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THE EFFECT OF DIRECT PAYMENTS ON FARM PERFORMANCE FOR THE CASE OF CEECs THROUGH STOCHASTIC FRONTIER ANALYSIS APPROACH

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Abstract

Since the 1980s, agriculture in CEECs has been under continues pressure due to the changes in political, economic and institutional circumstances that have been closely linked to the transition process as well as to the process of integration into the European Union and openness to the world markets. The transition process led the agricultural sector to experience substantial reforms at both macroeconomic and at microeconomic levels. These changes were expected to increase the performance indicators of farms in these countries, however, they are still lower compared with the performance indicators of farms in developed countries. The aim of this paper was to calculate the technical efficiency scores of farms in CEECs though Stochastic Frontier Analysis approach and to measure the effect of direct payments on performance indicators. By using the FADN data for 11 CEE countries for the period 2004-2016, the results suggested that the average technical efficiency was 84%. Compared to Kosovo, this average technical efficiency score, as a proxy for farm performance, is very high. However, compared to more developed countries, these efficiency score can still increase by making more targeted agricultural policies. Direct payments are suggested to significantly and negatively affect the technical efficiency scores.

Key words: *direct payments, performance, technical efficiency, SFA, CEECs*

INTRODUCTION

The transition process led the agricultural sector to experience substantial reforms. At macroeconomic level, the reforms were concerned on the elimination of central control, price liberalization and the imposition of hard budget constraints, while at microeconomic level they had to do with changing of the structure of the farms -from collective farms to individual farms as well as reducing the number of workers and changing the way of farm management. These changes were expected to increase the incomes of the agricultural sector as the farms would be more efficient, would have increased productivity, and would be more competitive [19]. Although immediately after the reforms, output has dropped uniformly in all Central and Eastern European Countries (now one referred as CEECs), after several years, productivity has increased significantly due the implementation of these reforms. So, the performance of the agricultural sector has begun to increase in the mid-1990s due to improved economic situation as a condition for EU membership and due to improved access to technology, capital and know-how. However, serious improvements still need to be made on performance indicators (e.g. technical efficiency) for the case of CEECs as theirs differ greatly with those of developed countries.

In order to increase the performance of the agricultural sector, every country has developed its own agricultural policies. However, the countries member of the EU are part of one agricultural policy known as Common Agricultural Policy (now on referred as CAP). This is a very important policy in the EU as it occupies 38% of the EU's budget [12]. Also the CEECs that joined the EU, some in 2004 and some in 2007, started to implement CAP and to benefit from it. However, the adaptation of CAP was challenging because in addition to transition and reform policy which needed to take place in these countries, they also needed to adapt the EU's new agricultural strategies.

With the accession of New Member states into EU, the CAP direct payments were extended also for the farmers of these countries by providing them the perspective for the development of agriculture through the systems of European funds and direct payments. As part of CAP, the amount of direct payments increased together with the number of beneficial farmers. After the accessfion of EU-10 in 2004, the average incomes for farmers increased by 70 %. For example in Estonia the incomes increased by 132%, in Latvia increased by 106%, in Poland by 95% and in Lithuania the average agricultural incomes inceased by 92%, while in the Old Member States the agricultural incomes remined unachanged [11]. Direct payments range from € 2,231 on average per farm (the case of Romania) to € 162,522 on average per farm (the case of Slovakia) [11].

Subsidies/direct payments, grants and other kinds of support are provided in order to increase the incomes of the farms and to increase their competitiveness. This in one of the main reasons why the government of each state supports the agricultural sector though different forms of support policies (e.g. direct payments) even though these supports are a huge burden for the budget of each country [15]. As a result, many research works have been conducted in order to analyse whether these agricultural support policies have achieved the desired goals, more specifically if they improved the performance of the farm.

Different papers consider different indicators for measuring the performance of the agricultural sector, but technical efficiency is the most used indicator for farm performance. In addition, factors affecting the performance of the agricultural sector are numerous, however what is of interest in this paper is to assess the impact of direct support (as proxy for support policies) policies on technical efficiency of farms (as proxy for performance). In the literature is identified the impact that the direct payments have on agricultural production, input allocation and income distribution but not also on technical efficiency [22]. Even though the theoretical results on this direct payment–efficiency link are ambiguous one can expect positive effect of direct payments on efficiency, negative effect, or no effect.

Regarding the positive effect, it is believed that agricultural direct payments help employment and increase capital investments. [13] suggests that this positive relationship is as a result of two conditions: Firstly, if they assist in the improvement of technology of the farm, thus increasing the initiative to innovate or to switch to new technologies, then efficiency will also increase. In this regard, also [24] suggest that with the help of direct payments, the farmers overcame their financial contains and can restructure or modernize their farm by improving their productive capacitates by either replacing their technologies or by investing in more advanced technologies. Secondly, if the support provided to farms helps them to better use economic resources, then efficiency will also increase [13].

[22] emphasizes that support policies alleviate farm lending restrictions and reduce risk aversion which is another factor that supports the positive relationship of direct payments on efficiency.

However, support policies may also be problematic and as a result efficiency might decrease because they can make the farm less productive due to two reasons [5]. First, support policies weaken managers’ motivation to produce at lower cost. Second, direct payments can help managers to avoid bankruptcy and as a result the managers postpone the activities to re-organize the farm in order to become more productive and to improve performance. Managers go to fundraising activity rather than production or prefer more leisure with a higher income from direct payments. According to [20], direct aids reduce the work time of farm managers and their efforts and as a result, the farm's effectiveness decreases. Support policies can also influence the change of farmer's orientation because make the farmers invest in sectors that have more support but in which may be less productive [4]. Even when support policies are important, farmers spend more time on other activities that may adversely affect farm performance [17] or just prefer more leisure with a higher income from direct payments [24]. In addition, support farms can change the combination of capital and labour by investing more in capital and thus may result in allocation inefficiency [12, 21]. For example, when these payments are linked to a special resource like capital, then they are used to increase this resource and not to other factors [16].

Also, one may expect no significant effect (i.e. null effect) of direct payments on technical efficiency, since this is not the primary aim of the subsidization policy. As suggested, the effect of direct payments on performance indicators of farm can be of both directions or no effect but it is also important to recognize that support policies affect restructuring of the farm in general because they effect the decision making of the famers and make them isolated from economic and technical signals and as such the performance indicators of the agricultural sector might decrease.

However, the economic theory does not provide enough guidelines on the direction of relationship between direct payments and technical efficiency and as such there is a small amount of studies conducted in this field [14]. As these studies are little and complex, this relationship and its direction is an open empirical question and is subject to empirical studies [17].

MATERIALS AND METHODS

In many countries of the world, agriculture is one of the most important sector for the development of the national economy and is the oldest sector in the history of the mankind. Because of its importance, it was decided in this paper to measure the technical efficiency rates of the farms in CEECs and to identifying potential sources of inefficiency by being focused on direct payments.

Efficiency is a very important indicator when evaluating the performance of a production units, of an industry, or of the whole economy. In the agricultural sector, efficiency is a key contributor to agricultural productivity growth and distribution of resources in the economy. As a result, there have been developed different techniques to measure the technical efficiency scores of the farms in the sample.

Stochastic Frontier Analysis (now one referred as SFA) is suggested as the most suitable technique to be used in agricultural studies because it is able to consider stochastic noise when measuring the technical efficiency scores [9]. In addition, as agricultural production is characterized with high level of uncertainty, due to factors out of the control of the farmers such as weather, pests, diseases, trade issues, access to material and other factors, then the use of SFA is suggested to be the most adopted methodology in measuring farm efficiency [9]. SFA can handle this stochastic noise because it is able to decompose the error term of the production function into the pure random error *(vi*) which accounts for measurement errors and effects of the factors that are out of the control of the farmer into the technical inefficiency terms (ui) which accounts for the deviation from the frontier [2]. As agricultural production is likely to be effected by unpredictable factors, by other variables such as size, organizational type, education and also by policy measures, then the SFA offers a better framework for this kind of analysis compared to other techniques (e.g. Data Envelopment Analysis).

It was the year of 1977 that marked the origination of SFA with the work of [1] and [21]. The model for panel data is the model to be used for the measurement of technical efficiency and sources of inefficiency for farms in CEECs. Panel data models have many potential advantages over cross-section data in frontier estimation. According to [8] panel date increase the degree of freedom for estimation of parameters, provide consistent estimators of form efficiencies, removes the necessity to make specific assumption for the distribution of u_i, do not require inefficiencies to be independent of the regressors. In addition, with panel data is possible to estimate the productivity change as well as the technical progress or regress [10].

This model for panel data is represented as below [7]:

$$\boldsymbol{y_{it}} = \boldsymbol{f}(\boldsymbol{x_{it,}}, \boldsymbol{\beta}) + \boldsymbol{\varepsilon_{it}}, \quad \text{where: } \boldsymbol{\varepsilon_{it=v_{it}-u_i}}$$
$$y_{it} = f(x_{it,}, \beta) + v_{it} - u_i \,, \;\; u_i \geq 0$$

where:

y_{it} represent the output of the i-th farm at t-th time;

x_{it} represent the inputs to be used in the production function
$f\ (x_{it,}, \beta\ )$ is functional form of the production function
β is the unknown parameters to be estimated though SFA
v_{it} represents the statistical noise (iid), $N(0, \sigma_v^2)$
u_i represent the component of technical inefficiency $N(\ \mu, \sigma_v^2)$.

On the other hand, technical efficiency of the farm is represented as observed output y_{it} over maximum feasible output [6]. As a result, this rate can be expressed in terms of the errors as [6]:

$$\boldsymbol{TE_{it} = exp - (u_i)}$$

Technical efficiency rates can range between 0 and 1, where the value of 0 means that the farm is technical inefficient while 1 means that the farm is 100% technical efficient. These values are as such because of u_{it} which is a nonnegative random variable. Otherwise $\boldsymbol{TE_{it}} < 1$ provides a measure of the shortfall of observed output from maximum feasible output in an environment characterized by $exp\ (v_{it})$, which allows for variation across producers [6].
In addition to the model for the measurement of technical efficiency score, there is another model which is used to identify the sources of inefficiency (in u_{it}). The inefficient term ($U_{it}\ s$) is supposed to be function of a set of other explanatory variables and can be presented by the equation below:

$$\boldsymbol{U_{it} = z_{it}\delta + W_{it}}$$

where:
z_{it} represent the independent variables;
δ represents the unknown coefficient to be estimated;
W_{it} denotes the truncation of the normal distribution with zero mean and variance σ^2.
For the measurement of the both models in the same time, otherwise known as a one-step or as simultaneous procedure, is used the Maximum Likelihood technique as proposed by [3].

RESULTS AND DISCUSSIONS

The data from the European Community's Farm Accounting Data Network (FADN) are used to measure the technical efficiency scores for 11 countries of CEECs: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and for Slovenia for the period 2004-2016. FADN enables us to create a strongly balances dataset with 143 observations.
For the technical efficiency model are used 5 variables categorized in three groups:
-1. Output variable - Total Agricultural Output (y) in value;
-2. Input variables: Classical inputs (Capital in value ***(x₁)***, Labour in annual working units ***(x₂)*** and Land in ha ***(x₃)***);
-3. Variable Input - Intermediate Consumption in value ***(x₄)***.
The descriptive statistics for these variables are presented in Table 1.

Table 1. Descriptive Statistics for CEECs

Var.	Obs	Mean	Std. Dev	Min	Max
Output (value)	143	100,260	151,858	0	665,263
Labour (AWU)	143	3.37	4.35	0	22.02
Land (UAA)	143	101.59	156.4	0	615.33
Var. Input (value)	143	76,561	120,960	0	497963
Capital (value)	143	262,698	342,458	0	1,682,114

Source: Author's own calculations.

As explained in the section above, in efficiency analysis is not important only to measure the technical efficiency score by using the variables presented in table 1. Of an equal importance in efficiency analysis, also presents the measurement of the effect of exogenous variables (Zs) on inefficiency term. The analysis of the second model can explain why some farms can perform better compared to other farms, in other words, why some farm are nearer the frontier and have higher technical efficiency rates.
The explanatory variables to be used in the inefficiency model are: direct payments to total

output, degree of specialization proxied by the ratio of total livestock ouput to total output and its square, total land to total labout, family labour to total labour, ranted land to total utilized land, financial helath proxied by short term and long term debt to total assests, and also are used two dummies: regional dummies and legal form dummies. Direct payments is the variabl of interest in this paper and is treated as exogenous because a farmer can not increase or decrease the amount of production only by increasing or decresing the amout of direct payments that they receive [25].

Before executing in STATA the MLE estimation of stochastic frontier model, it is preferred to firstly estimate the model with OLS and to investigate the skewness of the OLS residuals. For the case of CEECs, Table 2 presents the coefficient estimated by using OLS.

Table 2. OLS estimation of the model for CEECs

Ln Output	Coeff.	Std. Err.	t	P>|t|
Ln Capital	-0.0078	0.027	-0.29	0.771
Ln Labour***	0.0874	0.024	3.69	0.000
Ln Land	-0.0108	0.028	-0.38	0.704
Ln Variable Input***	0.8824	0.040	21.97	0.000
_cons	1.6705	0.167	9.97	0.000

Note: * significant at 10%, ** significant at 5%, and *** significant at 1% of significance level
Source: Author’s own calculations.

The coefficients from this OLS estimation for the variables of lnLabour and lnVariableInput are significant at 1% of the significance level and as such are suggested to be consistent for the production frontier model. On the other hand, lnCapital and lnLand from the OLS estimation are found to not be significant but will continue to be present in the stochastic frontier model. The OLS estimation also suggests that the output elasticity of the classical and the variable input is 95%, which is very close to the constant returns to scale.

In addition, the estimation of the OLS regression helps us to check the validity of SFA specification. With the other words, to see whether the SFA methodology, which is composed from the two error terms, is more appropriate compared to the standard OLS, which is composed from one error term. This is done through the test on OLS residuals proposed by [23]. If there exists a negative skewness on the OLS residuals that the SFA is valid and the MLE techniques can be used to estimate the stochastic frontier model. As such the hypothesis for the Methodology **(γ=0)** to be tested are:

Hypothesis 1: Methodology (γ=0)

H_0: OLS is appropriate for the estimation of the production function (SFA is invalid)

H_1: OLS is not appropriate for the estimation of the production function (SFA is valid)

To show more clearly if the OLS residuals are skewed to the left, is performed the skewness statistics as suggested by [8]. The skewness statistics shows a value equal to -3.260301. This negative number suggests that the OLS residuals are skewed to the left and as a result the null hypothesis of the no skewness on the OLS residuals is rejected. This test suggests that SFA is valid and the MLE technique can be used to estimate the SFA model. In addition, there is needed to make a distribution assumption on $\boldsymbol{u_i}$. In this paper, is assumed half-normal distribution on $\boldsymbol{u_i}$ as the most preferred assumption proposed in the literature. After making the distribution assumption, is needed to choose the function form that best represent the data. The mot two common functional forms are: Cobb-Douglas and Translog functional form. These two functional forms can be represented as:

Cobb-Douglas frontier model:

$$lny_{it} = \beta_0 + \sum_{j=1}^{K} \beta_j \ln x_{j,it} + v_{it} - u_i$$

Translog frontier model:

$$lny_{it} = \beta_0 + \sum_{j=1}^{K} \beta_j \ln x_{j,it} + \frac{1}{2}\sum_{j=1}^{K} \sum_{h=1}^{K} \beta_{jh} \ln x_{j,it} \ln x_{h,it} + v_{it} - u_i$$

The LR statistics, is a test that suggests whether the Cobb-Douglas functional form is preferred over the Translog functional form or vice-versa. The SFA can be used on both functional forms, however it is important to know whether for the dataset is more appropriate the Cobb Douglas functional (known as more restricted model) or the Trans-log functional form (known as less restrictive model). For the functional form, are presented the hypothesis below:

Hypothesis 2: Functional Form ($\boldsymbol{\beta_{ij}}$ =0)

H_0: Cobb-Douglas is a more suitable functional form for the dataset

H_1: Cobb-Douglas is not a suitable functional form for the data set.

The LR statistics can be calculated by the equation:

$$\boldsymbol{\lambda = -2[LLF_0 - LLF_1)}$$

where:

LLF_o - likelihood value from the Cobb-Douglas functional form

LLF_1 - likelihood value from the Translog functional form

When computing the calculation for the formula above in STATA, we receive a result of -60.3. This value, when compared to the critical value, suggest that we do not have enough statistical evidence to reject the null hypothesis. As the null hypothesis is not rejected, it is suggested that the Cobb-Douglas functional form better fits the data and will be used later in the analysis

In addition, it is important to test for technical inefficiency in our error term though the below mentioned hypothesis testing.

Hypothesis 3: No inefficiency (δ i= 0)

H_0:There is no technical inefficiency $(\boldsymbol{\sigma_u^2 = 0})$.

H_1: There is technical inefficiency $(\boldsymbol{\sigma_u^2 \neq 0})$

As in the above hypothesis testing, also in this hypothesis testing is used the LR value. The same formula will be applied in order to calculate the LR statistics, however, here the $\mathbf{LLF_o}$ represents the log likelihood values of the restricted OLS model whereas LLF_1 represents the likelihood value of the unrestricted SF model. The implementation of this formula gives us a number of 18.47, when compared with the critical value, suggests that the null hypothesis of no technical inefficiency is rejected.

All the hypothesis test conducted suggest that the SFA is valid, there is technical inefficiency and that in order to conduct the empirical analysis for our data, the Cobb-Douglas functional form is going to be used. In this model, the explained and the explanatory variables are expressed in their natural logarithmic forms as below.

$$\boldsymbol{ln}y_{it} = \beta_0 + \beta' lnx_{it,} + v_{it} - u_i$$

On the other side, the farm-level variables are going to used in order to measure their effect on technical efficiency rates. While the first model measures the technical efficiency rates, the second model measure the effect that some firm-level or exogenous variables might have on the technical efficiency rates by being focus on direct payments, The inefficiency model is presented as below.

$$\boldsymbol{U_{it} = z_{it}\delta + W_{it}}$$

When both of these models are estimated in the STATA software through the one-stage procedure, the results presented in Table 3 are achieved.

The variables of Capital and Land significantly and negatively affected the technical efficiency of the farm where as the Labour and the Variable Inputs effect the technical efficiency significantly and positively. Regarding the inefficiency model, is can be suggested that total direct payments to total output as a proxy for the effect of direct payments have a significant positive sign, meaning that it increases inefficiency, meaning that it has negative effect on technical efficiency score.

The increase of direct payments with 1%, decreases the output by 5.6%. The negative effect on efficiency is also observed in the share of rented land to total land as well as in the debt to asset ratio, meaning that an increase in rented land as well as in the total liabilities, decrease the technical efficiency scores.

Table 3. Maximum likelihood estimation of SFP together with the inefficiency mode for CEECs

Ly	Coeff.	P>|z|
Frontier		
Ln Capital***	-0.209	0.000
Ln Labour***	0.306	0.000
Ln Land***	-0.118	0.000
Ln Variable Input ***	1.008	0.000
_cons	3.170	.
Usigmas		
Z1- Total Direct payments to Total Output (%) ***	0.056	0.005
Z2- Share of Crop Output to Total Output (%) ***	-0.086	0.000
Z3-Total Land to Total Labour Ratio (%) ***	-0.001	0.000
Z4-Share of Hired Labour to Total Labour (%)	-0.001	0.953
Z5-Share of Rented UAA to Total UAA (%)*	0.029	0.051
Z6- Debt to Asset Ratio (Total Liabilities to Total Assets)***	0.054	0.003
_cons	-0.457	0.678
Vsigmas		
_cons	-35.71	0.898

Note: * significant at 10%, ** significant at 5%, and *** significant at 1% of significance level
Source: Author's own calculations.

On the other side, is found positive effect on technical efficiency score by these variables: the share of crop output to total output, total land to total labour, and the share of hired labour to total labour. However, the last variables in not significant whereas the other two variables are significant at 1% of the significance level. The average technical efficiency rates for all the data is summarized in Table 4. The table suggest that the average technical efficiency scores is 0.84, meaning that on average a farm can achieve up to 84% of the maximum output. The rest of the potential output, 16 %, is lost due to technical inefficiency. On technical efficiency, negatively and significantly have an effect the variables for the total direct payments to total output, share of rented land to total land, and the debt to asset ratio Most of the farms are located above 75% of technical efficiency rate.

Table 4. Summary of technical efficiency scores

Variable	Obs	Mean	Std. Dev.	Min	Max
TE	143	0.86	0.097	0.497	0.99

Source: Author's own calculations.

It was expected capital to have the positive, however the negative sign of capital was found also in the study of [18] in the case of the Polish farm with the explanation as the CEECs have old machinery and as a result are less productive. In addition, also the variable of land is found to be significant and negative with the reason that larger land in more difficult to manage and as a result can negatively affect the efficiency rates.

CONCLUSIONS

The aim of this research was to shed light on the effect of direct payments on technical efficiency of farms for the case of CEECs. Technical efficiency is used as an indicator for farm performance and as such was used also in this paper. As the agricultural sector is characterized with stochastic noise, then the SFA approach was used in order to conduct this research. After some hypothesis testing, it was suggested that the Cobb-Douglas functional forms were more appropriate for the data-set and as a result was used in the empirical analysis. The analysis paid attention to direct payments whish are considered as the most important variable in the inefficiency model as a large part of almost every budget spending's are headed for agricultural supports. Even though, the support for the farms has increased for CEECs, especially after the accession to the EU, in this paper is found to significant and negatively impact the technical efficiency rates. In this regard, it is suggested the agricultural policies to be more targeted in order to have the desired positive effect.

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