly difficult, as some of the information required for the analysis was fragmented or duplicated. The most important obstacles at this stage, can be summarized as follows:

- data address: recognition of the variables necessary to develop an economic analysis;
- definition of variables;
- elimination of *outliers*.

For the last point, a statistical technique has been used that leads back to the classic or univariate method (Alboni, 1994; Lee and Fowler, 2002). According to this formulation, the evaluation of anomalous values has been done on the single variable considered. The sample examined, after eliminating the *outliers*, is composed of 14,754 farms, 787 of which are organic.

The group of organic farms represents 5.4% of the total. About 50% are in the South and Islands, where most farms specialize in permanent crops and grazing livestock (24.4% and 10.0% respectively). As a whole, 37.5% of organic farms specialize in those two types of farming and 15.8% specialize in field crops.

3. The *distance* between organic and conventional farms through some structural and economic indexes.

The data have been analyzed starting from a set of variables processed for the two groups of farms observed and for the sample as a whole. The most widely-used Structural and Economic Indexes have been compared in order to highlight and measure the "distance" of Organic and Conventional Farming. Leaving aside issues related to the environmental impact of the production processes[6] of organic versus conventional farming, the comparison has been developed through an analyses of some of the most important structural and economic characteristics of farms.

Table 2 - *Cultivated Areas (CA) and Grown Cattle Unit (GCU) by Type of Farming – Averages.*

	CA			
	n_1	n_2	n_3	N
Specialist field crops	72.48	63.50	49.03	50.33
Specialist horticulture	10.13	4.26	4.23	4.26
Specialist permanent crops	24.94	21.92	14.11	15.34
Specialist grazing livestock	65.65	61.66	48.48	50.50
Specialist granivore	18.77	7.03	22.05	21.69
Mixed cropping	53.76	51.94	29.32	31.88
Mixed livestock	81.80	49.61	48.62	50.56
Mixed crops-livestock	61.87	55.93	43.29	45.92
Total	49.31	44.38	32.48	34.01

	GCU			
	n_1	n_2	n_3	N
Specialist field crops	6.36	2.20	3.67	3.71
Specialist horticulture	0.08	0.00	0.14	0.14
Specialist permanent crops	1.32	0.47	0.61	0.64
Specialist grazing livestock	62.75	63.33	82.55	79.96
Specialist granivore	320.63	294.48	615.09	603.11
Mixed cropping	15.20	18.53	5.11	6.39
Mixed livestock	67.55	67.85	322.84	293.87
Mixed crops-livestock	32.01	33.54	74.73	67.65
Total	24.55	23.99	39.95	38.28

Source: Own data processing on FADN data (2003).

The main aims of this part of the study are:

- to verify if, at national level, organic farms are on average larger in terms of surface area (ha) than conventional ones and if this information can represent a starting point for the search of economic benefits as far as economies of scale are concerned;
- to verify if organic farming is characterized by greater dynamism;
- to verify if a correlation exists between the age of farmer (young) and farming type (organic versus conventional);
- to analyse the most important structural and economic indexes.

[6] The SABIO project conducted the environmental impact analysis through a set of indicators based on land productivity, technical practices and energy used.

The first information that can be obtained from the results shown in table 2 is that on average, the cultivated area of organic farms (49.3 ha) is larger both if compared to the corresponding conventional farms (44.4 ha) and to the general average of the sample (34.0%).

Table 3 - *Economic Dimension related to Standard Gross Margin (SGM), Family Labour Force (FLF) and Total Labour Force (TLF) by Type of Farming – Averages.*

	SGM			
	n_1	n_2	n_3	N
Specialist field crops	56.28	57.89	52.18	52.52
Specialist horticulture	72.72	55.54	98.88	98.44
Specialist permanent crops	52.68	53.14	41.49	42.99
Specialist grazing livestock	52.48	51.17	70.32	67.86
Specialist granivore	47.31	47.82	116.18	113.51
Mixed cropping	62.35	52.70	39.45	41.42
Mixed livestock	55.16	46.80	101.91	96.13
Mixed crops-livestock	34.08	38.81	51.01	48.56
Total	52.46	51.83	56.61	56.13

	FLF			
	n_1	n_2	n_3	N
Specialist field crops	1.07	1.01	1.03	1.03
Specialist horticulture	1.54	1.34	1.41	1.41
Specialist permanent crops	0.97	0.98	1.01	1.01
Specialist grazing livestock	1.50	1.56	1.56	1.55
Specialist granivore	1.28	1.19	1.47	1.46
Mixed cropping	1.17	1.08	1.09	1.09
Mixed livestock	1.45	1.62	1.54	1.54
Mixed crops-livestock	1.49	1.45	1.34	1.36
Total	1.20	1.20	1.19	1.19

	TLF			
	n_1	n_2	n_3	N
Specialist field crops	1.84	1.56	1.61	1.62
Specialist horticulture	1.91	1.84	3.08	3.07
Specialist permanent crops	2.17	2.06	1.92	1.94
Specialist grazing livestock	2.07	1.91	2.04	2.03
Specialist granivore	2.17	2.63	2.82	2.80
Mixed cropping	3.18	2.36	1.92	2.01
Mixed livestock	2.24	1.95	2.94	2.85
Mixed crops-livestock	1.80	1.89	1.86	1.86
Total	2.16	1.96	1.98	1.99

Source: Own data processing on FADN data (2003).

As far as the average dimension of livestock rearing is concerned, the organic farms have more Grown Cattle Units (24.5 GCU) than the corresponding conventional ones, but less than the general average of the sample (more than 38 GCU). This result places the accent on the production difference: more extensive if organic, more intensive if conventional.

The analysis of the economic dimension of farming is then evaluated through the Standard Gross Margin (SGM), by type of farming (table 3).

It can be noted that the SGM of the organic farms is, on average, below the level registered for the total sample with a delta of 3.6%. In particular, those specialized in horticulture, grazing livestock and granivore but also the less specialized such as mixed cropping and livestock have a strong influence on the level of the total (organic) group average. In fact, the organic farms show better results than the general sample average, above that of the corresponding conventional group. A possible explanation could be the high production specialization that characterizes organic farming, thus confirming the a priori expectations.

The Family Labour Forces (FLF) employed on organic farms are, on average, the same as those on the corresponding conventional farms. Furthermore, the values reach the same level as the general sample. The Total Labour Force (TLF), instead, turn out be higher on average for the organic sub-sample than the corresponding conventional sample and also higher than the general sample. This result provides indications on the labour force specialization required by organic farming. The employment of a greater force of non-family units on the organic farms and the typical family labour force on conventional ones, testifies to the greater dynamism of the former. The labour force issue is strictly linked to farm size and is confirmed by what emerges on the cultivated area: larger surfaces require more labour.

Concerning management, 89.1% of organic farms are individually run, 7.9% are simple companies, 1.0% are co-operatives and 0.8% are limited liability partnerships. Almost the same picture emerges if we refer the type of management on the corresponding conventional farms and the general sample. There are very few young entrepreneurs in the FADN sample as whole, even if their presence is higher on organic farms than conventional, with a delta of 4.3%.

Some of the main structural characteristics of the groups of farms are shown in table 4.

***Table 4** – Main structural indexes.*

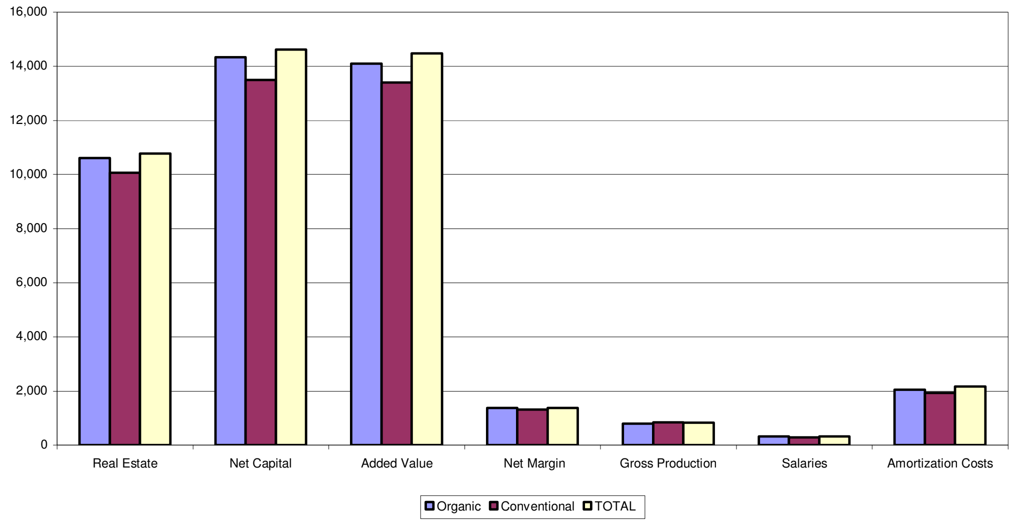
Structural Indexes	**n_1**	**n_2**	**n_3**	**N**
CA/TLF (ha)	29.62	25.25	18.71	19.64
CA RENT/CA (ha)	33.10	26.17	27.65	27.86
CV TOT/TLF (HP)	107.78	101.43	112.65	111.79
EXERCISE CAP./TLF (€)	55,088	47,767	52,256	52,167

Source: Own data processing on FADN data 2003.

The first index, which measures the amount of cultivated area per employee, provides evidence of the relative intensity in the land use. This index, on average, gives a higher value to the organic farms. The third parameter measures the level of mechanization in terms of available power. It turns out that, on average, the organic farms are better equipped than the corresponding conventional ones, even if the value remains below general average. The exercise capital/labour unit measures the business investments not related to the land, and also in this case, the value of organic farms is higher than the conventional ones.

Some of the main variables analysed for both farming types are shown in figure 1 (Real Estate, Net Capital, Added Value, Net Margin, Gross Production, Salaries and Amortization Costs). What generally emerged is that organic farms reach almost the same levels as the total sample as a whole, while the corresponding conventional farms show lower values.

Figure 1 *- Comparison of Main Structural and Economic Variables: Organic Farms, Conventional Farms and Total Sample. Average values on Standard Gross Margin.*



Source: Own data processing on FADN data 2003.

Looking at the average values on Cultivated Areas (table 5) it can be noted that conventional farms' Gross Production is significantly higher than the organic ones, as the Added Value and Net Margin. The average values on Total Labour Force instead, show opposite results, so the "distance" become shorter. That would probably mean that the two groups are quite similar and that, even if organic farms still produce a lower "economic value", they better compensate production factors, especially in terms of Labour Force.

Table 5 - Main Economic Indexes: Organic Farms, Conventional Farms and total Sample.

Economic Indexes	$\mathbf{n_1}$	$\mathbf{n_2}$	**N**
Gross Prod./TLF	47,300	41,429	45,518
Gross Prod./CA	3.32	7.714	25.869
Added Value/TFL	32,072	28,633	29,074
Added Value/CA	2.239	3.589	11.851
Net Prod./Gross Prod.	42.64	45.82	34.64
Net Margin/TLF	21,748	19,523	19,473
Net Margin/CA	1.5	2.042	8.442
Net Margin/Gross Prod.	35.93	38.29	35.87

Source: Own data processing on FADN data 2003.

The productivity of the two groups of farms, estimated through the relationship between gross production and the amount of the production factor used (table 5) shows opposite results if calculated on CA or TLF. On one hand, looking at the values on CA it would be possible to confirm the larger size of the organic farms in terms of cultivated areas. On the other, this could be read as a smaller gain in terms of revenues.

4. Frontier analysis

As is well established in the economics literature, *technical efficiency* (TE) is defined as the measure of the ability of a firm to obtain the best production from a given set of inputs (*output-increasing oriented)*, or as a measure of the ability to use the minimum feasible amount of inputs given a level of output (*input-saving oriented*) (Greene, 1980; Atkinson and Cornwell, 1994)[7]. In the case of the input-oriented approach, TE represents a cost efficiency measure that reflects the level of reduction of input use in order to obtain the same output level.

4.1 - The analytical framework

Several procedures and strategies have been proposed for measuring TE[8]. More precisely, frontier models can be classified in two basic types: parametric and non-parametric procedures. The former can be separated into deterministic (assumption that any deviation from the frontier is due to inefficiency) and stochastic (presence of statistical noise). Furthermore, models can be separated into primal and dual approaches depending on the underlying behavioural assumptions that are made[9].

Data Envelopment Analysis (DEA) is a *non-parametric* approach to estimate efficiency originally proposed by Charnes *et al*. (1978) and based on the well-known Farrell (1957)'s model. With respect to the stochastic approaches, the disadvantages in DEA applications are that 1) models are deterministic and are thus affected by extreme observations, 2) results are potentially sensitive to the selection of inputs and outputs, and 3) there is no way to test the model appropriateness to the data. On the other hand, among its advantages, DEA 1) consents to manage efficiency in multi-output situations better, and 2) it permits efficiency estimation without assuming an *a priori* functional form for frontier production (Charnes *et al*., 1978).

Solving a linear programming problem, DEA calculates efficiency by comparing each production unit against all the others. The best practice frontier is represented by a piecewise linear envelopment surface. Therefore, TE scores arising from DEA are invariant to technology, because obtained through comparisons between an observation and others and not with respect to an estimated frontier.

Several DEA methods have been proposed in the literature[10]. The discussion on DEA presented here is brief and concerns the input-oriented *Constant Return of Scale* (CRS) DEA and *Variable Return of Scale* (VRS) DEA.

The CRS DEA corresponds to the original method proposed by Charnes *et al*. (1978). It is an *input-oriented* methodology that measures TE under constant return of scale assumption. TE is derived solving the following linear programming model:

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7 When a firm operates in a constant return of scale area the two measures coincide (Färe and Lovell, 1978).

8 See Førsund *et al.* (1980), Bauer (1990) and Pascoe *et al.* (2000) for more detailed information on parametric techniques and their applications. A survey of applications in agriculture is shown in Bravo-Ureta *et al.* (2007).

9 For the choice of methodologies and the impact of such a choice on the empirical findings see wadud and White (2000) and Bravo-Ureta *et al.* (2007).

10 See Seiford and Thrall (1990), Charnes *et al.* (1994), Seiford (1996), Coelli (1996) and Herrero (2000) for a detailed illustration of DEA models.

$$
\text{(1)} \qquad \min_{\theta,\lambda} \quad \theta_i \qquad \text{subject to} \quad Y_i \leq Y\lambda, \quad \theta_i x_i \geq X\lambda, \quad \lambda \geq 0
$$

where θ_i is a scalar associated with the TE measure of the i^{th} DMU (Decision Making Unit that in this study is a farm), λ is an $N \times 1$ vector of weights relative to efficient DMUs, Y is the matrix of the M×N outputs and X represents the K×N input matrix.

Solving (1) we can obtain a measure of TE that reflects "distance" between the observed and optimal input usage:

$$
\text{(2)} \qquad ET = \frac{C_p^1}{C_p} \qquad (0 \leq ET \leq 1)
$$

where C_p and C_p^1 are the observed and minimum feasible (optimal) costs respectively.

Banker *et al*. (1984) suggested adapting the model in order to account for a variable return of scale situation. Adding the convexity constraint N1'λ = 1, the model can be modified into VRS DEA.

A measure of scale efficiency (SE) – that reflects the role of return of scale in technical efficiency - can be obtained by comparing TE^{CRS} and TE^{VRS} scores. Any difference between the two TE scores indicates there is scale inefficiency that limits achievement of an optimal (constant) scale.

$$
\text{(3)} \qquad TE^{CRS} = TE^{VRS} * SE
$$

Therefore, it can be calculated as (Coelli, 1996):

$$
\text{(4)} \qquad SE = \frac{TE^{CRS}}{TE^{VRS}}
$$

However, a shortcoming of the SE score is that it does not indicate if a farm is operating under increasing or decreasing return of scale. This is resolvable by simply imposing a *non-increasing return of scale* (NIRS) condition in the DEA model, i.e. changing the convexity constraint N1'λ = 1 of the DEA VRS model into N1'λ ≤ 1. If TE^{NIRS} and TE^{VRS} are unequal, then farms operate under increasing return of scale (IRS); if they are equal a decreasing return of scale (DRS) exists[11].

11 Obviously, in the special case where SE equals zero, a farm operates in a constant return of scale area.

4.2 The data

Frontier analysis using DEA was applied on three farming activities in which the organic method is widely adopted in Italy: seminative crops, olive-growing and fruit-growing. Due to lack of space, only the findings relative to efficiency analysis in the fruit-growing sector are reported in this paper[12].

Data were collected from the Italian FADN and concern 147 organic and 148 conventional fruit-growing farms that participated in the programme in 2003. The two sub-samples were selected according to the criteria described in section 2. The choice of using a sample composed of a similar number of farms in the two groups was made in order to have substantial homogeneity between organic and traditional farms as regards structural, environmental and managerial aspects. This approach is a well-known procedure in this type of study, which compares "*averages for groups of organic farms (…) with averages for conventional farms differentiated by region, type, size and other characteristics* [Lampkin, (1994), pag. 33]". According to Offermann and Nieberg (2000), this methodology has the advantage of minimizing the risk of including external aspects ("non-system determined") that can affect the results because comparability is guaranteed by the fact that organic and conventional farms show a similar "potential" endowment. However, a drawback of this approach is the risk of emphasising the well-known problem of *sample selection bias* (Esposti, 2007).

The variables used in DEA were defined as follows:

Y *Output*	represents the value of production by each farm (€);
x_1 *Land*	is the total amount of cultivated land by each farm (Ha);
x_2 *Labour*	represents the total amount of used labour (man-hours);
x_3 *Machinery*	is the annual utilisation of machinery expressed as annual mortgage quota (€);
x_4 *Other capital*	is the total amount of fixed capital expressed as annual mortgage quota (€);
x_5 *Technical inputs*	is the expenditure on fertilizers, pesticides and other technical inputs (€);
x_6 *Other expenditures*	is the value of other expenditures by each farm (€).

4. Empirical findings

Efficiency measures carried out using the Deap 2.1 program created by Coelli (1996).

The analysis was conducted, in a first step, assuming separate frontier functions for organic and conventional farms and, in a second step, refereeing TE to a unique production frontier for the two agronomic techniques. The purpose was to estimate the "distance" between organic and conventional fruit-growing farmers in terms of productivity.

Indeed, a critical point in this sort of analysis is to verify if organic and conventional farms operate on a substantial technological homogeneity[13]. Using a non parametric approach, refereeing efficiency analysis both to a unique reference frontier and to

12 Part of the research findings on olive-growing farms are reported in Cisilino and Madau (2007)

13 See Oude Lansink *et al.* (2002) and Madau (2007) for more information on this point.

separate (organic and conventional) frontiers could lead to a more realistic interpretation of TE. This interpretation consents to evaluate if the higher TE of conventional (organic) farms is originated by a best input use or by higher productivity.

In the first step, the underlining hypothesis is the non-technological homogeneity between the two agronomic methods. Efficiency measures cannot therefore be directly comparable and reflect the farmers' ability with respect to their own specific frontiers. On the contrary, the second TE measure also takes into account the productivity effect on the farm performance, and permits to estimate which type of farmers reveal a better overall ability in using their disposable inputs.

***Figure 2**. Input-oriented technical efficiency of different technologies*

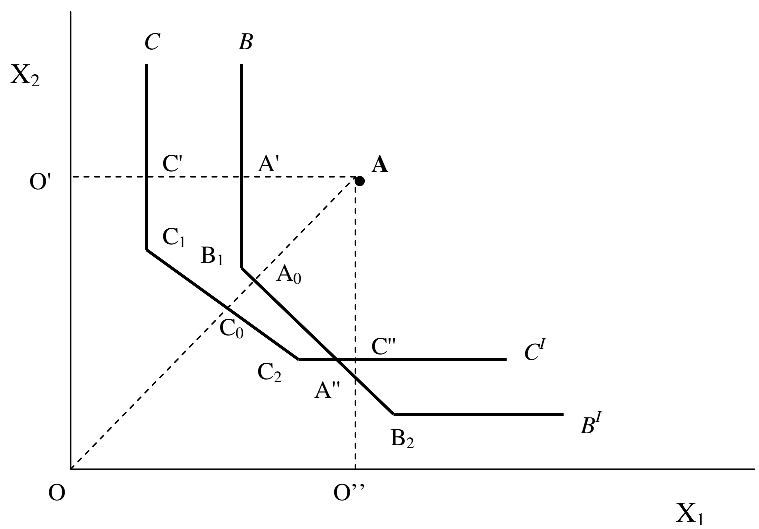

Figure 2 illustrates measurement of overall and specific TE, considering Farrell's (1957) efficiency model. Using DEA and assuming a production function with two inputs (X_1 and X_2) and one output, we can build a piecewise linear isoquant for organic (BB') and conventional (CC') farms separately[14].

If A is an observed organic farm, the TE measure relative to the organic frontier is given by:

(5) $$TE_o = \theta = OA_0 / OA$$

On the other hand, the piecewise envelopment of the two isoquants BB' and CC' – in which, for example, efficient farms are labelled C_1, C_2 and B_2 - represents the overall frontier for both technologies (organic and conventional). It is a consequence that the TE measure relative to all farms is given by:

14 In this case, conventional farming technology is assumed to be more productive than organic technology.

(6) $$TE_{all} = \theta_0 = OC_0 / OA$$

The TE_{all} measure is related to the TE_o measure by a productivity factor (φ) indicating the difference between the conventional and organic farming frontiers (Färe *et al.*, 1985):

(7) $$\theta_0 = \theta * \varphi$$

Therefore, we can obtain a productivity measure for the two groups as the ratio of TE relative to the reference group frontier (in this case the organic frontier) and the aggregate TE measure (Seiford and Thrall, 1990):

(8) $$\varphi = \theta_0 / \theta = TE_{all} / TE_o \qquad 0 \leq \varphi \leq 1$$

The nearer φ is to unity, on average, the more it indicates that the organic (conventional) technology is close to the overall general farming frontier. If the difference between the specific conventional and organic φ measures is appreciable, it means that the two techniques operate on a different technological level (no technological homogeneity).

The results are reported in table 6.

The non parametric Mann-Whitney *U*-test on efficiency and productivity difference was conducted to evaluate statistical significance between conventional and organic fruit-growing farms (Tab. 7).

The results suggest that, as expected, organic fruit-growing farmers are using less productive technology than conventional ones. Under a *variable return of scale* hypothesis, φ for the conventional sample is close to unity (0.968), indicating that these farms use a productive technology (for all inputs). On the contrary the corresponding measure for the organic farms is significantly lower (0.799) and suggests the presence of a productivity gap between the two agronomic methods.

With regards to TE, as we can see in table 6 the overall VRS score relative to their reference group is 0.727 and 0.673 for organic and conventional farms respectively. Since the difference between the two techniques is significant ($\alpha \leq 0.10$) it implies that organic fruit-growing farmers – despite using a less productive technology - show a better ability to utilize their disposable resources than conventional farmers. In other words, organic farmers could reduce the use of all inputs relative to their own frontier by about 27%, whereas this margin is about 33% for conventional farmers.

This evidence also indicates that TE in the organic group varies less than in the conventional sample, i.e. the conventional farms are more heterogeneous (with respect to the TE distribution in the sample) than the organic ones.

Specific scale efficiency (SE) is significantly different in organic fruit-growing's favour (0.825 vs. 0.781). This suggests that the influence of farm size on technical inefficiency is more relevant in conventional farms than in organic ones. Adjusting the scale of the operation, organic farms could improve their efficiency by about 17%, while the margin would be about 24% for conventional farms.

Efficiency analysis on a unique frontier shows a "distance" of about 5 percentage points between the two methods. TE^{VRS} measured relative to all farms reveals that organic (conventional) farms could reduce the use of their inputs by about 41% (about 36%), leaving aside their used technology. This means that organic farmers are able to partially compensate for their technical disadvantage with higher (specific) efficiency in input use.

***Table 6** – Technical efficiency, scale efficiency and productivity scores*

MEASURE		CRS	VRS	SE
		REFERENCE GROUP (SEPARATE FRONTIERS)		
TE organic	Mean	0.605	0.727	0.825
	s.d.	*(0.263)*	*(0.239)*	*(0.190)*
TE conventional	Mean	0.511	0.673	0.781
	s.d.	*(0.247)*	*(0.257)*	*(0.232)*
		GENERAL GROUP (UNIQUE FRONTIER)		
TE organic	Mean	0.452	0.586	0.776
	s.d.	*(0.249)*	*(0.254)*	*(0.216)*
TE conventional	Mean	0.486	0.637	0.781
	s.d.	*(0.244)*	*(0.254)*	*(0.233)*
		PRODUCTIVITY		
φ organic	Mean	0.741	0.799	
	s.d.	*(0.175)*	*(0.171)*	
φ conventional	Mean	0.972	0.968	
	s.d.	*(0.254)*	*(0.251)*	

Despite the statistical significance, the average difference between conventional and organic fruit-growing is appreciably less than the distance in terms of productivity (as shown above, about 17 percentage points).

***Table 7** – U-test statistics (z values) for differences in the TE^{CRS}, TE^{VRS}, SE scores*

	CRS	VRS	SE
TE all	-1.590	-1.772	-0.152
p value	*0.112*	*0.076*	*0.871*
TE specific	-3.048	-1.816	-2.730
p value	*0.002*	*0.069*	*0.010*
Productivity	-10.373	-7.655	
p value	*0.000*	*0.000*	

It implies that organic farmers achieve an absolute TE close to the conventional farmers score due to a more rational use of their inputs.

On the other hand, there are no differences in terms of SE (both scores are equal to 0.781). Imposing the NIRS condition to (4), it follows that most of the farms exhibit an increasing return of scale in both sub-samples (more than 90% in both types of farm). The cost inefficiency of fruit-growing farms could therefore be reduced by exploiting economies of scale in a size increase direction.

As underlined by Cisilino and Madau (2007), these results might appear surprising, but this pattern stands out in other studies on organic farming efficiency (Oude Lansink *et al.*, 2002; Cisilino and Madau, 2007; Tzouvelekas *et al.*, 2001a; 2002a; 2002b*)*[15]. A common underlying rationale is that producers believe that productivity is not high in organic farming and could force them to pay more attention to input use in order to compensate for the production deficit.

The lack of other empirical results in the literature on comparative efficiency between organic and conventional fruit-growing farms does not permit these results to be compared with other situations. However, as evidenced in some comparative studies, the higher specific efficiency seen in organic farms could also be a logical consequence of the fact that the farmers were producers who had knowingly and actively chosen the organic method. In other words, they have the right technical and professional skills to use the technical inputs efficiently.

On the other hand, although the observed organic farms show more efficiency than the conventional ones, their overall efficiency is in effect not entirely satisfactory. This would suggest that there is an ample margin for increasing managerial and technical skills to improve performance in organic fruit-growing so as to adequately compensate for the gap in terms of productivity (compared to conventional practices).

5. Conclusions

Organic and conventional farming can be defined as two different entities, mainly because of a formal difference, which becomes substantial when a comparison of business performances is made. Organic farms must observe Reg. EC 2092/91 and Reg. EC 1804/99, whereas conventional farms have the opportunity to adopt natural products without any obligation. This study highlights the main differences of those two productive methods, trying to measure the distance. It turns out that there are few differences.

Taking into consideration the profit and efficiency of the production factors, the economic indices show opposite results if reported to *cultivated area* or to *total labour force*. In the former case the results are always in favour of conventional farms. This could explain the greater extension of the organic farms in terms of cultivated areas (as also emerges from the structural indices), but would also mean lower revenues. Other indexes reveal that the profit in organic farming is guaranteed not only by the typical production processes, but also by extra-farming activities, even if in general, business profits (Net Margin/Gross Production) remain higher for the conventional farms.

Frontier analysis on a sample of Italian fruit-growing farms showed that organic farms have significantly higher efficiency measures than conventional ones (with respect to their own frontiers) but productivities that are, on average, significantly lower than the corresponding conventional values. It suggests that conventional fruit-growing farms adopt a more productive technology but that organic farms are able to partially compensate for this through a more efficient use of their disposable inputs.

These finding are in accordance with some empirical results from studies conducted on other farming activities. However, further research is needed to gain more insight into the long-term development of organic farms.

15 Other studies – *e.g.* the analyses of Tzouvelekas *et al.* (2001b) on cotton farms and Madau (2007) on Italian cereal farms – found that organic farming does not attain compensation for the lower productivity with more efficient input use.

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