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AN ANALYSIS OF CROP COSTS IN ITALIAN NITRATE VULNERABLE AREAS AND AGRI-ENVIRONMENTAL SUBSIDIES

ABSTRACT

In several Italian regions there are severe limitations and constraints in the use of chemical inputs in farms in order to protect the environment, as a consequence of the introduction of the UE Nitrates Directive in 1991. The purpose of this paper was to assess how chemical inputs impacted on the technical efficiency in farms in function of their location in vulnerable nitrate areas and also in function of their productive specialization over three seven-year periods of Common Agricultural Policy enforcement. The Italian FADN dataset from 2004 to 2020 was used for the purpose of this research. Significant differences were estimated in all investigated types of farming, even though there was no change in technical efficiency over the different periods of CAP enforcement. A difference in technology can partially explain the differences in technical efficiency and in the excess of inputs on investigated Italian farms.

Key words: DEA, technology gap ratio, MEA, FADN.

JEL Classification: Q12, Q18.

1. INTRODUCTION

In Italy, it is not so common to find studies aimed at assessing the patterns of inefficiency in used input and produced output in farms, and specifically in estimating if the location of farms in nitrate vulnerable areas is a driving factor influencing the technical efficiency. Furthermore, there are no complete studies investigating in depth if the location of farms in some areas with environmental constraints has acted on farmer's decisions, while the focus of researches has been predominately addressed to the assessment of risk preference only (Iyer *et al*., 2020).

2. STATE OF KNOWLEDGE

The most recent comparative literature review on the technical efficiency and financial subsidies allocated by the Common Agricultural Policy in all European

Union member states revealed a scarcity of studies in Central and Eastern European countries, such as Italy, aimed at assessing the reasons and motivations of farmers in participating in agri-environmental policy measures (Mikus *et al*., 2021; Nowak *et al*., 2015).

In general, in the literature, the relationships between agri-environmental policy and technical efficiency are characterized by unclear and mixed results (Minviel & Latruffe, 2017), and several authors argued that some agri-environmental policy measures played an important role in farmer's choice (Lastra-Bravo *et al*., 2015). Bojnec and Fertő in 2022 argued that rural development measures such as agri-environmental and less-favoured area subsidies have been fundamental in the labour input in Slovenian farms but not in Hungarian farms. Furthermore, some performance of farms such as the total factor productivity does not seem to be sensitive to agri-environmental subsidies (Baráth *et al*., 2020). The land capital endowment is one of the most important inputs to impact on the decision process in farmers stimulating the participation or not participation in agri-environmental policies (Defrancesco *et al*., 2018).

In the literature, there is not a clear relationship between farm location in nitrate vulnerable areas, agri-environmental payments and technical efficiency. In fact, an aspect that has not been investigated in depth is whether farms that decided to adhere to agri-environmental policies had been pushed in this decision by other exogenous variables. For example, the location of farms in nitrate vulnerable areas (NVZ) as defined by the Council Directive 91/676/EEC of 12 December 1991, on the protection of waters against pollution caused by nitrates from agricultural sources, could be an important aspect in farmers' decision not investigated in literature.

Some studies carried out in Wales have pointed out that the constraints due to NVZ rules have an impact on the investment costs for the farmer (Franklin *et al*., 2021). These authors argued about the role of environmental regulations, such as the location of farms in NVZ, which inevitably have had some impacts in the management of farms and in technical efficiency. A recent study in the Lombardy plain in Italy evaluated the effectiveness of the Nitrate Directive and argued that the governance framework does not support knowledge dissemination and changes in farmers' attitudes with an important role of local governance scale in a multi-interdisciplinary evaluation (Musacchio *et al*., 2020). In most limited areas located in this Italian region, the findings have underlined that there are imbalances between farming types (Gaviglio *et al*., 2021), both in terms of constraints, productivity and in terms of technical efficiency. The results of these latter authors assessed that crop farms are more efficient than livestock farms, due to a difference in productive technology, and there is a fundamental role of specific policies in sustaining the efficiency of farms and their diversified farm economy.

There is a strict link between the main purposes of the Common Agricultural Policy proposed in the Green Deal and farmers' decisions to participate in agri-environmental policies-NVZ, hence farm management has to promote a smart nutrient (fertilizers)/pesticide use, with a modest impact on the environment and on nitrate pollution as well (Nicholson *et al*., 2020). As argued by these latter authors, it is important to underline the fundamental role of the public administration in supportive actions towards farmers.

It is important to stress that the second pillar of the CAP has proposed lots of challenges related to climate change in agriculture by specific public voluntary measures (Pagliacci *et al*., 2020) and that the agri-environmental policies are just a part of the wide range of actions proposed and financially supported. According to Pagliacci *et al*. (2020), farmers' attitudes, motivations and social pressure have impacted farmer's decision to continue or discontinue some agri-environmental policies; hence, lots of non-financial factors can act on farmers' decision to adopt agri-environmental practices, with a need to complement the financial support allocated by the CAP to reduce the risks related to the drop of productivity and in technical efficiency as well. This can explain that the participation in agri-environmental measures reducing farm productivity, partially compensated by CAP financial supports, changes the technical efficiency. Furthermore, the research carried out by Pagliacci and others in 2020, can corroborate that there is a rational choice of farmers to participate in agri-environmental measures, explained by the hypothesis of rational inefficiency (Bogetoft & Hougaard, 2003).

A recent literature review argued that in some European countries, pollution could be reduced in farms, with significant impacts on the produced output as assessed in few specialized farms; hence, the incentives to reduce nitrate pollution can impact on the technical efficiency in farms (Latruffe *et al*., 2013). In Northern Italy, other studies in specialized farms such as rice, cereals, and livestock farms have emphasized economic, agronomic and ecological aspects in the framework of sustainability that can partially explain farmers' decision to participate in agri-environmental policies (Paracchini *et al*., 2015). According to these authors, the results pointed out that there are significant links between farmers' decision and the economic and productive performances. Drawing some conclusions, the use of environmentally friendly techniques, imposed by the participation in agri-environmental policies or by the NVZ, constraints impact to the use of specific inputs, as land, labor and other chemical inputs, with consequences on the output and technical efficiency (Hansson *et al*., 2020; Asmild *et al*., 2016; Minviel & Latruffe, 2017; Garrone *et al*., 2019; Latruffe & Nauges, 2014).

Minviel and Latruffe (2017), in their systematic literature review, have found that agri-environmental subsidies are negatively associated with farm technical efficiency in most investigated studies. Zhu & Lansink in 2010 argued that the share of total subsidies in total farm revenues had a negative impact on technical efficiency, even though the reason of these unclear and contrasting effects is due to two variables, namely land capital endowment and farm specialization (Galluzzo, 2013; 2022; Zhu & Lansink, 2010). In general, research findings underlined that technical efficiency is influenced by crop specialization, by financial subsides allocated by the CAP in the framework of the agri-environmental policy, and by land capital endowment (Cisilino *et al*., 2021; Galluzzo, 2016; 2013; Latruffe *et al*., 2017; Gorton & Davidova, 2004; Latruffe & Nauges, 2014; Bojnec & Latruffe, 2013; Garrone *et al*., 2019).

At this stage, the literature review pointed out that only few studies investigated the inefficiency patterns in farms located in NVZ and also participating in agri-environmental policies in all European countries. The results of the estimation of technical efficiency underlined that it is impossible to explain the real reasons that pushed farmers to be involved in some agri-environmental actions financed by the Common Agricultural Policy (Uthes & Matzdorf, 2016). For these reasons, the present research aims to fill this gap in the literature and it represents a novelty through the investigation of the possible driving factors that pushed Italian farmers whose farms are located or not located in NVZ and adhering to agri-environmental policies to improve their technical efficiency. The Green Deal could be a pivotal challenge in some specialized Italian farms, because these have to face twofold productive constraints, namely reduction in chemical inputs and location of farms in NVZ area. Recent studies investigating the impact of the Green Deal in some EU countries argued some significant costs for the EU farmers, with the consequence to change the National Strategic Plan to cope with the new strategy of a greener CAP (Shukadarova, 2022).

The purpose of this paper is to assess by a quantitative approach that the chemical inputs have impacted on the technical efficiency in farms in function of their location in vulnerable nitrate areas and also in function of their production specialization over three different seven-year periods of Common Agricultural Policy enforcement.

The main question was: have farmers been pushed to participating in agri-environmental measures by the location of farms in nitrate vulnerable areas? Consequently, nitrate vulnerable areas could have represented pivotal and exogenous pillars in the decision process of participation in the agri-environmental measures financed by the Common Agricultural Policy.

The purposes of this research were multidimensionally aimed at assessing if there is a technological gap between two clusters of farms located or not located in vulnerable nitrate areas. Furthermore, does the technical efficiency of farms change between these two groups of farms? How does the participation in agri-environmental policies and the technical efficiency diverge in specialized typologies of farming? In order to overcome the bottleneck of technical efficiency, it estimated the inefficiency patterns between farms located or not located in Italian nitrate vulnerable areas.

3. MATERIAL AND METHOD

The analysis was organized in three stages using the Italian Farm Accountancy Data Network (FADN) dataset from 2004 to 2020. By also using other primary sources of data published by the Italian Ministry of Environment and by the Italian Ministry of Agriculture, it was possible to define the share of nitrate vulnerable land in total usable agricultural areas in each Italian region. In order to assess if the share of land area classified as nitrate vulnerable in total land has implied some effects in the technology gap ratio and in the participation in the agri-environmental payments, a dummy variable 0/1 was used in function of location of farms in regions where the share of vulnerable nitrate areas was below (0) or above (1) the average value.

In the first stage, it was assessed if there is a technology gap ratio between farm located or not located in nitrate vulnerable areas; the second stage assessed the technical efficiency in farms and the last phase of investigation estimated the patterns of technical inefficiency in farms for all used input and all produced output.

Metafrontier-based quantitative approach is a useful quantitive method to assess the technology gap in technical efficiency analysis in all investigated Decision-Making Units (DMU) or investigated farms, which is an important tool in investigating the heterogeneity present between DMUs (Walheer, 2018). The use of a meta-frontier technology gap ratio is useful to estimate technology-related inefficiency effects in different European and not European countries (Asravor *et al*., 2019; Alem *et al*., 2019; Khanal *et al*., 2018).

In general, there are two different methodologies for the technical efficiency assessment. By a parametric or stochastic modelling (SFA) not used in this research or by a non-parametric modelling using the Data Envelopment Analysis (DEA) method, it is possible to estimate the technical efficiency in farms (Coelli *et al*., 2005; Kumbhakar *et al*., 2015; Galluzzo, 2021). The DEA had the positive aspect to estimate multiple inputs and multiple outputs without *a priori* defined functions of production and other specifications in the model (Coelli *et al*., 2005; Galluzzo, 2021).

In this analysis, the DEA approach used an input oriented variable returns to scale (VRS) model with the aim of minimizing inputs, as these variables can be managed by farmers as showed in Table 1. As mentioned before in the paragraph aim of the research, it has used a dummy variable 0/1 aimed at comparing the location in farms in nitrate vulnerable areas. If the value of average value of usable agricultural areas located in nitrate vulnerable areas in total agricultural areas is above the average national value, it is assigned the value 1 and 0 otherwise.

One of the main weaknesses of DEA is the incapacity of identifying inefficiency or efficiency patterns in each input and output variables. This bottleneck of DEA can be overcome by a new approach such as the Multi-directional Efficiency Analysis or MEA (Bogetoft & Hougaard; 2003; Asmild *et al*., 2003; Hansson *et al*., 2020). According to these authors, MEA has the advantage of simultaneously estimating efficiency in multi-input and multi-output models and assessing inefficiency in each of the used inputs and produced outputs in the production process (Manevska-Tasevska *et al*., 2021). According to these latter authors, through the Multi-directional Efficiency Analysis (MEA), it is possible to estimate the inefficiency patterns in input and output in terms of excess of input.

MEA identifies some deviations from the production frontier, expressed in terms of productivity change, due to variables not incorporated in the analysis of technical efficiency (Bogetoft & Hougaard; 2003, Hansson *et al*., 2020). MEA scores are in a range from zero in case of totally inefficient farms to 1 for totally efficient farms where there is no excess in input or in output. If the scores are equal to 1, this indicates that there is no potential for improvement on the input/output variables, while an input efficiency score of less than unit indicates that farms could reduce the input to be more technically efficient.

The estimation of the technical efficiency in terms of DEA and MEA approach used the RStudio software packages deaR, rDEA and Benchmarking.

Table 1

Input and output variables used in the estimation of technical efficiency in Italian farms

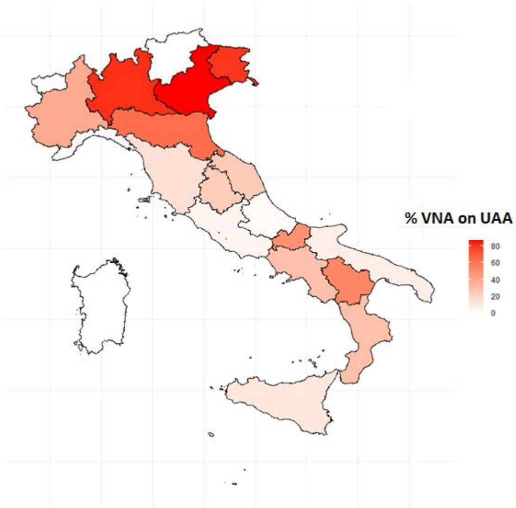
Variable	Unit	Description
Labor	Hours	Time worked in hours by total labour input on holding
Land capital	Ha	Usable agricultural areas in farms
Crop cost	Euro	Crop-specific inputs costs
Seed cost	Euro	Cost for seeds used in farms purchased in the market
Fertilizers	Euro	Cost for chemical inputs
Crop protection	Euro	Cost for crop protection
Other cost for crops	Euro	Other cost linked to crops
Overhead farm cost	Euro	Supply costs linked to production activity but not linked to specific lines of production
Assets	Euro	Only fixed and current assets in ownership are considered. Capital indicators are based on the value of the various assets at closing valuation
Total output	Euro	Total output produced plus agri-environmental payments allocated by the CAP
Output other activities	Euro	Output produced from other on farm activities

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

4. RESULTS AND DISCUSSIONS

The starting point of the research used as baseline the national share of vulnerable nitrate areas in total land endowment in terms of usable agricultural areas in all Italian regions, using data available and published by the Ministry of Agriculture Food and Forestry and by the Ministry of Environment. If the share was above the average value, it used the dummy variable 1 and this implies that the region is a vulnerable nitrate area; otherwise the dummy is 0 and the region is located in not vulnerable areas (Figure 1).

The comparison between farms located or not located in vulnerable nitrate areas has pointed out significant difference in labour, crop cost, seed cost, fertilizers, crop protection, overhead costs and assets (Table 2). No differences have been found in terms of land capital and other cost for crops between these two clusters of Italian regions. Farms located in nitrate vulnerable areas have higher level of total output and output from other activities compared to farms not located in vulnerable nitrate areas.



Source: Author's elaboration on data from the Ministry of Agriculture, Food and Forestry policies and the Ministry of Environment

Figure 1. Italian regions and share of vulnerable nitrate areas in usable agricultural areas

Table 2

Main descriptive statistics in function of the location of farms

Variable	All sample	Not NVZ	NVZ
Labour	3386.34	3231.64	3639.54
Land capital	21.52	20.64	22.94
Crop cost	1214.04	1357.68	978.90
Seed cost	3089.14	2482.58	4081.99
Fertilizers	2409.02	1929.42	3194.05
Crop protection	1768.75	1248.22	2620.77
Other cost for crops	1877.19	1870.96	1887.38
Overhead farm cost	11225.1	8736.45	15298.63
Assets	326886.8	284586.2	396126.4
Output	87451.48	66729.61	121370
Other output	3844.10	2921.86	5353.66

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

Comparing the three different times of CAP implementation, the research findings have pointed out no significant differences between all periods of investigation in labour and in land capital input variables (Table 3). On the contrary, significant fluctuations have been assessed in crop cost, fertilizers and crop protection cost. Focusing the attention on the assets input results, a drop in total assets in Italian farms was noticed in the last time of CAP implementation. Addressing the attention to the output variable research findings has pointed an increase of produced output and a very sharply increase of output from other on farm activities, which tripled from 2007–2013 to 2014–2020.

Table 3

Main descriptive statistics in function of the time of the CAP

Variable	CAP time 2004–2006	CAP time 2007–2013	CAP time 2014–2020
Labour	3500.41	3321.23	3330.27
Land capital	20.02	19.38	22.93
Crop cost	1710.10	991.55	1072.70
Seed cost	3085.60	2776.69	3056.22
Fertilizers	1559.08	2173.90	2921.58
Crop protection	1283.40	1559.10	2041.28
Other cost for crops	1959.38	1517.16	2034.01
Overhead farm cost	8882.38	10339.76	12090.84
Assets	327128.2	323165	299423.6
Output	74449.19	81236.61	91722.84
Other output	1956.35	2084.38	6097.11

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

Farms not located in nitrate vulnerable areas have a higher level of technical efficiency than farms located in nitrate vulnerable areas (Table 4) that have been statistically significant, and the results of TGR have underlined that there is not a homogenous technology between these two groups of farms. Hence, a different technology can impact on the allocation of inputs and consequently on the level of productivity and technical efficiency.

Table 4

Technical efficiency and technology gap ratio (TGR) in all investigated farms

	Technical efficiency	TGR
No vulnerable areas		
Average	0.7223886	0.9795348
St. dev.	0.1587435	0.0281793
Vulnerable areas		
Average	0.6361813	0.8764651
St. dev.	0.1521408	0.0782142
All sample		
Average	0.6896953	0.9404465
St. dev.	0.1617502	0.0728924

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

Comparing the three different periods of CAP programming, the findings of the research do not seem to underline statistical differences in terms of technical efficiency, which in average was in the range 0.69–0.70, corroborating that there is not a difference in technology between these three groups of farms (Table 5). Drawing some conclusions, it seems that the time of CAP programming did not impact on the technical efficiency in all Italian farms part of the FADN dataset, while the location of farms in NVZ or the non-location of farms in nitrate vulnerable areas seems to act on technical efficiency.

Table 5

Technical efficiency and technology gap ratio (TGR) in all investigated farms

	Technical efficiency	TGR
CAP time 2004–2006		
Average	0.7050357	0.9406281
St. dev.	0.1582263	0.0713208
CAP time 2007–2013		
Average	0.698336	0.9405371
St. dev.	0.1648931	0.0739425
CAP time 2014–2020		
Average	0.6899045	0.9398697
St. dev.	0.15922	0.0727614
All sample		
Average	0.6963406	0.9402943
St. dev.	0.1614693	0.0729597

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

The comparison between farms located in vulnerable or not vulnerable nitrate areas pointed out as there is a statistically significant difference in these two clusters of farms in terms of technical efficiency (Table 6). Farms not located in vulnerable nitrate areas were more technical efficient than farms located in nitrate vulnerable areas.

Table 6

Total technical efficiency (TE) and technical efficiency in each input and output in farms located or not located in vulnerable nitrate areas

	TE	Labour	Land	Crop cost	Seed	Crop protection
No vulnerable areas	0.736	0.877	0.816	0.785	0.752	0.769
Vulnerable areas	0.724	0.868	0.801	0.752	0.730	0.719
t-test	2.08	3.53	4.62	8.17	5.63	13.01
Sign.	**	***	***	***	***	***
	Other crop cost	Fertilizer	Farm overhead	Assets	Output	Other output
No vulnerable areas	0.751	0.769	0.834	0.831	0.718	0.304
Vulnerable areas	0.702	0.735	0.818	0.791	0.702	0.241
t-test	12.34	8.40	4.79	11.55	2.38	5.46
Sign.	***	***	***	***	**	***

** $p \leq 0.01$; ***$p \leq 0.001$

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

In order to overcome the main bottleneck of the Data Envelopment Analysis, the Multi-directional Efficiency Analysis (MEA) was used, able to underline the patterns of inefficiency in all used input and in all produced output. All inputs were more efficient in farms not located in nitrate vulnerable areas. Specifically, fertilizers, crop protection cost (pesticides), other crop cost and assets were more technically efficient in farms not located in nitrate vulnerable areas. Findings pointed out a significant difference both in total output produced in favour of farms not located in vulnerable nitrate areas and also in terms of other output produced in on-farms activities such as agritourism and agri-energy. The comparison between these two groups of farms in terms of other output underlined the highest difference in terms of technical efficiency, even though in both these two clusters the results were very far from the optimal level of the frontier of technical efficiency.

The different time of the Common Agricultural Policy implementation does not seem to impact on the level of technical efficiency and in the patterns of inefficiency in all investigated input and output (Table 7). Some fluctuations were assessed in the fertilizer input, with a drop in the technical inefficiency assessed over the three different times of investigation. By contrast, the input assets did not change over the three CAP stages of investigation. Focusing the attention on the variable output (total output and other output), findings underlined no significant fluctuations in total produced output and an increase of technical efficiency was found in the variable other output.

Table 7

Total technical efficiency (TE) and technical efficiency in each input and output at different CAP times

	TE	Labour	Land	Crop cost	Seed	Crop protection
CAP time 2004–2006	0.749	0.874	0.829	0.792	0.757	0.764
CAP time 2007–2013	0.741	0.877	0.819	0.782	0.751	0.758
CAP time 2014–2020	0.732	0.876	0.804	0.768	0.742	0.747
	Other crop cost	Fertilizer	Farm overhead	Assets	Output	Other output
CAP time 2004–2006	0.749	0.780	0.850	0.822	0.720	0.287
CAP time 2007–2013	0.742	0.764	0.833	0.818	0.715	0.234
CAP time 2014–2020	0.727	0.749	0.824	0.827	0.725	0.316

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

Table 8 shows the technical efficiency and the patterns of technical inefficiency in all input and output stratified in function of the investigated types of farming. Furthermore, in order to estimate some statistical differences between these two clusters of farms, the t test has been used. Olive farms and sheep and goat farms located in vulnerable nitrate areas have been more technically efficient and less technically inefficient compared to those not located in vulnerable nitrate areas. In terms of technical efficiency, farms specialized in cereals, other field crops, olives and sheep and goats have been more technically efficient in farms located in vulnerable nitrate areas than in farms not located in vulnerable nitrate areas.

Table 8

Total technical efficiency (TE) and technical efficiency in each input and output in different types of farming

	TE	**Labour**	**Land**	**Crop cost**	**Seed**	**Crop protection**
COP	[green]	[green]		[red]		[red]
Other field crops	[green]	[green]			[red]	[red]
Horticulture						
Wine		[red]	[green]	[red]		[red]
Orchard	[red]	[red]	[red]	[red]		[red]
Olives	[green]	[green]	[green]	[green]	[green]	[green]
Crops combined	[red]	[red]	[red]	[red]	[red]	[red]
Milk	[red]	[red]	[red]		[red]	[red]
Sheep and goats	[green]	[green]	[green]	[green]	[green]	[green]
Cattle		[red]				[red]
Granivores			[green]		[green]	
Mixed crops	[red]		[red]	[red]	[red]	[red]
Mixed livestock						
Mixed crops and livestock						
	Other crop cost	**Fertilizer**	**Farm overhead**	**Assets**	**Output**	**Other output**
COP			[red]	[red]		[red]
Other fieldcrops	[green]	[green]		[green]	[green]	
Horticulture						
Wine	[red]	[red]		[red]		[red]
Orchard	[red]	[red]		[red]	[red]	
Olives	[green]	[green]	[green]	[green]	[green]	[green]
Crops combined	[red]	[red]	[red]	[red]		
Milk	[red]	[red]	[red]	[red]	[red]	[red]
Sheep and goats	[green]	[green]	[green]	[green]	[green]	[green]
Cattle	[red]		[red]	[red]	[green]	[red]
Granivores						
Mixed crops	[red]	[red]	[red]	[red]	[red]	[red]
Mixed livestock						
Mixed crops and livestock						

Not significant differences | [green] Vulnerable nitrates areas | [red] Not vulnerable nitrate areas

Source: https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html

Milk, crops combined and mixed crops have been more technically efficient in areas not characterized by nitrate constraints. The inputs labour and land have been more efficient in farms specialized in cereals, oilseeds and protein crops and in farms specialized in other field crops located in nitrate vulnerable areas. Farms specialized in livestock such as cattle and sheep and goats have been more technically efficient in terms of total produced output; by contrast, the vast majority of specialized farms not located in nitrate vulnerable areas have pointed out a higher level of technical efficiency in the variable output produced in on-farms activities than farms located in vulnerable nitrate areas.

5. CONCLUSIONS

As investigated in the literature, the research findings underlined that technical efficiency is a very crucial issue in the management of farms. Summing up some final remarks, the results do not seem to have been driven in terms of technical efficiency by the agri environmental payments, in particular in farms located in areas with a share of vulnerable nitrate areas in total usable agricultural areas above the national average value. It seems that the type of farming acted on the technical efficiency more than the agri-environmental payments; hence, agri-environmental payments could be sensitive to farm specialization and farm location.

There is a heterogeneity in technology between these two groups of farms located or not located in vulnerable nitrate areas. Farms located in areas classified as vulnerable nitrate are less technically efficient than farms not located in nitrate vulnerable areas.

Some further final remarks have corroborated, as investigated in previous studies, that payments allocated by the second pillar of the CAP had some effects, as argued by Minviel and Latruffe in 2017, with different ambiguous effects in function of the type of farm specialization and location. Using the MEA, it was investigated in depth which input and output variables are more or less sensitive to the location in nitrate vulnerable areas and this represents a novelty in the study of technical efficiency.

In conclusion, the research findings underlined that farms not located in vulnerable areas had less constraints and this has had some effect in the opportunity of farmers in differentiating their productive specialization. The allocation of the land and labour inputs was different between these two clusters of farms, with some significant effects on technical efficiency.

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