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Impact of the Rural Development Programme Subsidies on the farms' inefficiency and efficiency

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Abstract: The aim of the paper is to assess the impact of subsidies from the Rural Development Programme of the Czech Republic for the years 2007–2013 (RDP) on the technical inefficiency and the efficiency of Czech agricultural holdings. An unbalanced panel includes 454 Czech farms and 2103 observations for years 2007–2013. The Parametric Stochastic Frontier Analysis is used to assess the technical inefficiency and efficiency. A "true" fixed effects model with RDP subsidies explaining the variance of the inefficiency term is estimated. The results are ambiguous. On one hand, the RDP subsidies contributed to the decrease of variance of the inefficiency term, but on the other, the effect is statistically significant only at 90% level of significance. Therefore, we further tested the medians of inefficiency (efficiency) which are lower (higher) in the subsidized farms. We concluded that there are statistically significant differences depending on whether the farm received the RDP subsidies or not. However, we suggest a further examination of the particular projects using the efficiency of investments indicators.

Key words: Common Agricultural Policy, Stochastic Frontier Analysis, subsidy, "true" fixed effects model

The Common Agricultural Policy (CAP) of the European Union (EU) is the oldest of all common policies. It is also one of the most financially demanding policies of the EU and the utilized policy-economical instruments bind a significant part of expenditures of the European budget. (Kroupová and Malý 2010) The entrance of the Czech Republic (CR) into the EU enabled the agricultural holdings to obtain subsidies in the framework of the CAP. Beside direct payments entitled on the eligible agricultural land or on the defined purposes, there are subsidies of the investment character provided within the Rural Development Programme of the Czech Republic for years 2007–2013 (RDP).

We proclaim that it is necessary to continuously analyse the effect and efficiency of the spent public finances. Together with Kumbhakar et al. (2009), we state that "subsidies should be designed in a way that does not promote inefficiency." Therefore, we analyse the impact of the RDP subsidies on the inefficiency and efficiency of Czech farms. The paper is structured as follows. Firstly, the type of subsidies provided and the results of the relevant current research are presented. The next section describes used methods and dataset. Consequently, the results are presented and discussed in the context of the previous findings. The last section concludes.

Direct payments (Single Area Payment Scheme – SAPS and until 2013 also the national Top-Up subsidies) "affect the amount of equity and therefore they are reflected in the company' financial resources by increasing the percentage of equity to the total liabilities" (Aulová 2010). It is in line with one of the main objectives of agricultural policy which is to maintain or even enhance the income of the farm households. (Benni and Finger 2013) Direct payments have also substantial effects on the development of agricultural production. The MacSharry and the later CAP reforms tried to decouple the payments, i.e. to separate their link to the amount of production. However, there was in the programming period of 2007–2013, and there still will be some voluntary coupled support available for certain sectors or regions after 2015. According to Fragoso et al. (2011), "the decoupling of the CAP payments leads the production decisions and the resources allocation to be

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more dependent on market prices and competitive advantages." We shall therefore also examine the effect of direct payments on the production level of agricultural holdings.

The effect of the subsidies from the RDP is less direct. The programme supports modernization of agricultural holdings, diversification of businesses, land adjustments, adding value to the production and other measures which should enhance competitiveness of the farms. By its definition, the RDP should contribute to the enhancement of the rural development. Therefore, we also should examine how the subsidies are spatially distributed in Czech regions according to their type. The typology of the EU distinguishes 6 predominantly rural regions in the CR: the Plzeňský, Jihočeský, Vysočina, Pardubický, Zlínský and Olomoucký region and 2 predominantly urban: the Capital City Prague and the Středočeský region. Others are intermediate.

"Theoretically, a negative influence of operational subsidies is expected, as subsidization brings a certain return to farmers who may thus lower their effort in the input waste" (Bojnec and Latruffe 2013). On the other hand, together with Timofti and Memeț (2012), we proclaim that "capital investments play a critical role in ensuring economic development and restructuring of agriculture". We suppose that they should increase or at least not lower the technical efficiency. New modern machinery and equipment can influence the production process in a positive way, to prevent wasting of resources and to enhance their efficient usage. Pitt and Lee (1981) defined the technical efficiency as the maximal quantity of output obtained using the given inputs. Two methods are usually used to assess the technical efficiency: the non-parametric Data Envelopment Analysis (DEA) or the parametric Stochastic Frontier Analysis (SFA). Some researchers use both methods as each of them has its advantages or disadvantages.

The advantages of the DEA are that it does not make any assumptions about the production technology or the variance of the inefficiency term. It is an extreme-point method which compares the decision making units only with the best ones and it does not require any assumptions about the functional form of the relation between inputs and outputs. It enables the inclusion of more outputs and only a small sample is sufficient (Vincent and Zegarra 2014). However, as Boudný et al. (2011) pointed out, the assessed units have to be relatively homogenous – i.e. they should use similar inputs to produce similar outputs. Speelman et al. (2008) see the disadvantage in the fact that it is a deterministic method which is susceptible to measurement errors and other noise in the data. Also the assumptions about the returns to scale in the production technology must be made.

The SFA is characterized by a priori defined finite set of parameters, which are consequently estimated from the data. It is the stochastic method which contains the statistical noise and enables hypothesis testing by usual statistical tests. While in the DEA, an equation has to be solved for each farm and year, the SFA is more flexible as it enables dealing with panel data. Therefore, we apply it in our research.

Many surveys have been done in the area of impact of the EU's subsidies on the efficiency and profitability of Czech agriculture and farms. For example, Malá et al. (2011) found a positive effect of direct payments on the increasing of the profit of agricultural producers. Boudný et al. (2011) found out that the higher are the SAPS and the Top-Up subsidies, the higher is the efficiency of farms in the CR. Contrary to that, a group of 25% of the highest efficient farms benefited from the fewer amounts of the LFA and AEO subsidies per hectare than a group of 25% the less efficient farms. Results of other researches are compared to ours in the discussion section.

METHODOLOGY

The aim of the paper is to access the impact of subsidies from the RDP on the technical inefficiency and efficiency of Czech agricultural holdings. The SFA method is used to estimate the production frontier in the Cobb-Douglas form (1).

$$y_{it} = \alpha_i x_{1,it}^{\beta_1} x_{2,it}^{\beta_2} \ldots x_{k,it}^{\beta_k} \varepsilon_{it} \quad (1)$$

where α_i is a group specific constant, y_{it} denotes production of a farm i in time t, and $x_{k,it}$ $(k = 1,\ldots K)$ represents K explanatory variables powered by the elasticity coefficients β_k. A stochastic term ε is time and individual variant and it consists of two parts – v_{it} and u_{it}. "The firm and time specific idiosyncratic term which locates the firm's own stochastic frontier is v_{it}, which can be either positive or negative. The second component, u_{it}, represents technical or cost inefficiency, and must be positive" (Greene 2002).

It is more convenient for the estimation to express the power function in the linearized form – i.e. in logarithms (2).

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$$y_{it} = \alpha_i + \boldsymbol{\beta}^T \mathbf{x}_{it} + v_{it} - u_{it} \quad (2)$$

where α_i is a group specific constant, the output $y_{1,it}$ is the logarithm of performance of the i^{th} farm in time t expressed as the sum of sales of own products and services in thous. CZK, change of stocks of own production in thous. CZK and activations in thous. CZK. It takes into account inflation using the price index of agricultural producers (2005 = 100). A matrix $\mathbf{x}_{it}$ contains explanatory variables: the consumption of material and services in thous. CZK ($x_{1,it}$), the consumption of capital – long term assets in thous. CZK ($x_{2,it}$)[1], labour – a number of workers calculated as labour costs divided by the average wages in the particular region and year ($x_{3,it}$) and land established as division of the total income from the SAPS per year by the SAPS rate in particular year ($x_{4,it}$). The land is further adjusted by the quality index calculated as the division of the official land prices in the region and year to the average official prices in the whole country in the given year.

There are two possibilities how to include subsidies into the SFA. "A more general approach enables the subsidies to influence the output directly as one of the primal input" (Bokusheva et al. 2012). However, we run to certain problems: "while the traditional inputs are necessary for the production, subsidies are not" (Kumbhakar et al. 2014). Besides, this approach requires that subsidies are obtained by all farms. This is the case of the SAPS subsidies in our sample, which are considered to be the explanatory variable of the frontier function ($x_{5,it}$) and the Top-Up subsidies ($x_{6,it}$) taken up by most of the farms in a sample. The RDP subsidies are incorporated differently. This second approach which allows the subsidies to affect productivity through the technical inefficiency function is recommended by Kumbhakar et al. (2014). The RDP subsidies were included in the dummy form taking value of 1 when the farm in the particular year received it or 0 when not. If they were in the nominal values, we would run into zero values.

While the distribution of v_{it} is considered to be normal ($v_{it} \sim N(0, \sigma_v^2)$), we have to assume some distribution of u_{it}. We considered the truncated normal distribution ($u_{it} \sim N^+(\mu; \sigma^2)$) as introduced by Battese and Coelli (1995). In this case, not only the variance, but also the mean of inefficiency the can be a function of explanatory variables. Hence, the inefficiency of the farms is explained directly in one step. The function of the inefficiency mean is written as follows (3).

$$\mu_i = \sum_{j=1}^{J} \delta_j z_{ij} \quad (3)$$

where μ_i is the mean of inefficiency term u_{it}, z_{ij} represents J explanatory variables related to the heterogeneity of the farms and δ_j are parameters of those variables. Our model includes only one explanatory variable of the mean inefficiency – a constant.

Heteroskedasticity in the farms' data is explained in the function of the inefficiency term's variance (4).

$$\sigma_{ui} = \exp\left(\sum_{j=1}^{J'} \omega_j z'_{ij}\right) \quad (4)$$

where σ_{ui} is the variance of inefficiency term u_{it}, z'_{ij} represents J' explanatory variables related to the heteroskedasticity and ω_j are the parameters of those variables. Here, we include the RDP subsidies and constant.

Originally the SFA models assumed that the inefficiency was time-invariant. Also if the heterogeneity among farms was time-invariant, it was captured by the inefficiency term. Greene (2002) proposed the "True" Fixed Effects Model (TFE) and the "True" Random Effects Model (TRE), where the inefficiency changes in time non-systematically. We utilize the TFE as presented above (2).

The estimation of the model is done by the maximum likelihood method which searches for values of parameters which maximizes the likelihood function $L(\beta) = \phi(y; \beta)$ or the logarithm of the likelihood function respectively $\ell(\beta) = \ln(L(\beta))$. The parameters are set in that way that the likelihood that the true value will be measured is maximal.

The inefficiency was calculated according to Jondrow et al. (1982) as the expected value of u_i given ε and efficiency as the exponential of the negative expected value of u_i given ε which was also developed by Jondrow et al. (1982).

Consequently, the farms were divided according to the fact whether they obtained the RDP subsidy or not and tested by the nonparametric t-test that two independent samples (unmatched data) are from the populations with the same distribution, i.e. whether the technical efficiency statistically significantly differ in case of the subsidized firms and non-subsidized firms.

We also examined the regional distribution of inefficiency and efficiency. However, the statistical

[1]Both variables are adjusted by the price index of industrial producers (2005 = 100).

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differences among farms cannot be tested due to the insufficient number of observations in some regions.

The calculations were done in the software Stata 11.2. The maps are displayed in the ArcGIS 10.1.

DATA

The accountancy data were obtained from the Albertina database of Bisnode s. r. o. company and combined with the database of the subsidies' beneficiaries managed by the State Agricultural Intervention Fund.

We have an unbalanced panel of 454 agricultural holdings mostly with the mixed production (there are only 4 with animal and 10 with crop production). 512 observations are for firms which received the RDP subsidies and 1591 observations for firms which did not. There were between 1 to 6 observations for each farm (on average 4.7), but only units with more than 1 time occasion were considered in the calculation of technical efficiency. Hence, we have 449 farms and 2098 observations in total.

We selected farms which received the Single Area Payment (SAPS) in order to make the sample as homogenous as possible. Agricultural holdings with some subsidies might be favoured to those without subsidies. Hence, when we refer to the "subsidized" farms, we mean those which received the RDP subsidies. Considering that the SAPS are available to all farms in the sample, we can introduce them (together with the Top-Up subsidies) into the production function among the explanatory variables as one production factor.

On average, one farm produced the goods in the value of 49 337 thous. CZK a year using the material value of 36 335 thous. CZK and the capital of 57 987 thous. CZK. Farms which received the RDP subsidies had a higher average production. An average farm employed 56 persons and cultivated 893 hectares of land. On average, one farm received 5038 thous. CZK from the SAPS and 3052 thous. CZK on the Top-Up. This accounts for 8090 thous. CZK of the additional income every year. Besides, 488 farms also at least once received subsidies from the RDP. Naturally in 2008, there were only 15 farms as the RDP begun its functioning. Most of farms obtained the RDP payments in the year 2009 (190 farms) and 156 one year later when the highest amount was redistributed (454 026 thous. CZK). The highest average amount was given in 2012 to 14 farms (3347 thous. CZK).

According to our sample, the subsidies from the RDP are not distributed equally in the regions of the CR as it should be done regarding the nature of the programme. They should support mainly the farms located in rural areas in order to maintain sustainable development of those territories. However, the Czech RDP considers as rural all regions with the exception of the capital city. In our sample, the highest share of subsidized farms from the RDP was in the Plzeňský region (36%) and the lowest in the Královéhradecký region (14%). The highest subsidies per one farm were obtained in the Moravskoslezský region (6.06 mil. CZK). However, there were only five farms sharing the total amount of 28.56 mil. CZK. Most beneficiaries are from the Jihomoravský and Pardubický regions. The highest total amount of subsidies was given to the Pardubický region (94.66 mil. CZK), but per one farm, the amount was only 4.06 mil. CZK.

Farms in the typical rural regions such as the Jihočeský, Vysočina, Zlínský and Olomoucký received less than 2 mil. CZK each. The lowest amount of subsidies was obtained in the Liberecký region and Královéhradecký region. Both are of the intermediate type.

RESULTS

The results of the stochastic frontier estimation (displayed in Table 1) are according to the expectations. The increase of all production factors causes the increase of technical efficiency by a certain percentage. The Cobb-Douglas form of the production function enables us to interpret the coefficients as elasticity. The most sensitive is the production on the changes in the land availability, where 1% growth of the cultivated land causes 0.33% increase of production. On the other hand, a less sensitive is the production on the higher Top-Up subsidies (which is desired) and capital. When the consumption of capital increases by 1%, the production increases by 0.10%. However, the coefficient is statistically significant only at the level $\alpha = 0.1$. The effect of the SAPS subsidies is strongly positive and significant. Despite the attempts to decouple those payments, there is still a link to the production (it increases by 0.24% when the amount of the SAPS grows by 1%). Pechrová and Vlašicová (2013) came to the same conclusion in the case of organic farms. On the other hand, Malá et al. (2011) concluded that in the plant production, the direct payments do not motivate

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Table 1. TFE model estimation results

Variable	Coefficient	Variable	Coefficient
Frontier			
β_1 [ln(x_1)]	0.2549 (0.0562)***	β_4 [ln(x_4)]	0.2394 (0.0025)***
β_2 [ln(x_2)]	0.0969 (0.0547)*	β_5 [ln(x_5)]	0.2394 (0.0025)***
β_3 [ln(x_3)]	0.3037 (0.0008)***	β_6 [ln(x_6)]	0.0231 (0.0022)***
Mean of inefficiency (μ_u)		**Variance of inefficiency (σ_u^2)**	
δ_0 [const.]	–37.0173 (4.6441)***	ω_0 [const.]	1.9982 (0.1301)***
		ω_1 [Dummy RDP]	–0.1248 (0.0685)*
Model's statistics		**Variance of stochastic term (σ_v^2)**	
Wald χ^2 (6)	4.53e^{09}***	γ_0 [const.]	–30.8514 (1.8502)***
Log likelihood	1406.1632		

Standard errors in parenthesis, significance levels: *α = 0.1; **α = 0.05; ***α = 0.01

Source: own calculations

agricultural businesses to increase the production. Hence, it seems that the effect depends on the type of production of the agricultural holding. The sum of coefficients for the production factors is 1.16, i.e. higher than 1, which implies that the farms achieve increasing returns to scale.

The average efficiency was 86.74% which shows that the farms could increase their efficiency by almost 13.26% to be 100% efficient. Half of them were efficient from 91.03%. The distribution of both inefficiency and efficiency can be seen in the Figure 1.

As visible from Figure 2, the inefficiency and efficiency of the firms developed over time reflecting the overall development of the economy. There can be for example seen a strong increase of inefficiency in 2008 (and a decrease of efficiency) followed by a mild increase in the later years. However, the highest efficiency was at the beginning (2007), while the highest inefficiency in 2012. Both inefficiency and efficiency seem to develop without any relation to the subsidies. Even the still growing amount of average subsidies (all in total) per one holding did not prevent the decrease in the technical efficiency.

The regional distribution of inefficiency and efficiency is displayed in Figure 3. The most inefficient were the farms in the rural Jihočeský region (30.23%). However, surprisingly the farms in another rural region – Plzeňský – were less inefficient (10.92%) and the most efficient. On average, they should improve their efficiency only by 9.26% to be 100% efficient. This might be due to the contribution of the RDP subsidies, as in the Plzeňský region; there is the highest

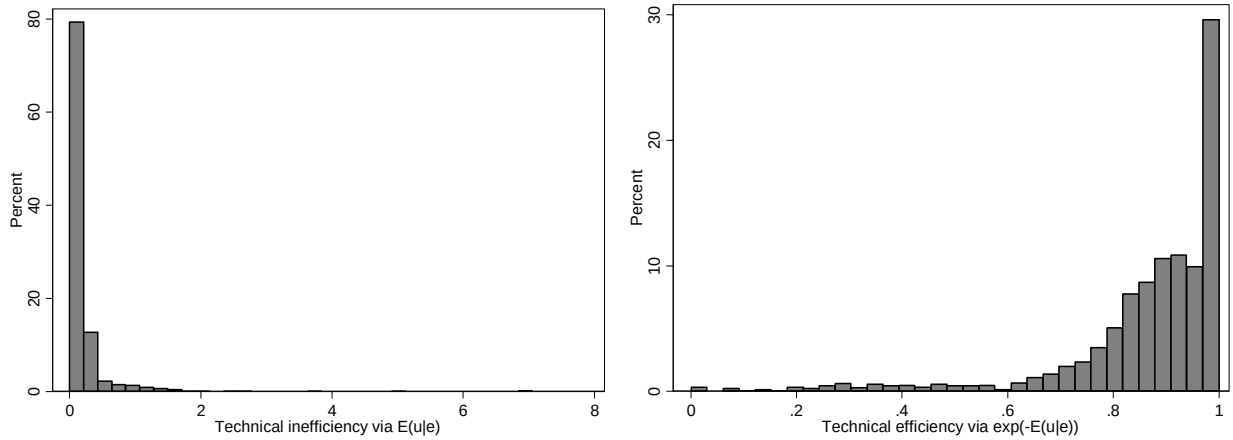

Figure 1. Distribution of inefficiency (on the left) and efficiency (on the right) among farms

Source: own calculations, displayed in Stata 11.2.

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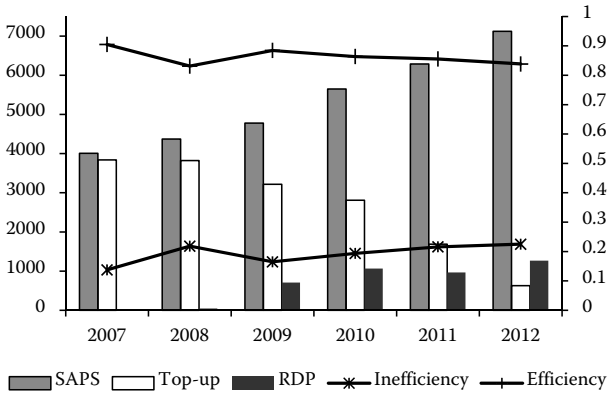

Figure 2. Development of the average technical inefficiency and efficiency and the average amount of subsidies in the period 2007–2012

Source: own calculations

share of farms subsidized from the RDP. The lowest efficiency was indicated in the Moravian-Silesian region (only 78.74% on average). It is surprising as those five farms obtained from the RDP the highest amount of all regions (on average 6.06 mil. CZK). The inefficiency of the farms in the only one urban region considered (Středočeský) was the lowest, but the efficiency was not the highest (86.25%). Overall, it seems that the most inefficient are the farms in the intermediate regions, while those in the rural areas belong to the most efficient ones (on average).

The subsidies from the RDP were included in a form of a dummy variable into the function of the variance of inefficiency (σ_u^2) and they explain the heteroskedasticity among farms. The dummy variable shows that when the farm is granted an amount from the RDP, its inefficiency declines. This was expected and it is a desirable result. Regarding the influence of subsidies, inefficiency in the subsidized firms was lower (16.74% on average) than in the non-subsidized firms (19.25%). We tested using the Wilcoxon rank-sum test whether the medians (7.90% for the subsidized farms and 9.83% for the non-subsidised farms) are equal. The calculated p-value (0.0134) is lower than the significance level 0.05, suggesting the rejection of the null hypothesis. We can conclude that the median of inefficiency statistically significantly differs depending on whether the farm received the RDP subsidies or not.

The same situation is with the technical efficiency. It is slightly higher in the case when the farms received subsidy from the RDP (the mean is 87.74% and the median 92.40%) than in case when it did not (the mean: 86.42%, the median: 90.64%). We tested whether the differences are statistically significant. The p-value 0.0144 enabled us to reject the null hypothesis. We may conclude that the median of efficiency differs in both groups of farms – subsidized and non-subsidized.

The same results were obtained when we used the t-test (assuming the normal distribution of inefficiency and efficiency which was rejected by the Shapiro-Wilk test). We may conclude that to a certain level the RDP subsidies have a positive and statistically significant impact on the technical inefficiency (lower it) and efficiency (increase it).

DISCUSSION

When assessing the effect of subsidies, it is necessary to distinguish their type. Operational subsidies (e.g. the direct payments per 1 ha or 1 head of specific livestock or the payments to variable inputs) tend to increase the inefficiency of the farms as it was proved by many researches. Contrary to that, it is expected that the investment subsidies will have a positive effect on the technical efficiency. "The RDP support investments should increase the total performance and sustainability of agricultural holding or they are related to the agro-environmental goals." (EC 1305/2013) The positive effect of the RDP subsidies

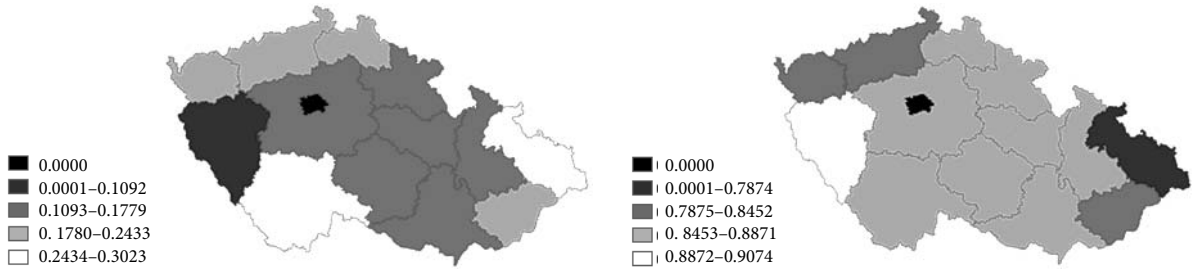

Figure 3. Distribution of technical inefficiency (left) and technical efficiency (right) in the regions of the CR (averages for years 2007–2012)

Source: own elaboration

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on efficiency was proved for example by Pechrová and Vlašicová (2013) in case of the organic farms. We found that the RDP subsidies lower the inefficiency, but only with 90% reliability. Similarly, Bojnec and Lattrufe (2011) found a non-significant impact of the investment subsidies received by farms (but a positive impact of the operational subsidies for small farms in Slovenia).

We further tested the differences in technical inefficiency (efficiency) as it is lower (higher) in the RDP-subsidized farms. It was proved that at 95% probability, the null hypothesis is rejected and that the RDP subsidies have a positive impact on lowering (increasing) the technical inefficiency (efficiency).

Besides the effects on the technical inefficiency (efficiency), there are other impacts of subsidies. Bojnec and Latruffe (2013) discovered that the support contributed negatively to the farms' technical efficiency, but positively to the allocative efficiency and profitability. Hence, a broader evaluation of the role of the public support on different components of the farms' performance is needed.

CONCLUSION

The aim of the paper was to access the impact of subsidies from the Rural Development Programme of the Czech Republic for the years 2007–2013 on the technical inefficiency (efficiency) of Czech farms. A sample consisted of farm which received the Single Area Payment. An unbalanced panel included 454 Czech farms and 2103 observations for years 2007–2013. Using the Stochastic Frontier Analysis, a Cobb-Douglas function in the linearized form was estimated. The distribution of the stochastic term was normal; in the of inefficiency term we supposed the truncated normal. A "True" Fixed Effects model with the RDP subsidies explaining the heteroskedasticity (variance of inefficiency term) was constructed. The RDP subsidies contributed to the decrease of variance of the inefficiency term. The dummy variable showed that when the farm was granted an amount from the RDP, its inefficiency declined. This was expected and desirable. However, the effect was statistically significant only at the 90% level.

Consequently, the technical inefficiency and efficiency were calculated. We found statistically significant differences in the median of inefficiency (efficiency) between the groups which received subsidies and which did not.

Based on both the variance of the inefficiency function and the statistical testing, we may conclude that to a certain level, the RDP subsidies have a positive and statistically significant impact on the technical efficiency. With caution, we can formulate some implications for the policy makers. The preceding analysis provides some evidence for the justification of the continuation of the EU subsidies in the framework of the CAP. It was proved that the farms subsidized from the RDP are statistically significantly less technically inefficient (higher technically efficient). It seems that the rural development policy has achieved its objective in the enhancement of competitiveness of agricultural holdings.

We must keep in mind that our data have limitations as they are based on financial statements of the farms and do not necessary fully reflect the reality. Also the subsidies do not affect only the efficiency but other performance indicators of the farms. And what is more, the projects financed from the RDP differ. Hence, a further examination of the particular projects using the efficiency of the investments indicators is a challenge for the future research.

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