Bulgarian Journal of Agricultural Science, 28 (No 1) 2022, 36–41

Farms specialization, economic size and technical efficiency in Italian farms using a non-parametric approach

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Abstract

Galluzzo, N. (2022). Farms specialization, economic size and technical efficiency in Italian farms using a non-parametric approach. *Bulg. J. Agric. Sci., 28 (1)*, 36–41

Italian farms are characterized by small dimensions in terms of land capital endowment and also in terms of economic size that are two bottlenecks influencing the technical efficiency. The main purpose of this paper was to assess by a non-parametric input-oriented model the technical efficiency in all Italian farms since 2004 to 2019 investigating if the farms specialization and economic size are pivotal variables influencing the technical efficiency. Results have underlined as the dimension of farms in terms of economic size is not so determinant for the technical efficiency. By contrast, the specialization of farms is the main factor able to act to the technical efficiency. In fact, horticulture farms have had the highest level of technical efficiency and the mixed farms the lowest. This research has partially filled the gap in the Italian economic literature investigating the relationships between economic dimension of farms and technical efficiency.

Keywords: Data Envelopment Analysis; Common Agricultural Policy; second pillar; labour; small farms

Introduction

The endowment of land capital is the most important variable to influence the production of farms and the technical efficiency. In some European countries such as Italy, Romania, Malta the main bottlenecks in farms is the land capital and the fragmentation of usable agricultural areas (UAA). The average value of Usable Agricultural Area (UAA) assessed in all European Union states has been equal to 12.6 ha (Galluzzo, 2017). In Italy, the average value of land capital in farms is close to ten hectares with negative implications to the technical efficiency and negative impacts on the socio-economic development of rural areas (Galluzzo, 2013; 2017). It is important to underline as the vast majority of farms belongs to smallholder farmers managed and owned by a unique farmer and its family members (Galluzzo, 2016; 2017).

A literature review has been carried out in several European nations such as Italy, France, Slovenia, Hungary and Poland technical and allocative efficiency is influenced by the crop specialization, by the agri-environmental policy (organic system of production), by the typology of ownership and by the dimension of farm in terms of land capital endowment (Cisilino et al., 2021; Galluzzo, 2017; 2013; Latruffe et al., 2004; 2008; 2012; 2017; Gorton & Davidova, 2004; Latruffe & Nauges, 2014; Bojnec & Latruffe, 2008; 2009; Garrone et al., 2019). Nowak et al. (2015) have assessed the technical efficiency in all EU countries. According to these authors, the technical efficiency in the different states diverges with the highest values in some countries as Cyprus, Denmark, Greece, France, Spain, the Netherlands, Luxembourg, Italy and Malta due to different factors influencing the technical efficiency even if the size of the farm did not impact the technical efficiency.

In Italy findings on technical efficiency and other variables as farm size, typology of ownership and efficiency have corroborated as small family farms typical of the agrarian productive fabric have been less technical efficient

that the large farms (Galluzzo, 2013; 2017; Cisilino et al., 2021). Furthermore, in Italian farms the choices of farmer to be involved in agri-environmental policy and the crop specialization have acted to the technical efficiency (Madau, 2007; 2010; Madau et al., 2017). Madau (2007; 2010) has argued as in farms specialized in arborous crops, farms size, land capital fragmentation, age of farmers and location of farms has influenced the level of efficiency. However, organic farming has increased the technical efficiency compared to the conventional one in particular in small Italian farms specialized in olive productions and the factors pushing the decision to be part in organic process of production is driven by the intensity of labor and machines while farm localization is a factor discouraging the conversion to the organic system (Raimondo et al., 2021).

In Italian literature few studies only have investigated if there is a nexus between farm dimension, in terms of economic size, and farms specialization and technical efficiency (Galluzzo, 2013; 2017). In this field of study, findings in small farms managed by only one entrepreneur have pointed out as small family farmers are able to maximize some inputs as the labour with the consequence of minimizing the economic and entrepreneurial risk (Bielik & Rajčániová, 2004; Latruffe et al., 2004; Bojnec & Latruffe, 2008). In fact, the diversification in farms typical of small farms reduces the socio-economic marginalization in less favored areas and the permanent emigration from rural areas (Galluzzo, 2013). Forleo et al. (2021) have argued as diversified Italian farms are able to improve their performances even if the location of farms and its size are important in the technical efficiency performances of Italian farms (Alvarez & Arias, 2004).

Nevertheless, the role of farms specialization and economic dimension in Italian farms are unclear and this is the novelty of this research: to fill the gap in literature about the relationship between economic dimension of farms, specialization and technical efficiency. Focusing the attention to the dimension of farms in terms of usable agricultural areas but not in terms of economic size, research's outcomes have pointed out as the dimension of farms is not fundamental in the technical efficiency (Hall & LeVeen, 1978; Kumbhakar et al., 1991; Kumbhakar & Dunbar, 1993). On the contrary, the management, the organization and the allocation of production factors as labor input and assets are fundamental to impact to the technical efficiency (Bielik & Rajčániová, 2004; Latruffe et al., 2004). Drawing some conclusions about the role of CAP subsidies and technical efficiency in literature the effect is mixed and sometimes unclear (Minviel & Latruffe, 2017; Garrone et al., 2019). Furthermore, Kleinhanss et al. (2007) have highlighted that there is a positive impact of financial supports, allocated by the Common Agricultural Policy, towards the productive specialization and efficiency (Galluzzo, 2017); other studies have also corroborated as between productive specialization and technical efficiency there is a relationship (Błażejczyk-Majka et al., 2012).

Aim of the Research

The first and most important purpose of this paper was to estimate by a quantitative approach in a sample of Italian farms part of the Farm Accountancy Data Network, over the time 2004-2019, if farming specialization and the economic size of farms have influenced the technical efficiency of Italian farms. The main goal of this study was to assess if small farms, in terms of economic size, have been less technical efficient than the large ones and if the high specialized farms in horticulture, wine and milk have been more technical efficient than the mixed farms. The policy implications are important in suggesting if small farms need of more attention about the allocation of subsidies than the large ones because of the modest values of technical efficiency.

Methodology

Since the early 1960s, the European Union has arranged an annual survey with the purpose to evaluate the impact of the Common Agricultural Policy payments on the farmer's income and other economic and managerial aspects in a sample of European farms (European Union, 2017; Galluzzo, 2017). Using the Italian FADN dataset by the software R, package rDEA, this study has investigated if the farming specialization and the economic size have impacted the technical efficiency.

The assessment of technical efficiency can be done using two different quantitative approaches as a parametric or stochastic frontier modelling (SFA) or a non-parametric model as the Data Envelopment Analysis or DEA method (Farrell, 1957; Aigner et al., 1977; Lovell, 1993; Coelli et al., 2005; Battese & Coelli, 1992; 1995; Kumbhakar et al., 2015). In this paper it has used the DEA approach that does not need *a priori* specifications in the model (Coelli et al., 2005; Lovell, 1993). The estimation of technical efficiency has used an input oriented variable returns to scale DEA model with the aim to minimize the inputs that can be modified by the farmer (Chavas & Aliber, 1993; Galluzzo, 2017). The sample is made up of farms from each of the 20 Italian regions since 2004 to 2019 stratified in function of their economic size, in terms of standard output from 2000 – 8000 euro to more than 500 000 and in function of their productive specialization as field crops, horticulture, wine, other permanent crops, milk, other grazing livestock, granivores and mixed.

The Data Envelopment Analysis model assumes certain constraints, namely that there are *n* farms or Decision Makin Unit (DMU) producing a well-defined quantity *s* of output *y* in such a way that $y \in RS^+$ by using several *m* inputs combined in a multiple arrangement and in combination of $x \in R^+$ (Galluzzo, 2013; 2017; Charnes et al., 1978; Banker et al., 1984; Cooper et al., 2007). Charnes et al. (1978) have proposed as the technical efficiency of each DMU can be estimated by solving a linear programming problem with the goal to minimize in an input-oriented approach the inputs in the production process in the dual forms (Charnes et al., 1978; Banker et al., 1984; Coelli et al., 2005; Battese & Coelli, 1992; 1995; Galluzzo, 2017; Cooper et al., 2007), that can be expressed as:

$$\min \theta_k^c - \varepsilon\left(\sum_{i=1}^{s} S_i^- + \sum_{r=1}^{m} S_r^+\right) \quad (1)$$

$$s.t. \ \sum_{j=1}^{n} \lambda_j \, x_i \ + S_i^- = \ \theta_0 \, x_{ik}, \ i = 1, 2 \ldots, m,$$

$$\sum_{j=1}^{n} \lambda_j \ x_i \ + S_i^- = \ \theta_0 \ x_{ik}, \ i = 1, 2 \ldots, m, \quad (2)$$

$$\sum_{j=1}^{n} \lambda_j \, y_{ij} - S_r^+ = y_{rk}, \ r = 1, 2 \ldots, s, \quad (3)$$

$$\theta_k^c, \lambda_j, S_i^-, S_r^+ \geq 0,$$

where λ is a semi-positive vector in R^k.

In each DMU the estimation of the technical efficiency has been made by the parameter θ which is the level of technical efficiency. A value equal to 1 implies the optimal combination of inputs and output; ε represents a non-Archimedean infinitesimal to overcome some issues linked to testing multi-optimum solutions in the model of solving the minimisation problem (Charnes et al., 1978); λ is a convex coefficient in the input *x* in each DMU producing a level of output *y* in each farm (Coelli et al., 2005; Battese & Coelli, 1992; 1995; Cooper et al., 2007). S_r^+ and S_r^- are non-negative output and input slacks; drawing some methodological conclusions, if θ is equal to 1 and all input and output slacks are equal to zero the investigated DMU is technically efficient (Cooper et al., 2007; Charnes et al., 1978; Banker et al., 1984; Coelli et al., 2005; Battese & Coelli, 1992; 1995). By contrast, if θ is not equal to 1 there is an inefficient allocation of inputs for the produced output or rather the farm uses an excess of input producing the same level of output.

Results and Discussion

The investigated sample is made by 1620 farms located in all Italian region and predominately in Tuscany (185 farms), Friuli Venezia Giulia (131) and Emilia Romagna (115). The input and output values in euros have been deflated using the data published by Eurostat hence, this study has compared the input and output in constant value base year 2015. The descriptive statistics have pointed out an average value of usable agricultural area close to 36 ha with some farms specialized in horticulture near to one hectare and field crops farms with a land capital endowment close to 450 ha (Table 1). The assets have been in average close to 670 000 euro with significant fluctuations among Italian regions and type of farming. The produced output has been close to 124 000 euro with the lowest value close to 7000 euro and the highest value equal to 1.9 million of euro. The incidence of the payments allocated by the Common Agricultural Policy has been in average value close to 14 000 euro made predominately by the payments disbursed by the first pillar of the CAP; by contrast, the financial subsidies allocated by the second pillar of the CAP have been lower in average value to 3000 euro.

The average value of technical efficiency estimated in all Italian farms has been equal to 0.617 that means an inefficient use of all inputs combined in the productive process of 47.2% hence, the farms produce the same quantity of output using an excess in input. In the Italian FADN sample more than 36% of farms are part of the range of technical efficiency

Table 1. Main descriptive statistics on Italian farms over the time 2004-2019

Variable	Obs	Unit	Mean	Std. dev	Min	Max
Labor	1620	hour	4.155 90	2.816 22	917.91	34.937 57
UAA	1620	hectare	35.50	45.55	0.44	490.08
Total input	1620	€	76.555 17	132.916 70	4.442 00	1.323.132 00
Assets	1620	€	669.066 60	816.874 40	61.514 00	87.772.182 00
Total output	1620	€	124.111 90	184.850 80	7.137 00	1.907.323 00
Total CAP	1620	€	13.914 24	20.399 96	–	272.307 00
First pillar subsidies	1620	€	11.063 86	18.120 86	–	269.759 00
Second pillar subsidies	1620	€	2.850 38	5.214 70	–	68.607 00

Source: author's elaboration on data Italian FADN published on https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

between 0.61 – 0.70 and only 22 farms out of 1620 have had a value of technical efficiency equal to the optimal threshold of 1 (Table 2). Findings have pointed out that there are not farms with a technical efficiency very poor under 0.30.

Table 2. Summary of the technical efficiency investigated in all Italian farms

Range	n° of farms	%
0.30-0.40	12	0.74
0.41-0.50	189	11.67
0.51-0.60	597	36.85
0.61-0.70	522	32.22
0.71-0.80	192	11.85
0.81-0.90	56	3.46
0.91-0.99	30	1.85
1.00	22	1.36

Source: author's elaboration on FADN data published on https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html)

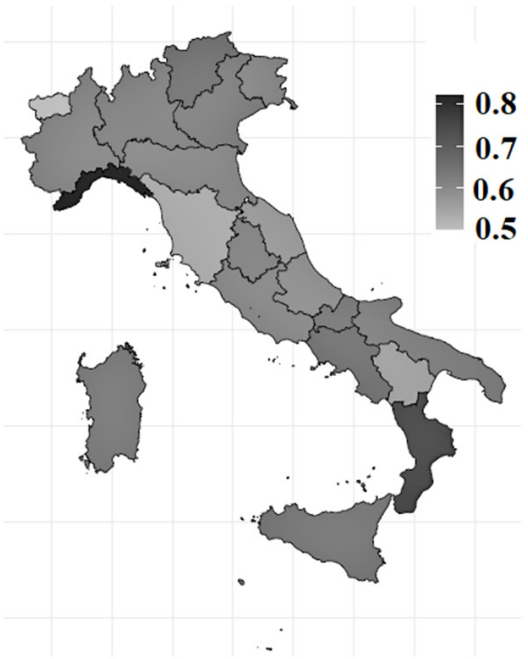

Fig. 1. Average value of technical efficiency in all Italian regions over the time 2004-2019

Source: author's elaboration on FADN data published on https://agridata.ec.europa.eu/extensions/FADNPublicDatabase /FADN-PublicDatabase.html)

Addressing the attention to the different Italian regions it emerges as the highest value of technical efficiency has been found in Liguria regions in the north-west of Italy with a technical efficiency close to 0.82 (Figure1). In this region are concentrated predominately farms specialized in horticulture. By contrast, the lowest value of technical efficiency has been found in Valle d'Aosta in the north-west as well. Findings have pointed out as the vast majority of the farms located in the north of Italy have been characterized by higher values of technical efficiency and this is the consequence of a large diffusion of farms specialized in milk and other grazing livestock, in wine and in field crops.

Comparing the different type of farming in Italian farms part of the FADN dataset, it merges as the highest average value of technical efficiency has been found in horticulture farms and by contrast the lowest value has been found in farms specialized in mixed farms that have not a well define agricultural production (Table 3). Italian farms specialized in wine and in other permanent crops have had the same level of technical efficiency equal to 0.63. Farms specialized in granivores or rather in chicken and pig farming has had in average value a technical efficiency close to 0.74.

The last part of the research has been addressed in estimating if the economic size of farms in terms of standard output has been correlated to the technical efficiency in all Italian farms since the time 2004-2019. In general, small farms classified in the cluster of standard output between 2000-8000 euro have had the highest level of technical efficiency equal to 0.766 in a range min-max between 0.64 – 1 (Table 4). In the same time, findings have underlined as farms classified as large farms with an economic size above 500 001 euro have had an average value of technical efficiency close to 0.72.

Table 3. Technical efficiency in all Italian type of farming since 2004 to 2019

Type of farming	n°	Mean	St. dev	Min	Max
Fieldcrops	589	0.606	0.085	0.385	0.965
Horticulture	52	0.851	0.134	0.545	1.000
Wine	215	0.635	0.112	0.391	1.000
Other permanent crops	312	0.632	0.121	0.392	1.000
Milk	139	0.567	0.087	0.372	0.805
Other grazing livestock	234	0.580	0.091	0.362	0.866
Granivores	40	0.739	0.148	0.524	1.000
Mixed	39	0.530	0.072	0.413	0.724
Total	1620	0.617	0.114	0.362	1.000

Source: author's elaboration on FADN data published on https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html)

Table 4. Economic size and technical efficiency in all Italian farms

Economic size (€)	n°	Mean	St. dev	Min	Max
2000 – 8000	18	0.766	0.116	0.642	1.000
8001 – 25 000	393	0.638	0.124	0.403	1.000
25 00 1 – 50 000	380	0.589	0.107	0.362	0.966
50 001 – 100 000	345	0.587	0.093	0.386	0.916
100 001 – 500 000	441	0.631	0.106	0.437	1.000
> 500 001	43	0.716	0.153	0.420	1.000
Total	1620	0.617	0.114	0.362	1.000

Source: author's elaboration on FADN data published on https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html)

Conclusions

Drawing some final remarks, the study has pointed out as in Italy there is a significant dichotomy about regions in function of their productive specialization and in general farms specialized in horticulture have had the highest level of technical efficiency due to a significant concentration of investments in assets such as machinery and in greenhouses. Italian farms specialized in field crops have had an average value of technical efficiency lower than farms specialized in other permanent crops. In field crops farms have been very important the financial subsidies allocated by the first pillar of the Common Agricultural Policy that represented a tool to reduce the risk of investments in farms. The role of the direct payments allocated by the second pillar of the CAP has been fundamental for small farms located in disadvantaged rural areas and for farms classified under 8.000 euro of standard output. In general, decoupled payments and other direct subsidies disbursed by the Common Agricultural Policy have represented a good opportunity for farmers to improve investments in farms and their technical efficiency even if the labour input has been very intense in all investigated Italian farms. In fact, in average every farm has employed more than 4.000 hours of workforce in farm.

In general, the dimension of farms, in economic size, did not represent a constraint in the technical efficiency according to which the smaller is the dimension of farm the poorer is the level of technical efficiency. In fact, small farms have been more technical efficient than the large farms in terms of economic size. This has implied an efficient allocation of input in small farms compared to the other clusters of enterprises investigated in this paper.

The specialization of farms has been a driver able to influence the technical efficiency of farm. In fact, in the investigated sample farms specialized in the mixed production have had the lowest level of technical efficiency due to a diversification in farms which has represented a tool in reducing the inefficiency and in increasing the level of income.

In conclusion, this analysis has filled the gap in Italian literature about the role of farm specialization and economic dimension of farms to the technical efficiency comparing the different Italian regions over the time 2004-2019. However, one of the main bottlenecks of the DEA is to define the level of technical efficiency in farms without explaining which input or output are involved in the inefficiency patterns in terms of excess of input and output.

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Received: November, 4, 2021; *Accepted:* December, 7, 2021; *Published:* February, 2022