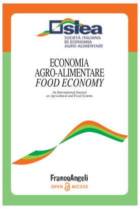
Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 23, Iss. 3, Art. 5, pp. 1-24 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag3-oa12772



Estimation of the impact of CAP subsidies as environmental variables on Romanian farms

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Abstract

Romanian agriculture is characterised by the presence of small farm enterprises, with an average value of land capital of less than 5 hectares in more than 95% of cases. The aim of this research was to assess the level of technical efficiency in farming through a non-parametric approach such as the Data Envelopment Analysis (DEA), and also to estimate the impact that financial subsidies allocated under the first and second pillars of the Common Agricultural Policy (CAP) have had on the technical efficiency. In the application of this analysis, these two inputs have been considered as environmental variables in order to evaluate their effect in fostering the technical efficiency using a two-stage DEA method. The results have revealed the pivotal impact of financial subsidies disbursed through the first and second pillars of CAP in enhancing technical efficiency in the Romanian farms included in the FADN dataset. In contrast, the subsidies disbursed under only the second pillar of the CAP in the framework of rural development have not been found to have had any discernible effect on the technical efficiency of Romanian farms. The novelty of this quantitative approach in the estimation of technical efficiency lies in its focus on the role of environmental variables as drivers in affecting the technical efficiency of farms, defining, in addition, how important they are in addressing efficiency and in shifting enhancing the function of technical efficiency on farms as well. Some conclusions were drawn: it is important to increase the endowment of subsidies for rural development and as well as

Article info

Type:
Article
Submitted:
07/04/2021
Accepted:
30/06/2021
Available online:
12/01/2022

JEL codes:
Q12, Q18, R15

Keywords:
Data Envelopment Analysis
Technical efficiency
Separability test
Rural Development Programme
FADN

Managing Editor:
Lucia Briamonte,
Luca Cesaro,
Alfonso Scardera

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decoupled payments in order to raise the level of technical efficiency in Romanian farms. At the same time, the findings suggest the need for Romanian farmers to reduce the level of certain inputs, such as labour, on the one hand, while on the other, increasing the dimension size of farms in terms of land capital and encouraging greater investment in labor-saving technology, even if significant imbalances remain between different Romanian regions, both in terms of the level of technical efficiency achieved and also in terms of output yield, and in the endowment of land capital and other assets.

Introduction

Over the last 20 years, the Common Agricultural Policy (CAP) has undergone profound and structural changes necessitated by ever more severe budgetary constraints following international agreements in WTO trade negotiations and the various phases of enlargement of the European Union that have occurred since the early 2000s. At the same time, public opinion has modified its attitude to farmers, who are now seen to be one of the main bastions for the protection of the environmental and drivers of economic development for rural areas. All these economic and social constraints have radically modified what is one of the oldest policies of the European Union. Meanwhile, for the current seven-year period of Common Agricultural Policy planning for 2021-2027, partly in view of the possible phasing out of direct payments from 2028, and as a consequence of the economic crisis brought about by the Covid-19 pandemic, the European Commission has introduced strictly demanding strategies for European farming that have led to a complete overhaul in the allocation of European Union funding for different economic and productive sectors (Beluhova-Uzunova *et al.*, 2017; Galluzzo, 2020a; 2021). Over the years, it is clear that a new strategy for addressing the primary sector has developed, which has seen the CAP transition from being a commodity-specific policy based on a high level of price support for agricultural commodities and by decoupled payments and other direct payments, to being a farmer-specific policy that is addressed, primarily, to protecting the environment as well as to stimulating greater multifunctionality in farms as well as in the wider rural area through funding made available under the second pillar and the LEADER initiative.

Since the launch of the Agenda 2000 project in the early 2000s, the structure of the Common Agricultural Policy has completely changed in shape and function, and is now based on two pillars, each with different and specific targets of action, namely supporting for farmers, through decoupled payments and various direct grants, and encouraging rural development in a holistic model of socio-economic growth for rural areas. The first pillar, through such instruments as the Single Payment Scheme (SPS) established in 2005, and the Single Area Payment Scheme (SAPS), is primarily addressed to farmers, indirectly supporting farmers' productions through decoupled payments, whilst the second pillar is focused on rural areas, aiming to improve living conditions in rural territories through innovative bottom-up initiatives such as the LEADER programme (Galluzzo, 2020a). The purpose of the second pillar is to stimulate investments in structural and productive infrastructure while also supporting, through specific financial measures, the diversification of rural areas (Galluzzo, 2020b; 2020c). In this light, the second pillar is fundamental to disadvantaged and scarcely populated rural areas characterised by small farming enterprises, as in many parts of Romania, which are at severe risk of depopulation owing to demographic ageing processes and permanent emigration encouraged by a scarcity of working opportunities (Galluzzo, 2018; 2020b). In fact, lots of Romanian farms have got modest endowment of land capital which is lower than 5 hectares in the hands of aged farmers; hence, the CAP subsidies are fundamental in increasing labour saving investments, stimulating a generational turn over and improving training and new skills in farmers increasing the technical efficiency. Consequently it is fundamental to investigate in depth if the Common Agricultural Policy subsidies are able to increase the technical efficiency in Romanian farms. In particular, the novelty of this study is to define which subsidies, between decoupled aids, directs payments or financial supports in investments and in on farm productive diversification, are more adequate in improving the technical efficiency in farms considering the financial subsidies as an environmental exogenous variable able to act on the efficiency in farm.

One of the main differences between the two pillars lies in the allocation of financial resources (Galluzzo, 2020a). In fact, the total amount paid in subsidies under the second pillar of the Common Agricultural Policy is significantly lower than that paid under the first pillar (Galluzzo, 2016; 2019a; 2019b; 2020b; 2020c; Stanciu, 2017), which corroborates the hypothesis that the CAP is a crystallised policy able to promote an indirect economic development through the first pillar while also encouraging greater diversification through financing made available in the framework of the Rural Development Programme.

In the process of the European Agricultural Fund for Rural Development (EAFRD) programming have been defined some selection criteria of the measures in the Rural Development Programme considering as constraints and criteria of selection of measures of financing the typical features of the Romanian agriculture such as the aging of farmers, the age of the entrepreneurs, the farm fragmentation, in particular in some counties close to Moldavian area, the clima protection aspect, the role of new young farmers in the management of farms, sustainable development, innovation and training of farmers, and the cooperation among EU countries with LEADER initiatives. Focusing the attention to the European Agricultural Guarantee Fund (EAGF) some criteria of selection in financed measures have been focused on investments in job creation, innovation in fruit sector, actions in supporting agro-food marketing, ecosystem services and providing in basic services in rural areas.

1. Background

The productivity of farms can be simply expressed as the ratio between the value of the output and the value of the inputs used in the productive process, without taking other factors into consideration (Osman & Anouze, 2014). It follows, then, that technical efficiency is the ability of an enterprise to obtain an optimal level of output using a given input (Farrell, 1957; Coelli *et al.*, 2005; Galluzzo, 2020a).

In general, the main elements used in estimating the technical efficiency (TE) of farms and in assessing the impact of financial subsidies allocated under the Common Agricultural Policy (CAP) have been assessed considering different constraints able to influence the efficiency score, such as the dimension of farms, the level of the farm's income, and the degree of socio-economic sustainability (Galluzzo, 2013; 2020a; Latruffe *et al.*, 2016; Latruffe *et al.*, 2017; Minviel & Latruffe, 2017; Garrone *et al.*, 2019). Various researchers, including Garrone *et al.* in 2019, Minviel and Latruffe in 2017, and Latruffe *et al.* in 2017, have previously conducted complete and exhaustive bibliographic analysis of the role of technical efficiency and financial subsidies allocated by the European Union, comparing different studies and European countries. These authors have deeply investigated the role of subsidies and agricultural productivity in the EU through the most recent literature studies related to technical efficiency.

Decoupled payments act predominately on the level of a farmer's income through the dimension of the farm in terms of its endowment of land capital, and this has encouraged an increasing demand for land capital (Bartolini & Viaggi, 2013; Galluzzo, 2020a) that is also aimed at reducing the inefficiency in small farms. In relation to other European countries, recent studies have shown that subsidies can act on the technical efficiency and also on the levels of technology utilised (Latruffe *et al.*, 2017; Kumbhakar & Lien, 2010). Summing up, the research outcomes have underlined either a null or fairly minimal impact of payments allocated under the second pillar to disadvantaged rural areas (Baráth *et al.*, 2018; 2020; Nowak *et al.*, 2015; Rudinskaya *et al.*, 2019; Garrone *et al.*, 2019; Galluzzo, 2020a; Czyzewski *et al.*, 2017). As such, it is difficult to find a univocal interpretation of the impact of CAP subsidies on farms. Furthermore, it is hard to assess if there is a correlation between technical efficiency, public financial support for agriculture, and employment opportunities in rural areas (Petrick & Zier, 2011; Galluzzo, 2019a).

As mentioned above, a wide review of the available literature in the field of technical efficiency has identified many studies that have investigated the effect of financial subsidies allocated through the Common Agricultural Policy in depth through a quantitative approach, predominately using Data Envelopment Analysis (DEA) as well as Stochastic Frontier Analysis (SFA), the findings of which reveal a wide disparity in the impact they have had on the technical efficiency of farms in different European countries (Garrone *et al.*, 2019; Minviel & Latruffe, 2017; Latruffe & Desjeux, 2016; Galluzzo, 2016; 2020a; Forleo *et al.*, 2021; Nowak *et al.*, 2015; Laurinavicius & Rimkuviene, 2017; Czyzewski *et al.*, 2017; Gorton & Davidova, 2004). Several studies have pointed out that other variables influencing the technical efficiency, such as the level of the farmer's knowledge, can increase the farm's technical efficiency and economic performance (Manevska-Tasevska, 2016). Other authors have assessed the efficacy of financial subsidies allocated through the CAP in reducing imbalances between farms and territories through stimulating greater innovation in technology and reducing the technological divide on one hand, while also increasing the level of technical efficiency on the other (Baráth *et al.*, 2020; Zhu & Lansink, 2010; Ayouba *et al.*, 2017; Gorton & Davidova, 2004).

Several scholars have argued that financial support allocated under the first and second pillars of the CAP has reduced the need for farmers to improve their economic performance, level of technical innovation, and technical efficiency, even if the effect of decoupled payments on the farm's technical efficiency is ambiguous, being so strongly influenced by the farm's productive specialisation, and by the type of the subsidy disbursed, for example decoupled or direct, which can have various distorting effects on farmers' technical efficiency, innovation, and productivity (Mennig & Sauer, 2019; Garrone *et al.*, 2019; Latruffe *et al.*, 2017; Galluzzo, 2016; 2019a; 2020a; Nowak *et al.*, 2015; Swinbank, 2008; Zhu & Lansink, 2010; Rude, 2008; Ciaian & Swinnen, 2006; Ciaian *et al.*, 2014; Rizov *et al.*, 2013).

Von Witzke and Noleppa argued in 2007 that direct payments to German farms have had an unequal impact on smaller-sized farms, but that they have had a generally positive impact on farms located in disadvantaged rural areas. In contrast, other scholars addressing their field of study to new member states of the European Union have found a null or negative impact of subsidies allocated under the CAP on the general level of technical efficiency (Galluzzo, 2020a; Von Witzke & Noleppa, 2007; Baráth *et al.*, 2018; 2020; Nowak *et al.*, 2015). This last aspect has been found to be particularly true in farms located in mountainous and disadvantaged rural areas (Rudinskaya *et al.*, 2019; Baráth *et al.*, 2018; Galluzzo, 2016; 2019a; 2020a). However, other studies have underlined that there is a significant but modest nexus between financial support provided under the CAP and the economic development of rural areas, owing to the complexity and the different socio-economic peculiarities of the rural areas in EU countries (Shucksmith *et al.*, 2005; Crescenzi & Rodriguez-Pose, 2011; Galluzzo, 2016; 2019a).

More recent studies have investigated the impact on technical efficiency of decoupled payments and other financial support allocated in rural areas through the framework of the second pillar of the CAP in France and in some other European countries (Latruffe & Desjeux, 2016; Latruffe *et al.*, 2017; Minviel & Latruffe, 2017). According to these latter authors, research findings have found different effects in function of farms' productive specialisation. Indeed, a negative effect of investment subsidies on technical efficiency has been assessed in farms specialising in beef production while, in contrast, a generally positive effect of production subsidies has been found in farms specialising in field crops and dairy (Latruffe & Desjeux, 2016; Latruffe *et al.*, 2017; 2016; Minviel & Latruffe, 2017). Furthermore, these studies have underlined that rural development subsidies such as Less Favoured Areas (LFA) payments and agri-environmental payment schemes have had no discernible effects on technical efficiency in investigated farms (Galluzzo, 2020a; Latruffe & Desjeux, 2016; Latruffe *et al.*, 2017). On the contrary, studies carried out in new member states of the European Union have demonstrated a pivotal role of subsidies allocated under the second pillar of the CAP to farms, with the exception of LFA subsides, which had no impact (Baráth *et al.*, 2018; Galluzzo, 2020a; 2020b; 2019a).

In the available literature, there are not many studies aimed at estimating the impact of financial subsidies allocated under the first and second pillars of CAP to farmers in a two-stages methodology based on the non-parametric approach using Data Envelopment Analysis (Horvat *et al.*, 2019; Gutiérrez *et al.*, 2017; Forleo *et al.*, 2021; Gutiérrez & Lozano, 2020; Todorović, *et al.*, 2020). In the two-stages DEA approach proposed by Simar and Wilson in 2011 and 2007 and Daraio *et al.* in 2018, the technical efficiency has first been estimated through the DEA approach and then, in the following second stage, the results of the DEA have been correlated to certain environmental variables, such as the financial subsidies allocated under the first and second pillars of the CAP, which are considered as environmental variables able or not able to act on the technical efficiency score.

The main purpose of this study was to assess, in all Romanian farms, the impact of financial subsides allocated under the first pillar of the CAP, such as through decoupled payments and direct payments, and the second pillar of the CAP, through the Rural Development Programme, on the technical efficiency of farms, considering these subsidies as environmental variables correlated to the technical efficiency as estimated through the DEA approach in the first stage of the investigation. The element of innovation represented by this approach lies in the attempt to assess if those financial subsidies have influenced the technical efficiency as environmental variables, hence, by this two-stages DEA, it is possible to understand their role and how and if they should be implemented in the financial allocation to farmers. The main policy implications are the opportunities it gives policy makers to implement their allocation of funding, understanding the effect that first and second pillar subsidies and payments have on the technical efficiency of farms.

2. Materials and methods

In the literature, there are two different methodologies for assessing the level of technical efficiency in farms, one through a parametric or stochastic modelling (SFA), and the other through a non-parametric modelling, using the Data Envelopment Analysis (DEA) method (Farrell, 1957; Lovell, 1993; Coelli *et al.*, 2005; Battese & Coelli, 1992; 1995; Kumbhakar *et al.*, 2015; Aigner *et al.*, 1977; Cooper *et al.*, 2007). The SFA requires a well-defined function, such as the Cobb-Douglas, a logarithmic function, or the translog, and other a priori specifications in the model in terms of inputs and outputs, and their transformation (Coelli *et al.*, 2005; Lovell, 1993; Aigner *et al.*, 1977). In contrast, the DEA estimates multiple inputs and multiple outputs without the requirement for defined functions of production and other a priori specifications in the model (Coelli *et al.*, 2005; Bravo-Ureta & Pinheiro, 1993; Galluzzo, 2019a; 2019b; 2020a).

In this paper, the DEA approach has been used in an input-oriented variable returns to scale (VRS) model with the aim of minimising the inputs in each Decision Making Unit (DMU) of observation, which are the Romanian farms included in the Farm Accountancy Data Network (FADN) dataset (Galluzzo, 2013; 2015; 2019a; 2020a; 2020c). The sample is made up of farms from each of the 8 Romanian regions over a 12-year period of observation, from 2007 to 2018. As proposed by both Charnes *et al.* (1978) and Banker *et al.* (1984), the Data Envelopment Analysis model assumes certain constraints, namely that there are n DMUs which produce 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, 2019b; 2020a; Cooper *et al.*, 2007).

According to the methodological assumptions proposed in literature by different authors such as Charnes *et al.* (1978), the technical efficiency of each DMU can be estimated by solving a linear programming problem aimed at minimising, in an input-oriented approach, the level of inputs used in the production process in the dual forms (Charnes *et al.*, 1978; Banker *et al.*, 1984; Coelli *et al.*, 2005; Bravo-Ureta & Pinheiro, 1993; Battese & Coelli, 1992; Galluzzo, 2020a; 2019b; 2013; Cooper *et al.*, 2007), that can be expressed as:

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

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

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

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

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

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

For every Decision Making Unit (DMU), an estimation has been made of θ, which is the level of technical efficiency. A value which is equal to 1 implies the optimal combination of inputs and output, and so a minimising of the costs; ε is a non-Archimedean infinitesimal, proposed by Charnes *et al.* in 1978, able to overcome some difficulties linked to testing multi-optimum solutions in the model of solving the minimisation problem; and λ is a convex coefficient in the input x in each DMU_j producing a level of output *y* in the farms *j* (Coelli *et al.*, 2005; Battese & Coelli, 1992; Galluzzo, 2020). Meanwhile, S_r^+ and S_r^- are non-negative output and input slacks; thus, if θ is equal to 1 and all input and output slacks are equal to zero, the DMU is technically efficient (Charnes *et al.*, 1978, Banker *et al.*, 1984; Coelli *et al.*, 2005; Battese & Coelli, 1992). In contrast, as the above-mentioned authors proposed, if θ is not equal to 1 and all input and output slacks are different to zero, this implies that there is an inefficient use of resources as inputs for the amount of output produced by that DMU.

The general aim of the estimation of technical efficiency is to assess the distance of a hypothetical function of production from the frontier, hence, it is an assessment of an inefficient use of inputs, consequently defining an index of technical inefficiency (Bielik & Rajcaniova, 2004; Galluzzo, 2013; 2016a; 2017; 2018a). Summing up, farms located along the hypothetical function of production are efficient, whilst those located outside this frontier are inefficient, due either to an excess of input, in the case of the input-oriented approach, or a shortage of output in the case of the output-orientated approach (Galluzzo, 2015; 2016a; 2017). The value of technical efficiency should be greater than 0 and lower than 1, which is the frontier of optimal technical combinations of input-output, representing a well-defined use of technology by the DMU (Coelli, 1996; Coelli *et al.*, 2005; Galluzzo, 2013; 2015; 2016; 2017). Through either a decrease in inputs, in the input-oriented model, or an increase in output, in the output-oriented model, it is possible to move DMU_j from an inefficient position to an efficient one, so increasing that DMU's technical efficiency score (Galluzzo, 2020a; 2019; 2017; Latruffe *et al.*, 2017).

In this paper, the technical efficiency in all Romanian farms included in the FADN dataset over the period 2007 to 2018 has been estimated using a non-parametric model applied to specific assumptions in a variable return to scale (VRS) input-oriented model (Farrell, 1957; Battese & Coelli, 1992; 1995; Coelli *et al.*, 2005) using the R, Stata and Xlstat software. In order to make the dataset homogenous, the effect of inflation has been removed; in fact, the input and output variables in the dataset, expressed in Euros, have been deflated using the Eurostat deflator and all data are in constant values, referred to the year 2010.

The first step of the research was to select the input and output variables and the environmental variables, making reference to previous published studies in relation to DEA and technical efficiency available in the literature (Forleo *et al.*, 2021). The input variables selected for the assessment of technical efficiency in the DEA input-oriented approach were: land capital, measured in terms of usable agricultural areas (UAA); labour, measured in man hours and relating to both family members and hired labour; specific costs, comprising seeds, fertiliser, pesticides, and other items; total farming overhead costs or, rather, supply costs linked to production activity but not linked to specific lines of production; and assets. The output comprises the total value of the production yield of farms, expressed in Euros and referred to the year 2010. The environmental variables (Z) selected for this research were decoupled payments and direct payments allocated under the first pillar of the CAP, and financial subsidies disbursed by the Rural Development Programme.

With the purpose of assessing whether certain environmental variables, such as financial subsidies allocated under the first and second pillars of the CAP, have acted on technical efficiency in the DEA, the research has adopted the approach proposed by Simar and Wilson in 2007, called two-stage DEA (Simar & Wilson, 2011; 2015; Daraio & Simar, 2005; Daraio *et al.*, 2015;

2018; Bădin *et al.*, 2012). The estimation of technical efficiency in the two-stage DEA approach has been made using the R software package rDEA, with the aim of producing bias-corrected efficiency scores in input-oriented DEA models, using the above-mentioned environmental exogenous variables in a bootstrap replication in the first and second loop.

In any case, in order to estimate if the environmental variables (Z) have had some effect on the overall technical efficiency of the farms included in the FADN sample and previously estimated by the DEA, the separability test proposed in the literature has been applied (Simar & Wilson, 2007; 2011; 2015; Daraio *et al.*, 2015; Daraio & Simar, 2005; Kourtesi *et al.*, 2012; Wang & Schmidt, 2002). The environmental variable (Z) is a vector able to act on the input and output variables and on the production function, changing its shape and affecting also the distribution of the inefficiency scores not dependant on the environmental variable (Bădin *et al.*, 2010; Kourtesi *et al.*, 2012; Wang & Schmidt, 2002). Under the assumption of separability, the environmental variables do not have any effect. In contrast, if the assumption of separability decays, the impact of the environmental variables influences the level of efficiency (Kourtesi *et al.*, 2012). According to these authors, it is possible to assess the separability using the test proposed by Daraio *et al.* in 2015, based on the distance between the efficiency boundaries, once with the effect of the environmental variables and another without any effect of the environmental variables. The null hypothesis is that, in the case of separability, the two boundaries are the same (Kourtesi *et al.*, 2012; Wang & Schmidt, 2002; Bădin *et al.*, 2010; Simar & Wilson, 2007; 2015; 2011; Daraio *et al.*, 2015; Daraio & Simar, 2005) estimated as Daraio *et al.* (2015) proposed, by:

$$\hat{\tau}_n = [\textstyle\sum_{i=n}^{n}(\widehat{D}'_{\mathrm{FDH,i,n}})(\widehat{D}_{\mathrm{FDH,I,n}})]/\mathrm{n} \geq 0 \qquad (4)$$

where n is the sample size

$$\widehat{D}_{\mathrm{FDH,I,n}} = \mathrm{Y_i}(\hat{\lambda}_{\mathrm{FDH,i,n}}(\mathrm{X_i},\mathrm{Y_i}) - \hat{\lambda}_{\mathrm{FDH,i,n}}(\mathrm{X_i},\mathrm{Y_i}\mathrm{I}\mathrm{Z_i})) \qquad (5)$$

A large value of t rejects the null hypothesis of separability, meaning that the selected environmental variables do have an effect.

For the purposes of this research, the impact of different environmental variables has been estimated on the basis of four hypotheses. In the first hypothesis, the impact of three environmental variables has been estimated, namely decoupled payments and direct payments allocated under the first pillar, and financial subsidies allocated under the second pillar of CAP. In the second hypothesis, the impact of two environmental variables has been tested: direct payments allocated under the first pillar of CAP, and financial subsidies allocated under the second pillar of CAP. The third hypothesis has estimated the effect of decoupled payments and direct payments allocated under the first pillar of CAP. Finally, the fourth hypothesis has taken into account only the effect of financial subsidies allocated through the Rural Development Programme in the framework of the second pillar of the Common Agricultural Policy. All four hypotheses have been tested using the global separability test proposed by Daraio *et al.* in 2015 with a level of a 0.05.

3. Results

Over the period of investigation, the research findings have underlined a modest land capital endowment in all Romanian regions which is, on average, close to two-thirds less than the average value of 15 hectares assessed through Eurostat for the European Union as a whole (Table 1). This has had some implications on the total produced output in the farms included in the FADN sample, and on the level of assets and investments in farms. Romanian farms that are included in the FADN dataset have shown a remarkable demand for labour capital, with an average of over 3,000 hours, due to a low level of investment in machinery and to the division of the land into small and scattered plots, which are more labour-intensive. A significant incidence of financial aid allocated by the Common Agricultural Policy can be ascribed to

Table 1 - Descriptive statistics in all Romanian farms included in the FADN dataset over the period of investigation

	Labour	UAA	Total output	Specific costs	Total farming overhead costs
Mean	3,243.49	10.96	16,212.94	4,980.39	2,589.39
St. deviation	1,032.31	5.07	10,122.45	2,461.80	1,381.31
Median	3,196.70	9.84	14,570.48	4,843.32	2,344.51
	Assets	**Total subsidies**	**Direct payments**	**RDP**	**Decoupled payments**
Mean	57,185.20	2,205.27	2,042.09	89.85	1,334.49
St. deviation	67,340.33	1,330.88	1,304.99	169.21	1,037.55
Median	43,451.64	1,932.50	1,709.00	15.50	1,055.00

Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

the first pillar, notably in terms of decoupled payments, whilst the total value of financial subsidies allocated under the second pillar, specifically through the Rural Development Programme, averages less than 100 Euros per farm.

Table 2 - Descriptive statistics in all Romanian regions in input and output variables used in the analysis of technical efficiency dataset

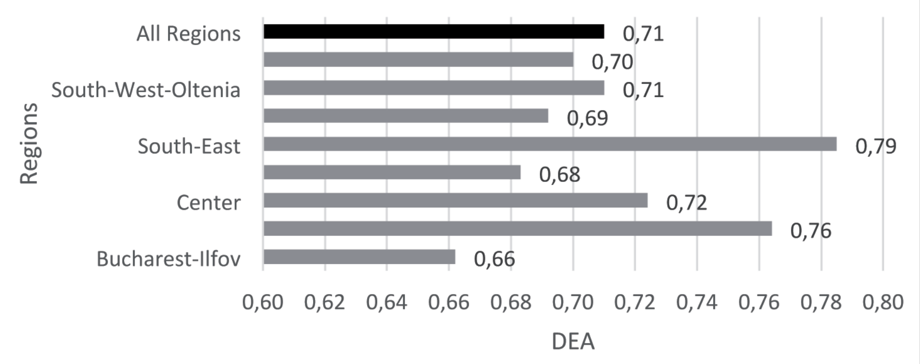
	Labour	**UAA**	**Total output**	**Specific costs**	**Total farming overhead costs**	**Assets**	**Total subsidies**
				North-East			
Mean	3,122.55	7.57	10,608.33	3,685.15	1,693.10	26,941.37	1,320.75
St. deviation	1,103.13	1.94	2,934.43	1,228.45	411.82	5,094.55	622.95
Median	2,784.90	7.19	10,681.12	3,400.96	1,749.90	26,326.33	1,159.50
CV	0.35	0.25	0.27	0.33	0.24	0.18	0.47
				South-East			
Mean	3,445.04	15.17	17,994.89	5,900.14	3,037.26	43,711.75	2,885.66
St. deviation	565.41	4.06	5,691.55	2,027.42	660.94	14,276.44	1,245.40
Median	3,359.99	14.53	18,844.63	5,501.96	3,030.57	41,575.65	2,457.00
CV	0.16	0.26	0.31	0.34	0.21	0.32	0.43
				South-Muntenia			
Mean	3,255.28	11.38	15,877.75	5,703.18	279.28	44,188.77	2,024.66
St. deviation	596.60	3.33	4,192.33	155.78	508.37	9,026.12	880.64
Median	3,264.03	10.71	15,847.95	5,436.71	2,815.73	43,955.44	1,865.00
CV	0.18	0.29	0.26	0.27	0.18	0.20	0.43
				South-West-Oltenia			
Mean	3,376.51	7.13	10,322.38	3,027.42	1,746.62	29,591.06	1,208.00
St. deviation	883.80	1.93	2,458.92	1,148.57	376.18	10,469.04	537.44
Median	3,311.99	6.47	9,053.50	2,789.00	1,701.72	28,594.34	1,072.00
CV	0.26	0.27	0.23	0.37	0.21	0.35	0.44
				West			
Mean	3,113.40	14.54	18,603,32	5,879.11	2,848,050.00	53,972.22	2,626.08
St. deviation	697.63	4.17	6137,23	1,944.39	712.05	10,952.59	1,268.83
Median	2,937.24	14.64	18490,66	5,615.83	3,093.83	5,3037.02	2,378.50
CV	0.22	0.28	0,32	0.33	0.24	0.20	0.48
				North-West			
Mean	3,711.10	8.34	13,492.06	4,489.06	2,142.56	44,406.85	1,884.67
St. deviation	829.80	1.56	2,411.67	1,555.01	435.03	5,936.07	722.27
Median	3,419.91	7.69	13,391.99	3,847.62	2,081.02	43,824.95	1,601.50
CV	0.22	0.18	0.17	0.34	0.20	0.13	0.38

Table 2 - Continued

	Labour	UAA	Total output	Specific costs	Total farming overhead costs	Assets	Total subsidies
Central							
Mean	3,215.20	10.31	16,824.00	7,090.10	2,552.51	47,991.34	2,631.41
St. deviation	646.58	2.30	4,460.25	4,141.45	541.52	8,567.18	1,269.30
Median	3,053.75	9.63	15,977.17	5,574.52	2,429.25	43,824.95	2,262.00
CV	0.20	0.22	0.26	0.58	0.21	0.13	0.48
Bucharest-Ilfov							
Mean	2,708.86	13.22	25,980.76	4,068.93	3,900.32	166,678.20	3,060.91
St. deviation	2,070.53	9.30	23,715.10	2,290.64	3,224.79	151,469.60	2,183.96
Median	2,464.09	13.59	22,726.36	4,567.59	2,827.98	127,779.40	2,722.00
CV	0.76	0.70	0.91	0.56	0.82	0.90	0.71

Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

Fig. 1 - Average results of the Data Envelopment Analysis (DEA) in all Romanian regions

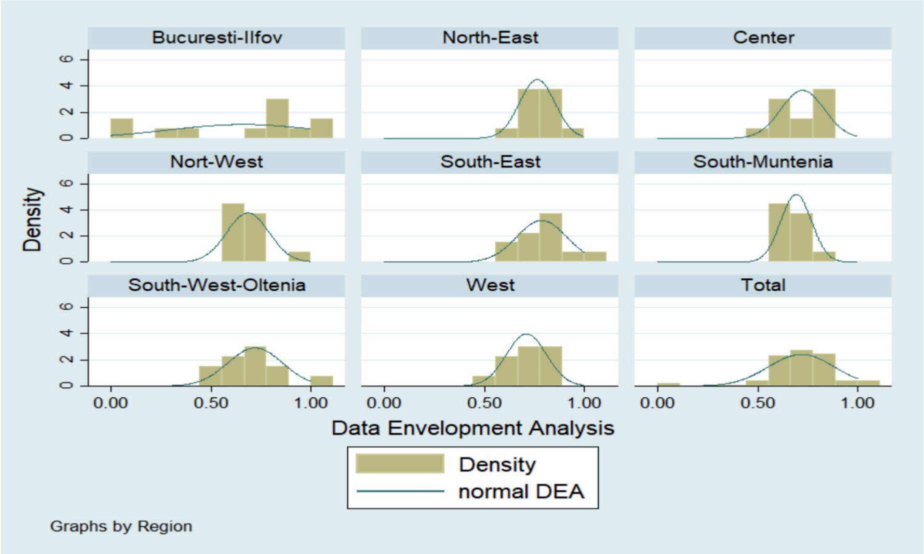


Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

Comparing all Romanian regions, the highest value in terms of average land capital endowment can be found in the South-East region; in contrast, the lowest value can be found in the South-West Oltenia region, which also registered the highest level of labour capital (Table 2). Rather on its own, among all the regions of Romania was Bucharest-Ilfov, where the highest value of assets and total output were assessed, and where the lowest value of labour input was registered, which shows an average value of usable agricultural area of around 13 hectares per farm.

The assessment of the technical efficiency estimated through the Data Envelopment Analysis in an input-oriented model has revealed an average value in all Romanian regions close to 0.71 that is below the optimal threshold equal to 1 (Figure 1). The highest value of technical efficiency has been found in farms located in the South-East region whereas, in contrast, the lowest value of technical efficiency has been estimated in the Bucharest-Ilfov region, which is characterised by an adequate level of usable agricultural area and the highest level of produced output from farms. The Romanian regions of the North-West and North-East, characterised by having the highest concentration of farms, revealed the highest level of technical efficiency. In South-Muntenia where, according to the most recent Census of Agriculture carried out in 2010 by the National Romanian Institute of Statistics, there is a concentration of more than 800,000 farms out of the national total of 3.8 million agricultural holdings, the level of technical efficiency is below the national average, with many farms that are not technically efficient.

Fig. 2 - Density of the Data Envelopment Analysis (DEA) in all Romanian regions



Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

Comparing the results of the technical efficiency estimated by the Data Envelopment Analysis (DEA), the distribution has been homogenous in all farms in the sample, as described in Figure 2, with some significant differences among all 8 Romanian regions, particularly the region of Bucharest-Ilfov. The research findings have corroborated that among all the farms included in the FADN dataset, few showed a value of technical efficiency close to the optimal value equal to 1, whilst the vast majority of farms in all Romanian regions have been technically inefficient, due to a non-efficient use of inputs in the productive process.

Romanian areas where the agriculture is the most important economic sector such as North-East and South-East the level of technical efficiency have been higher than areas close to urban areas such as Bucharest. The reasons of this low level of technical efficiency are due to small farms, aging of farmers and to a modest investment in improving new technologies in farms. Anyway, the land capital fragmentation is the most bottleneck influencing the management and investment choices in farms; hence, the financial subsidies of the CAP are addressed in improving generation turnover and investments in traditional crops in Romanian farms. For policy makers it is important to support farmers both the financial subsidies and decoupled payments allocated by both pillars of the CAP. The improvement of land capital endowment and investments in training are fundamental both for farmers in order to get better their technical efficiency and also for policy makers to define the main political priorities for rural areas. The estimation of the technical efficiency by a non-parametric approach has some constraints correlated to the short period of investigation; furthermore, the DEA is not able to analyse the source of inefficiency in each inputs and output which are fundamental for the policy maker in defining some specific policy measures adequate to the farmers need analysing which inputs or output are less or more technical inefficient.

In order to assess if the selected environmental variables (Z), namely different combinations of financial subsidies allocated through the first and second pillars of the Common Agricultural Policy, have had an impact on technical efficiency, a separability test as proposed by Daraio *et al.* in 2015 has been applied with a level of α of 0.05 (Kourtesi *et al.*, 2012; Wang & Schmidt, 2002). The environmental variables (Z) selected in this research were decoupled payments and direct payments allocated in the first pillar of the CAP, and financial subsidies allocated through the Rural Development Programme under the second pillar. These have generated four different combinations for the estimation of the two-stage DEA:

1. All subsidies have been estimated as environmental variables;
2. Decoupled payments and financial subsidies allocated through the second pillar of the CAP have been entered as environmental variables in the two-stages DEA;

Table 3 - Descriptive statistics comparing the DEA and the two-stage DEA using different simulations in terms of combinations of financial subsidies allocated through the CAP in the framework of the first and second pillars

	DEA	**DEA 2-stages all subsidies**	**DEA 2-stages decoupled payments and RDP subsidies**	**DEA 2-stages direct payments and decoupled payments**	**DEA 2-stages RDP subsidies**
Mean	0.71	0.66	0.66	0.66	0.67
St. deviation	0.16	0.14	0.13	0.14	0.13
CV	0.22	0.20	0.19	0.21	0.19
Range	1	0.90	0.91	0.90	0.91
Min.	0	0	0	0.20	0
Max.	1	0.90	0.91	0.90	0.91

Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

3. Only the aid allocated through the first pillar of the CAP as direct payments and decoupled payments have been considered as environmental variables;
4. Only the subsidies allocated through the second pillar of the CAP in the form of RDP payments have been included in the two-stage DEA model.

The separability test has revealed that the selected environmental variables, comprising the various subsidies allocated under the first and second pillars of the Common Agricultural Policy including both direct payments and RDP subsidies, have had some effects on the function of technical efficiency, as well as on the technical efficiency score of farms. In contrast, the combination of decoupled and direct payments allocated under the first pillar of CAP has been assessed to have not acted on technical efficiency as an environmental variable in the two-stage DEA. The Levene test on the average values accepts the null hypothesis according to which the variance in all different simulations has been the same. The effect of the introduction of the environmental variables in the two-stage DEA has reduced the average value of the technical efficiency, which has shifted from 0.71 to 0.66. As such, it is possible to say that these subsidies have an impact on the technical efficiency in farms (Table 3).

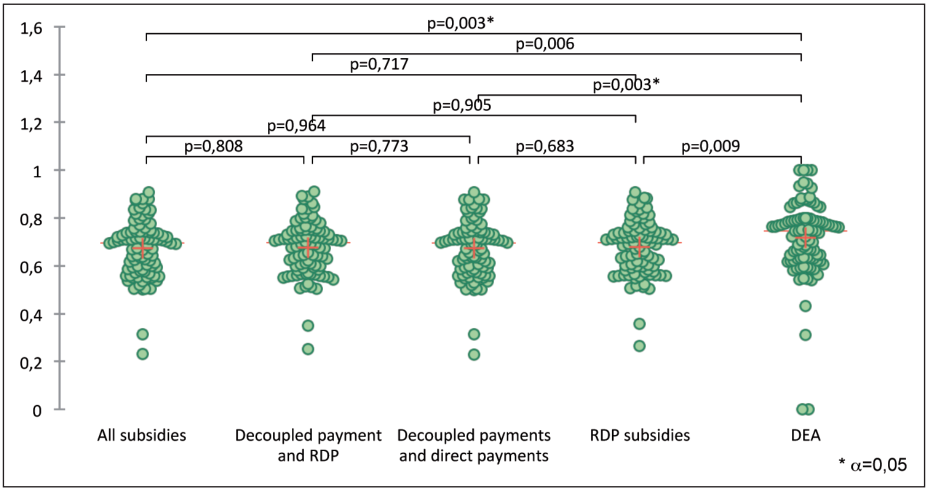
A further stage of the investigation in respect to the impact of environmental variables on the technical efficiency estimated by the Data Envelopment Analysis has used the significant difference combining the results of the DEA to the results of the two-stage DEA. The purpose of this test was to corroborate the role of the financial subsidies as environmental variables in influencing the technical efficiency.

Table 4 - Main significant differences in the estimation of the DEA and the two-stage DEA in the FADN sample

	DEA two stages in all subsidies allocated by the I and II pillar CAP	**DEA two stages in decoupled payments and RDP financial support**	**DEA two stages in decoupled payments and direct payments I pillar CAP**	**DEA two stages in RDP payments**	**DEA**
DEA two stages in all subsidies allocated by the I and II pillar CAP	No	No	No	No	YES
DEA two stages in decoupled payments and RDP financial support	No	No	No	No	No
DEA two stages in decoupled payments and direct payments I pillar CAP	No	No	No	No	YES
DEA two stages in RDP payments	No	No	No	No	No
DEA	YES	No	YES	No	No

Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

Fig. 3 - Level of significance comparing DEA to the different two-stage DEA in all Romanian regions under the four simulations



Source: author's own elaboration on data available at https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html.

Table 4 shows the significant differences comparing the results assessed by the DEA and the different combinations of the two-stage DEA in all Romanian farms included in the FADN dataset. The findings have revealed that there is some level of divergence comparing the two-stage DEA, estimating that all the financial subsidies allocated through the CAP and the financial subsidies allocated through the first pillar only, or rather decoupled and direct payments, have had some effect, with a level of significance of < 0.01 (Figure 3).

4. Conclusions

The rural and agricultural fabric in Romania is characterised by small farms scattered, particularly in rural areas, across several plots of land, for which it is very difficult to improve productivity and technical efficiency through investment in labour-saving machines and other equipment. In fact, according to the Eurostat, more than 95% of Romanian farms have less than 5 hectares of land capital. As such, the role of financial subsidies, particularly through the second pillar of the CAP, should be to increase investment in technology and promote greater diversification in farming activity, with the aim of enhancing farmers' income and, consequently, reducing the level of permanent rural emigration. The poor endowment in land capital is one of the most important constraints in agriculture, while at the same time, the low level of investment is the main factor responsible for a modest level of asset ownership and a high demand for labour, predominantly from within the family unit, for which it is possible to define a specific Romanian model of labour-intensive family farming.

This research has underlined that, in order to increase the level of asset ownership in farms that could, at the same time, reduce the high demand for labour – two factors that are important for increasing the technical efficiency in farming and, thus, the socio-economic survival of farms – the financial subsidies allocated through the European Union in the framework of the Common Agricultural Policy are fundamental. In fact, the two-stage DEA has confirmed, through the separability test, the role and impact of these environmental variables in increasing the technical efficiency in farms.

The analysis has also underlined the value of this quantitative approach in assessing the impact of environmental variables on technical efficiency. In particular, using the test of separability it has been possible to identify a discernible impact of environmental subsidies on the technical efficiency estimated in the first stage by the Data Envelopment Analysis. In regards to the implications of the two-stage DEA for policy in assessing the importance of financial subsidies on farms, moreover, this study shows that it has been possible to estimate which different combinations of subsidies can act on the technical efficiency in Romanian farms. Findings in this analysis have underlined as Romanian farms need of CAP subsidies in order to improve their technical efficiency and their effect is positive and clear if farms receive subsidies both by the first and also by the second pillar of the CAP. An unique type of subsidies is not adequate to improve the technical efficiency in Romanian farms. For the policy makers is important to tailor measures of intervention adequate to increase technical efficiency in farms, also able to encourage some structural changes in Romanian farms such as generational turnover, investments in labour saving techniques and increasing of land capital. For the future it is important to deal with the role of generational turnover in farm as a tool improving the technical efficiency in Romanian farms investigating also the casues of inefficiency in each input and output.

Drawing some conclusions, the findings have underlined the importance of financial subsidies allocated by the first and second pillars of the CAP to farming in Romania. In particular, subsidies paid under the first pillar of the CAP have been shown to have had an impact on the level of technical efficiency, while, due to the modest amounts involved, the research outcomes have not revealed any discernible impact of financial aid disbursed through the second pillar.

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