Effects of Farm Specialisation, Environmental Subsidies and Agri-Districts on Technical Efficiency in Italian Farms

Nicola Galluzzo
Association of Geographical and Economic Studies of Rural Areas (ASGEAR) – Rieti, Italy
E-mail: asgear@libero.it

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Abstract

Since the early 2000s, Italy has seen a significant increase in the number of agri-districts and rural districts focused on stimulating the production of Ag commodities and high-quality foods that have a low environmental impact. The core purpose of this study is to assess the impact that financial subsidies, allocated under the first and second pillars of the Common Agricultural Policy in the form of environmental payments and subsidies to disadvantaged rural areas, have had on Italian farms in the period from 2004 to 2017. To this end, the study has made an analysis of technical efficiency using a non-parametric approach (DEA) and an analysis of the total factor productivity (TFP), based on a sample of data from the European Farm Accountancy Data Network. By employing a two-step approach for the estimation of the DEA, it has been possible to assess the role of ag-districts and the recognition of certified quality foods on technical efficiency, filling the gap in knowledge regarding the effect that environmental subsidies have on influencing technical efficiency in farming. Drawing some conclusions, the analysis has highlighted an uneven distribution of technical efficiency between various Italian regions and typologies of farming, with a differing impact of financial subsidies allocated under the first and second pillars of the Common Agricultural Policy, both in regards to the technical efficiency of farms and also in relation to environmental protection.

Key words: Data Envelopment Analysis; Common Agricultural Policy; FADN; two-stage DEA

Ефекти от специализацията на фермите и субсидиите за околната среда и аграрните райони за техническата ефективност на италианските ферми

Никола Галузо
Асоциация за географски и икономически изследвания на селските райони (ASGEAR) – Риети, Италия
E-mail: asgear@libero.it

Резюме

От началото на 2000-те години в Италия се наблюдава значително увеличение на броя на селскостопанските области и селските райони, фокусирани върху стимулирането на производството на селскостопански стоки и висококачествени храни, които имат ниско въздействие върху околната среда. Основната цел на това проучване е да се оцени въздействието, което финансовите субсидии, разпределени по Първия и Втория стълб на Общата селскостопанска политика под формата на екологични плащания и субсидии за селските райони в неравностойно положение, са оказали върху италианските ферми в периода от 2004 г. до 2017 г. За тази цел на изследването е направен анализ на техническата ефективност, като са използвани непараметричен подход (DEA) и анализ на общата факторна производителност (TFP), въз основа на извадка от данни от Европейската мрежа за счетоводни данни на земеделските стопанства. С помощта на двустепенния подход за оценка на DEA се оценява ролята на аграрните области и признаването на сертифицирани качествени храни върху техническата ефективност, запълвайки пропуските в знанията относно ефекта, който субсидиите за околната среда имат върху техническата ефективност в земеделието. Правейки някои изводи, анализът подчертава неравномерното разпределение на техническата ефективност между различните италиански региони и типологиите на земеделието, с различно въздействие на финансовите субсидии, разпределени по Първи и Втори стълб на Общата селскостопанска политика, както по отношение на техническата ефективност на фермите, така също и във връзка с опазването на околната среда.

Ключови думи: анализ на обхвата на данните; Обща селскостопанска политика; FADN; двуетапен DEA

Introduction

As a consequence of the reforms made to the Common Agricultural Policy, the role and function of farms has completely changed since 1992. Nowadays farmers have been assigned a fundamental role in environmental protection which has to be compensated by a specific public policy, both at national and also international level. As Galluzzo has noted (2017), various scholars have assessed technical efficiency in European farming through a quantitative approach using the Farm Accountancy Data Network dataset, addressing their scope of research to comparing technical efficiency either between different countries or different typologies of farming specialisation (Veveris et al., 2007; Latruffe et al., 2012; Latruffe and Nauges, 2014; Galluzzo, 2015; 2019a; Bojnec and Latruffe, 2008). The main target of studies concerning technical efficiency in farming has been to assess if there are some nexus among farm size, crop specialisation, typology of farm, and the levels of technical and economic efficiency in different European countries (Bielik and Rajcaniova, 2004; Latruffe et al., 2004; Galluzzo, 2017). In 2017, Minviel and Latruffe investigated the impact of different financial subsidies allocated through the Common Agricultural Policy on the technical efficiency of a number of European farms included in the FADN dataset. These authors argued that the effect of financial payments aimed at environmental protection allocated by the CAP has been decidedly mixed, with negative, null, and positive effects found in six, one, and four cases, respectively, from a sample of 195 observations carried out in studies published in main journals between 1986 and 2014. At the same time, Zhou et al. (2018), widening the field of investigation by considering the relationships between technical efficiency and sustainability through a quantitative, citation-based approach for the years 1996 to 2015, found a sharp increase in the number of studies published regarding these topics over the period investigated.

It is important to know the effect of financial subsides allocated by public interventions on technical efficiency. In fact, according to Kumnhakar and Lien (2010), subsidies have both a positive impact on efficiency and a negative impact on productivity, and policymakers need to address this when defining specific agricultural policies. Kumbhakar and Lien in 2010 focused their attention on decoupled and coupled subsidies, and argued that these aids influenced the growth of farms, and their opportunity to remain or exit the productive process, while also influencing investment decisions. Conversely, coupled subsidies can reduce the use of inputs in farms and, subsequently, productivity, while also representing a positive opportunity for innovation in farms. Focusing attention on productivity, the effect of subsidies is inconclusive and unclear; while productivity is influenced by the typology and structure of the fund rather than the total amount allocated by the public policy, subsidies generally have positive effects on production and negative effects on total factor productivity (Bazyli and Katarzyna, 2017; Rizov et al., 2013).

A comparative study among all European countries over time aimed at estimating the technical efficiency in agriculture, carried out in 2017, revealed that the non-parametric approach represents a powerful tool for investigating performance in agriculture, even if there is a hiatus between the old member states of the EU and the new ones, with a few exceptions due to the influence of external variables such as the quality of the soil, and the age, skills base, and education level of the farmers (Laurinavičius and Rimkuvienè, 2017; Nowak et al., 2015). Meanwhile, the size of farms has a more direct impact on the technical efficiency of farms than their particular specialisation, both in countries within the European Union and also other countries outside (Galluzzo, 2013; Mugera and Langemeier, 2011), and the size of farms and the degree of their specialisation have been found to produce both positive and negative changes in technical efficiency (Zhu and Lansink, 2010). Nevertheless, in general, the notion that the physical dimension of farms represents an important element in the protection of the environment is well-rooted in public opinion. According to this idea, the smaller the size of farms, the greater the level of environmental protection they offer, hence the financial support allocated to them should be different in order to better promote the protection of the environment through an increase in investments and eco-efficiency in the countryside (Czyżewski et al., 2018). However, some recent investigations regarding the CAP have detected a repositioning, towards a policy where the key elements are linked to the environmental aspects which are central in the European Union's new greening approach (Erjavec and Erjavec, 2015).

In the Netherlands, a study investigating the impact of agri-environmental subsidies to farms has highlighted that, using a different quantitative approach such as the hyperbolical approach, farms that do not receive any support are less efficient, since there is a significant decrease in desired output which influences their overall efficiency (Skevas et al., 2018). In other European countries, the payment of agri-environmental subsidies does not seem to positively impact the total factor productivity and, in the main, the inputs and outputs involved (Baráth et al., 2020). Meanwhile, in France, subsidies allocated to farmers within the framework of the single farm payment, which have no connection to the level of production yield, have increased the level of technical efficiency (Ayouba et al., 2017).

A recent overview of the main relationships between financial subsidies in agriculture and productivity in EU farms was presented by Garrone et al. in 2019. Focusing their attention on the financial subsidies allocated under the second pillar of the CAP, these authors found that investments aimed at increasing human and physical capital can reduce costs, thus increasing productivity. Drawing some conclusions, agri-environmental measures can be said to have a broadly negative impact on both productivity and efficiency, due to the significant reduction in the use of certain chemical products such as fertilisers and the adoption of alternative farming practices, even if the effect is so far unclear and not yet deeply investigated in Italian farms. This research, therefore, was aimed at filling the gap in knowledge concerning the effect of agri-environmental subsidies on Italian farms, considering whether such exogenous variables as the recognition of products as certified quality foods and the establishment of rural agri-districts based on less environmentally invasive practices are able to positively influence the technical efficiency and productivity of farms.

The core purpose of this study was to assess the impact of financial subsidies allocated under the first and second pillars of the Common Agricultural Policy, such as environmental payments and subsidies to disadvantaged rural areas (LFA payments), on the technical efficiency and the total factor productivity of Italian farms in the period from 2004 to 2017. The secondary objective of the research was to assess if the level of specialisation was a significant stimulus in relation to technical efficiency, and which financial subsidies had a relationship to the typology of farming (TF) over this time. The novelty of this research lies in the attempt to investigate, in an Italian context, the impact of agri-environmental subsidies and LFA payments on technical efficiency in different typologies of farming. Furthermore, this research fills the gap in assessing if certain environmental variables such as certified quality food and rural agri-districts have an influence on technical efficiency. One of the main implications for policymakers is the assessment of whether the instigation of agri-districts and the concentration of products with Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) status are able to stimulate an increase in technical efficiency in farming. Furthermore, this research is able to suggest to policymakers which variables in the second pillar, such as LFA subsidies and agri-environmental payments, could be useful for increasing technical efficiency in Italian farming, compared to the total subsidies allocated under the first pillar of the CAP based on inputs.

Material and methods

The assessment of technical efficiency can be estimated using two methods, namely through a parametric or stochastic modelling (SFA) or a non-parametric modelling using the Data Envelopment Analysis (DEA) method (Farrell, 1957; Lovell, 1993; Coelli et al., 2005; Battese and Coelli, 1992; Kumbhakar et al., 2015). The first requires a specific and well-defined function and other a priori specifications (Coelli et al., 2005; Lovell, 1993) while, in contrast, the DEA estimates multiple inputs and multiple outputs without defined functions of production (Coelli et al., 2005; Bravo-Ureta and Pinheiro, 1993; Galluzzo, 2019a; 2019b). In this paper, the DEA approach in an input oriented variable returns to scale (VRS) model has been used with the aim of minimising inputs in each Decision Making Unit (DMU) of observation, which are represented by Italian farms included in the Farm Accountancy Data Network (Galluzzo, 2013; 2015; 2019a; Chavas and Aliber, 1993). For current purposes, the VRS has been used in order to also assess the pure technical efficiency that is fundamental in the Malmquist estimation of total factor productivity (Banker et al., 1984; Zhu, 2000). As these authors have noted, the PE is the ratio of the technical efficiency, estimated under the constant returns to scale (CRS) assumptions, to the technical efficiency assessed under the VRS assumptions (Galluzzo, 2019b). The sample is made up of a panel data of farms from 21 Italian regions over 14 years of observation (2004–2017), grouped into the 8 main typologies of farming as defined by the FADN for both the 2008 and 2017 years, and involves 2,301 observations, considering that using panel data does not imply a significant advantage of SFA over DEA that allows the use of multiple outputs (Ruggiero, 2007). As proposed by both Charnes et al. (1978) and Banker et al. (1984), the DEA model assumes that there are n DMUs which produce a quantity s of output y in such a way that $y \in RS^+$ by using m inputs in multiple arrangement and in combination of $x \in R^+$ (Galluzzo, 2019b).

According to the methodological assumptions proposed by Charnes et al. (1978), the technical efficiency of each DMU can be estimated by solving a linear programming problem aimed at minimising the level of input used in the production process in the dual forms (Charnes et al., 1978; Banker et al., 1984; Coelli et al., 2005; Bravo-Ureta and Pinheiro, 1993; Battese and Coelli, 1992; Galluzzo, 2019b; 2013) that is expressed as:

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

subject to

$$\theta x_j - X\lambda \geq 0$$
$$Y\lambda \geq y_j$$
$$\lambda \geq 0$$

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

The second step in the Data Envelopment Analysis consisted of estimating whether certain environmental variables, such as the number of Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) products in each region are able to act on the technical efficiency. This was done using the two stage DEA for the estimation of the impact of the environmental variables, verifying their role through a separability test (Simar and Wilson, 2007; 2011; Daraio et al., 2015; 2018; Bădin et al., 2012). The estimation of the technical efficiency in the two-stage DEA was made using the RStudio software, producing bias-corrected efficiency scores in input-oriented DEA models with the environmental exogenous variables using a bootstrap replication in the first and second loop.

The following step was the estimation of the impact of the two selected environmental variables on the technical efficiency that was previously estimated through Data Envelopment Analysis by applying Tobit modelling (Simar & Wilson, 2007; Horvat et al., 2019), stratifying the data in function of the particular typology of faming. The estimation of separability, which is important for assessing whether the selected environmental variables have an effect, has been verified using a t-test comparing the technical efficiency estimated by the DEA modelling and the technical efficiency estimated by the two-stage DEA.

With the purpose of estimating the total factor productivity change, the technical efficiency change, and the technological change in a panel data, a Malmquist TFP Index has been calculated using the DEAP and Win4DEAP 2 software (Coelli et al., 1998; Färe et al., 1994). The efficiency change is able to assess the change in the distance from best practice, while the technological change measures the shift in the technology frontier between two different years, and hence is a measure of innovation (Coelli et al., 1998; Färe et al., 1994).

Results and discussion

Table 1 shows the main descriptive statistics investigated in the sample of Italian farms that are included in the FADN dataset. Focusing on the coefficient of variation, it emerges that labour capital has seen a greater fluctuation than the value of crop subsides. Furthermore, the average amount of land capital (UAA), which is close to 15 hectares, is more or less identical to the average value assessed in all European farms by Eurostat. The subsidies paid to farms located in lagging-behind rural areas are higher than payments allocated to crops under the first pillar of the Common Agricultural Policy. Drawing some conclusions, environmental payments and LFA subsidies have been financially less modest than the decoupled payments based on crop yields allocated within the framework of the first pillar of the CAP.

The average score of technical efficiency estimated in all Italian farms was found to equal 0.723, which is below the optimal threshold of 1. Focusing on the different typologies of farming, however, the technical efficiency estimated by the input oriented model reveals that farms specialising in horticulture, granivores, and wine have shown the highest levels of technical efficiency while, in contrast, mixed farms and farms specialising in other grazing productions dem-

Table 1. Main descriptive statistics in all FADN Italian farms from 2004 to 2017

Variable	Unit	Obs.	Mean	St. dev.	Min.	Max.	Var. Coeff.
Labour	hours	2,301	2,841.292	2,049.29	0	18,006.35	1.386
Usable Agricultural Areas	hectares	2,301	15.81	15.94	0	94.29	0.992
Specific Costs	€	2,301	2,7585.63	57,303.46	0	672,914	0.481
Farming Overheads	€	2,301	9,473.88	12,326.99	0	157,963	0.769
Assets	€	2,301	39,4375.4	47,1622.2	0	7,548,288	0.836
Crop Subsidies	€	2,301	366.48	1,242.61	0	24,540	0.295
Environmental payments	€	2,301	581.05	1,038.28	0	11,161	0.560
LFA subsidies	€	2,301	439.25	1,177.19	0	11,727	0.373
RDP subsidies	€	2,301	1,128.96	2,074.94	0	22,662	0.544
Total output	€	2,301	79,239.31	12,5701.9	0	1,237,767	0.630

Source: Author's own elaboration on data available at https://ec.europa.eu/agriculture/rica/database/database_en.cfm).

onstrated the lowest levels of technical efficiency (Table 2). The research findings reveal that the average value of technical efficiency found in farms specialising in field crops estimated in all Italian regions is close to 0.957, with a value of scale efficiency close to 0.891, while those specialising in mixed crops have a higher average level of technical efficiency, equal to 0.989 and 0.985 for VRS technical efficiency and scale efficiency, respectively. In overall terms, farms specialising in field-crops were found to be technically efficient, with a value equal to 1, in 9 regions out of 21, compared to 12 regions out of 21 for mixed crops.

The finding show that excess inputs have affected all typologies of farming, with the highest input excesses relating to the decoupled payments allocated under the first pillar of the CAP and labour, in terms of working hours. On the contrary, the lowest input excesses have been found in usable agricultural area, while a very modest excess was identified in relation to the subsides allocated within the framework of the second pillar, such as LFA payments and environmental subsidies that, on average, amount to 217 and 271 euros per farm, respectively. With respect to crop subsidies, excess inputs were found in field-crop and mixed types of farming, while the greatest excess in environmental payments was found in dairy farms, which were found to have the highest excess in decoupled payments allocated under the first pillar of the CAP (Table 3).

In assessing the effect of the two selected environmental variables, the diffusion of recognised agri-districts in Italian regions and the certification of quality food products as PDO and PGI, both of which imply a particular respect for the environment in view of the strict regulations for adhesion, the research outcomes underlined a positive impact in relation to these two variables. In fact, the separability test showed that there was no separability, hence these exogenous variables can be said to have had an influence on technical efficiency, both across the different typologies of farming and also in all the different Italian regions. Drawing some conclusions, it appears that a more environmentally friendly approach, that can be found in some regions and in relation to certain certified agricultural productions, can influence the technical efficiency of farms, stimulating farmers to play an active role in the environmental protection supported by the CAP. With the purpose of corroborating whether the exogenous variables have influenced the technical efficiency in farms estimated by the DEA, a Tobit modelling was made, with the finding underlining that quality food certification and the number of rural agri-districts did have a direct impact on technical efficiency, with a p value $< 1\%$.

In figure 1, it is possible to observe that field-crops, horticulture, wine, other permanent crops, and granivores have all been influenced by the exogenous variables, reflecting a significant impact of environmental protection measures on

Table 2. Technical efficiency estimated by a VRS input model

Type of farming	Mean	Max.	Min.	St. dev.	Var. Coeff.
Field-crops	0.6842	1	0.4825	0.1123	0.1641
Horticulture	0.8835	1	0.5024	0.1203	0.1361
Wine	0.7996	1	0.5474	0.1370	0.1713
Other permanent crops	0.7823	1	0.5260	0.1408	0.1801
Dairy	0.6524	1	0.4005	0.1193	0.1828
Other grazing	0.6125	1	0.3900	0.1093	0.1785
Granivores	0.8468	1	0.5254	0.1347	0.1591
Mixed	0.6125	1	0.3630	0.1130	0.1845
Total	**0.7232**	**1**	**0.3630**	**0.1553**	**0.2148**

Source: Author's own elaboration on data available at https://ec.europa.eu/agriculture/rica/database/database_en.cfm).

Table 3. Mean in excess of inputs using DEA VRS input model

Type of farming	Inputs						
	Labour	**UAA**	**Crop subsidies**	**Environmental payments**	**LFA payments**	**Total RDP**	**Decoupled payments**
Field-crops	864.26	6.74	430.78	192.37	68.12	315.01	2,071.48
Horticulture	660.64	0.65	13.43	10.59	3.35	26.58	90.90
Wine	632.52	2.03	41.56	176.75	19.06	214.06	303.06
Other permanent crops	638.25	1.92	38.31	159.78	28.07	205.07	474.58
Dairy	1,591.55	11.92	76.33	540.39	733.21	1,329.91	3,003.74
Other grazing	1,343.72	15.37	100.53	553.43	568.78	1,205.11	2,972.05
Granivores	745.40	3.52	67.91	102.23	19.64	158.74	951.65
Mixed	1,321.91	9.81	234.10	304.62	191.38	573.05	2,498.13
Total	**989.15**	**6.78**	**134.42**	**271.19**	**217.90**	**534.61**	**1,615.83**

Source: Author's own elaboration on data available at https://ec.europa.eu/agriculture/rica/database/database_en.cfm).

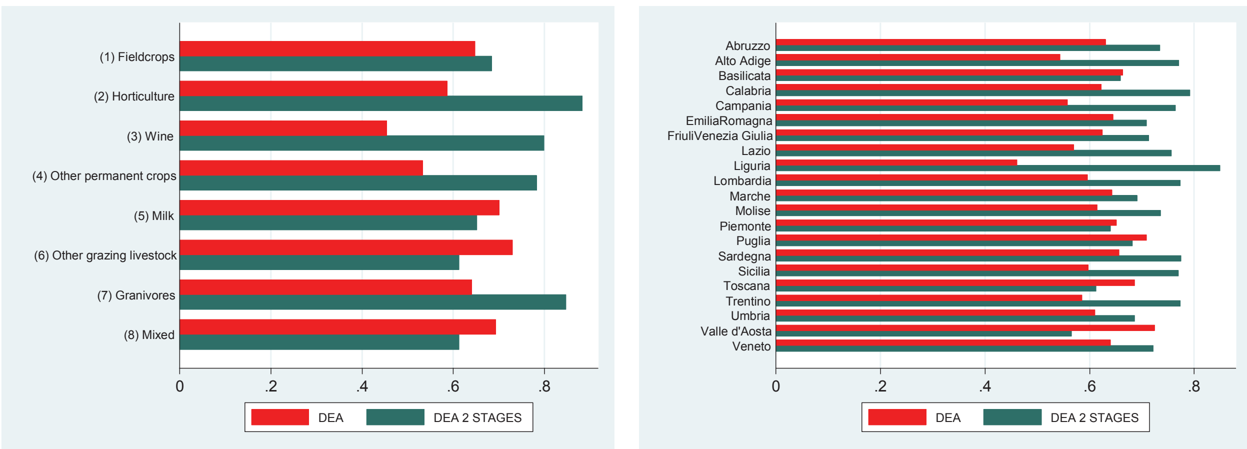

Fig. 1. Comparing technical efficiency in the DEA and in the 2 stages DEA in all Italian farms included in the FADN dataset for each typology of farming and in different Italian regions

Source: Author's own elaboration on data available at https://ec.europa.eu/agriculture/rica/database/database_en.cfm).

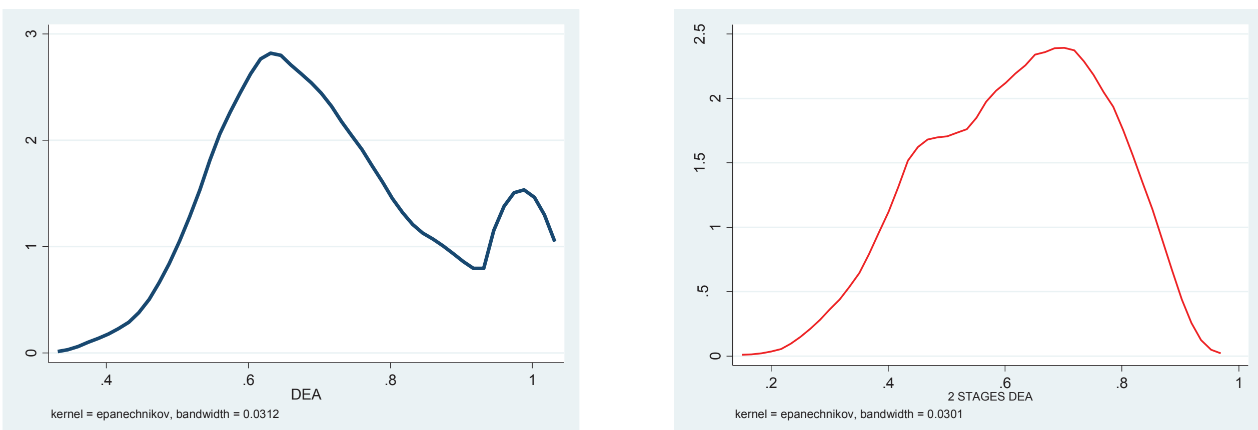

Fig. 2. Different distribution of technical efficiency using the DEA (on the left) and the 2 stages DEA approach (on the right) in Italian farms included in the FADN dataset

Source: Author's own elaboration on data available at https://ec.europa.eu/agriculture/rica/database/database_en.cfm).

the productive process owing to the strict regulations involved. Moreover, in terms of the different Italian regions, Liguria and Lombardy in the north, Lazio in the centre, and Calabria, Sicily, and Sardinia in the south have all seen a marked influence on the technical efficiency of farms by the exogenous variables, for which a low use of chemical products is stipulated. In general, then, it can be said that environmental variables have had a discernible effect on technical efficiency. In fact, comparing the distribution of technical efficiency estimated by the DEA and the two stages DEA, findings reveal an overall increase in the technical efficiency value of farms (Fig. 2).

The analysis of the Malmquist index in all Italian regions over the period of investigation shows an increase in technical efficiency in 18 regions out of 21, but a technological change in only 5 regions out of 21. Meanwhile, in 8 Italian regions out of 21 there was a change in total factor productivity greater than 1, even if the average value of technological change was below 1, and only above 1 for technical efficiency and pure technical efficiency, resulting in an overall modest increase in technical efficiency, with an increased and different allocation of inputs. During the two years of observation, 2014 and 2015, there was a significant technological change, while the years 2017 and 2004 showed the worst results in terms of technological change. In fact, overall, the change in technical efficiency in farms was more intense than the technological change over the whole period of investigation. Focusing attention specifically on mixed farming and field-crops, the results reveal that, across all regions and over the period of investigation, there was a technological change equal to 0.818, implying a low level of increase in new techniques and productive factors in both these types of farming.

Conclusions

The subsidies allocated under the Common Agricultural Policy have had a direct and positive impact on the technical efficiency of farms, as well as on the technological change in farming, even if the further stage of investigation carried out with the two-stage DEA has highlighted the importance of exogenous variable in increasing technical efficiency. As such, a specific focus on adopting more environmentally friendly practices, for example by reducing the use of chemical products, is particularly important for increasing technical efficiency in Italian farms. No significant differences were identified in terms of total factor productivity between mixed and field-crop farms, while, in contrast, the effect of exogenous variables has been more intense.

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