Technical efficiency of arable farms in Serbia: do subsidies matter?

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Abstract

This paper analyses the technical efficiency of arable farms in Serbia and its determinants using a two-stage double bootstrap Data Envelopment Analysis (DEA) approach on the Farm Accountancy Data Network (FADN) data from 2014 and 2015 with special emphasis on the impact of agricultural subsidies on the technical efficiency of arable farms in Serbia. Bias-corrected DEA efficiency scores were first calculated and then regressed on a set of explanatory variables using the double-truncated regression approach. The estimates suggest that the share of rented land, land to labour ratio and financial stress variables are the main determinants of arable farm efficiency in Serbia. For the subsidies we found that area payments and input subsidies have some impacts on the technical efficiency of arable farms. In contrast, investment and other subsidies were found to have an insignificant impact on farm technical efficiency. These results suggest that the future potential shift of the Serbian agricultural support towards the Common Agricultural Policy (CAP)-like area based payments is expected to have a minimal but likely positive impact on farms technical efficiency in Serbia.

Keywords: *Technical efficiency, Arable farms, Agricultural subsidies, Serbia, Data Envelopment Analysis, Double bootstrapping.*

1. Introduction

Understanding how agricultural subsidies impact farm efficiency is one of a major research topic studied in agricultural production economics motivated by its implications for policy making. There are two opposing policy relevant arguments regarding the impact of agricultural subsidies on farm efficiency. On the one hand, within the context of the World Trade Organization (WTO) trade liberalisation agenda, the discussion centres on the distortionary impact of subsidies on agricultural markets (including farm efficiency). On the other hand, many developing and transition countries call for maintaining agricultural support to stimulate productivity growth and improvement of farm efficiency in order to address concerns related to food security and rural poverty (Gorton and Davidova, 2004; FAO, 2011; Minviel and Latruffe, 2017).

Theoretical studies are inconclusive in providing an exact explanation of the impact of agricultural subsidies on farm efficiency. Subsidies may have either a positive impact or a negative impact on farm efficiency depending on channels through which they impact efficiency. The negative impact of subsidies on efficiency may, among others, be caused by allocative and tech-

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nical efficiency losses induced by distortions in production choices and factor use and soft budget constraints. The positive impact of subsidies may be due to investment-induced productivity gains caused by interactions of credit and risk attitudes with subsidies (e.g. subsidy-induced credit access, lower cost of borrowing, reduction in risk aversion) (Rajan and Zingales, 1996; Hennessy, 1998; Blancard *et al.*, 2006; Ciaian and Swinnen, 2009; Rizov *et al.*, 2013). Empirical literature finds mixed effects of subsidies on farm efficiency depending on contextual factors, type of subsidies, data and applied methodology (Minviel and Latruffe, 2017). For example, a negative impact of agricultural subsidies on technical efficiency was found by Zbranek (2014) and Zhu and Oude Lansink (2010), who showed that in some European Union (EU) countries the share of total subsidies in total farm revenue has a negative impact on technical efficiency. Similarly, Latruffe and Fogarasi (2009) and Bojnec and Latruffe (2013) argued that less subsidized farms were more technically efficient, while Lakner (2009) shows that the agri-environmental payments and investment support have negative effects on the technical efficiency of organic dairy farms in Germany. Subsidies may affect negatively farm performance also because they are often conditional on meeting certain environmental requirements which might adversely impact the economic efficiency of resource allocation (e.g. land) on farms. For example, Cimino *et al.* (2015) show that greening requirements linked to direct payments have a negative effect on gross margin of arable farms in Italy and that the green payments usually do not compensate the reduction of farm gross margin for the affected farms. On the other hand, there is evidence supporting the positive influence of subsidies on farm technical efficiency. Galanopoulos *et al.* (2011) found that subsidies have a significant impact on the technical efficiency of the small-sized farms in EU, while Pechrová (2015) emphasised that subsidies for Less Favourable Areas positively affect farm efficiency. Sauer and Park (2009) find a positive influence of organic subsidies on total factor productivity change (technical efficiency change and technological change) for organic dairy farms in Denmark. Latruffe *et al.* (2017), in addition to positive association between subsidies and technical efficiency on dairy farms in some European countries, also found a negative or no significant relationship in some EU countries.

The existing empirical studies usually employ a two-stage approach to analyse the impact of subsidies on farm efficiency whereby efficiency measures are estimated in the first stage and then these efficiency measures are regressed on subsidies and other explanatory variables in the second stage (e.g. Lansink and Reinhard, 2004; Johansson and Öhlmér, 2007; Lakner, 2009; Sauer and Park, 2009; Zhu and Lansink, 2010; Lenglet *et al.*, 2014; Poudel *et al.*, 2015). The most often used methods to estimate farm efficiency are the non-parametric approach with Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Analysis (SFA) (Coelli *et al.*, 2005). However, when it comes to the second stage, a Tobit regression model (Tobin, 1958) is often used to investigate explanatory variables that affect technical efficiency. In this regard, Simar and Wilson (2007) have criticised the use of the Tobit regression model where DEA efficiencies are used as the dependent variable in the second stage – due to the fact that the statistical inference for the calculated coefficients is biased due to the serial correlation of DEA efficiency estimators. Therefore, they proposed an alternative estimation and statistical inference procedure based on a double-bootstrap approach (Algorithm 2). This approach has been applied relatively widely to analyse the technical efficiency in the agricultural sector (Balcombe *et al.*, 2008; Latruffe *et al.*, 2008a; Monchuk *et al.*, 2010), but it has not yet been applied to investigate the technical efficiency of farming sector in Serbia.

This paper contributes to the literature by analysing the impact of agricultural subsidies on technical efficiency of arable farms in Serbia. We have applied a two-stage double bootstrap DEA approach using the Farm Accountancy Data Network (FADN) data from 2014 and 2015. Serbia represents particularly interesting case study as it is a transitional country facing economic development challenges and changing agricultural policy environment. Serbia is under the EU accession negation process which requires reforming its agricultural policy to make it compatible with the Common Agricultural Policy (CAP). Most empirical studies analysing the impact of subsidies on farm efficiency focus on developed countries. There is significantly less work done on developing and transition countries particularly from the Western Balkans. A better understanding of the relationship between subsidies and farm efficiency could provide a relevant input to support the evidence based policy making and the potential future reforms in Serbia. This is particularly relevant given that agricultural policy in Serbia is under a constant adjustment driven by the EU accession process and internal political economy factors (Bogdanov and Rodić, 2014; Bogdanov *et al.*, 2017).

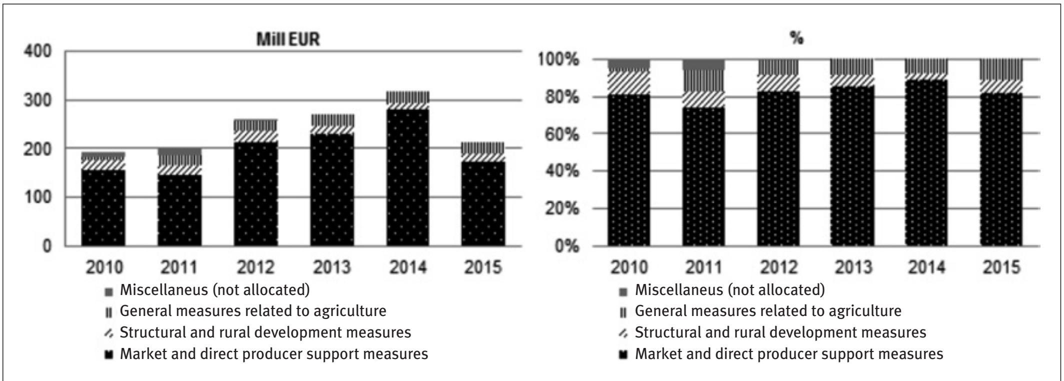
The rest of paper is structured as follows. The next section describes agricultural subsidies in Serbia. The third section outlines the methodology and data employed in the paper. The fourth section presents the estimated results. The final fifth section summarises and concludes the paper.

2. Agricultural subsidies in Serbia

During the past decade the agricultural policy in Serbia was marked by frequent changes in the policy framework, the implementation mechanism and the magnitude of the support. These policy changes were mostly driven by internal political factors as well as by the EU accession process aiming to gradually approximate Serbian agricultural policy with the EU CAP (Bogdanov and Rodić, 2014; Bogdanov *et al.*, 2017). The Serbian agricultural subsidies can be structured in three groups: (i) market and direct producer support measures; (ii) structural and rural development measures; and (iii) general measures related to agriculture. Figure 1 shows the development of agricultural subsidies in Serbia for the period 2010-2015. Over this period, the level of subsidies varied from EUR 191.1 million in 2010 to EUR 315.4 million in 2014. The market and direct producer support represented the largest share of the total subsidies (more than 70%) followed by rural development payments (between 4% and 12%). The total subsidies increased continually until 2014. In 2015, a significant budgetary cut was implemented causing total agricultural subsidies to fall by 33% compared to 2014, with direct producer support experiencing the largest decline (38%). On the other hand, the support allocated to rural development increased (by 24%), as well as their proportion in the total agricultural subsidies (from 4.0% in 2014 to 7.4% in 2015). The general support remained at the same level in absolute terms (EUR 24 million) in the period 2010-2015, while their proportion of the total agricultural subsidies increased from 7.6% in 2014 to 11.3% in 2015 (Bogdanov *et al.*, 2017).

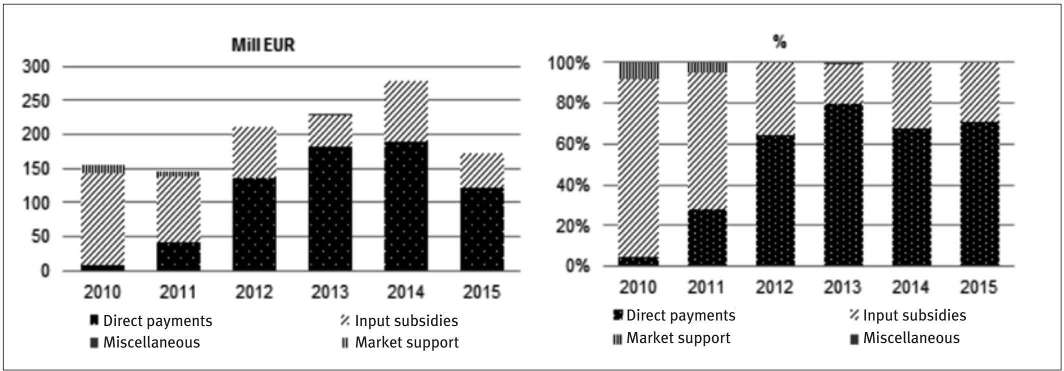
The market and direct producer support in Serbia have been undergoing constant adaptation and change over time. A key reform was implemented at the beginning of the 2000s, which introduced direct payments coupled to production levels, cultivated area or animal numbers. The aim of the

Figure 1 - Development of agricultural subsidies in Serbia, 2010-2015.



Source: Bogdanov et al., 2017.

Figure 2 - Development of market and direct producer support in Serbia, 2010-2015.



Source: Bogdanov et al., 2017.

direct payments was to compensate farmers for cuts in market support. Figure 2 shows the development of the market and direct producer support in Serbia for the period 2010-2015. The total value of the market and direct producer support increased from EUR 154.7 million in 2010 to EUR 278.8 million in 2014 and then decreased to EUR 172.5 million in 2015. There was a significant shift in the structure of the market and direct producer support over the period 2010-2015. Direct payments increased from less than 15% in 2010 to around 70% of the total direct producer support in 2015. Input subsidies, which are the second most important, accounted for around 30% of the total market and producer support in 2015, decreasing for more than 85% in 2010 (Bogdanov *et al.*, 2017).

The area and animal direct payments varied considerably in the 2010-2015 period in terms of the payment amount (total and per hectare/head), product coverage and eligibility criteria. In 2012, area payments were intended only for areas under arable crops; however, since 2013, this support has been extended (in the form of a flat rate area payment) to permanent crops. In parallel, area payments replaced some previously used input subsidies for fertilisers and fuel in 2013. In the relatively short period since the introduction of area payments, there has been a constant decrease in their per hectare value: from EUR 56.8 per ha in 2012 to EUR 49.3 per ha in 2015. In addition, the maximum area eligible for area payments was reduced significantly in 2015 from 100 ha to 20 ha. This relatively low eligibility threshold made area payments (mainly for larger farms) similar to a lump sum payment scheme. Essentially, the reduction of the total agricultural subsidies and, particularly, the sharp decline in direct payments in 2015 relative to 2014 is in most part a result of the reduction in the maximum eligible area for area payments (Bogdanov *et al.*, 2017).

Direct payments granted per animal head were introduced in 2007 in Serbia. In comparison with area payments, they are more diversified in terms of the number of measures and supported animal types. In 2010 and 2011, animal payments were implemented for breeding animals (cows, sheep and goats and pigs) and, since 2012, they have been extended to fattening cattle and pigs. Since 2013, animal payments have also included support for fattened lambs, beehives, various types of parental poultry and, since 2015, for suckler cows (Bogdanov *et al.*, 2017).

Input subsidies were granted mainly for diesel fuel and mineral fertilisers in the period 2010-2015. However, their value decreased continually over this period. A particular drop in input subsidies was observed in 2015 (from EUR 84.3 million in 2014 to EUR 48.6 million in 2015) caused by the reduction of the maximum area eligible for fuel and fertiliser subsidies (from 100 ha to 20 ha). In addition to fuel and fertilisers subsidies, insurance subsidies were implemented in Serbia in the period 2010-2015. However, their proportion in the total value of input subsidy was relatively small (less than 3.7%) (Bogdanov *et al.*, 2017).

The rural development support includes various set of measures such as on-farm investment support, subsidies for sustainable rural development and subsidies for improvement and development of rural economy (e.g. rural infrastructure). Investment support represents the main bulk (on average 84% in the period 2010-2015) of the rural development support in Serbia. The primary aim of this support is to promote the improvement of farm competitiveness and product quality standards. The investment support gained in importance over time. The total value of investment support was EUR 10.0 million in 2014 increasing to EUR 13.8 million in 2015 (Bogdanov and Rodić, 2014; Bogdanov *et al.*, 2017).

In summary, agricultural subsidies were substantially changed in Serbia over the 2010-2015 period, particularly in 2015. The changes introduced in 2015, among others, led to the reduction of the overall support to the farming sector and the redistribution of subsidies among farms (particularly caused by changes in eligibility criteria for direct payments and input subsidies) to the detriment of large arable farms. This paper aims to shed light on the potential impacts of subsidies and their changes on technical efficiency of arable farms in Serbia. In further analysis we consider the following agricultural types of the subsidies implemented in Serbia which are relevant for arable farms: (i) area payments, (ii) input subsidies, (iii) investment subsidies, and (iv) other subsidies.

3. Methodology and data

3.1. *Methodology*

In line with previous literature, we have applied double bootstrap DEA analysis proposed by Simar and Wilson (2007) to assess the technical efficiency of arable farms and the impact of agricultural subsidies on technical efficiency scores. The DEA method involves the liner programming method to construct a non-parametric envelopment frontier over the data points, so that all observed points lie on or below the production frontier (Farrell, 1957; Charnes *et al.*, 1978; Coelli, 1996). A farm is considered efficient when there is no other farm producing the same level of outputs with a lower level of inputs. The literature on farm efficiency measurement often focuses on two efficiency concepts: (i) the technical efficiency, i.e. the ability to produce maximal output from a given amount of inputs and (ii) the price efficiency or allocative efficiency, i.e. the ability to choose an optimal set of inputs such that their marginal revenues are equal to their marginal costs (Farrell, 1957; Färe *et al.*, 1990; Jha *et al.*, 2000; Henderson and Kingwell, 2002). The technical efficiency is the main indicator used in the literature to measure farm efficiency.

Technical efficiency can be measured with DEA by two approaches: (i) input-oriented model which measure how much inputs could be reduced while maintaining the existing level of output, or (ii) output-oriented model which measure how much output could be increased while using the given amount of inputs. Coelli *et al.* (2005) argues that "one should select the orientation according to which quantities (inputs or outputs) the managers have most control over". Given that farmers have usually more control over inputs than over outputs, we have opted for the input-orientated DEA model.

DEA models can differ with respect to the assumed returns to scale technology: (i) CCR (Charnes Cooper Rhodes) model which assumes the constant return-to-scale (CRS) and is appropriate when the farm operates at an optimal scale (Coelli *et al.*, 1998) and (ii) BCC (Banker Charnes Cooper) model which assumes variable returns-to-scale (VRS). We have applied the second model anticipating that some factors (e.g. imperfect competition, financial constraints) may not allow a farm to operate optimally (Banker *et al.*, 1984).

The input-oriented BCC model evaluates the efficiency of farms by solving the following minimisation problem:

(1) $\min \theta$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{r0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0$$

where x and y are inputs and outputs, respectively; i is the number of inputs (i = 1, 2, ..., m); r is the number of outputs (r = 1, 2, ..., s); j represents j^{th} farm (j = 1, 2, ..., n); λ_j is the weights used to construct the efficient frontier which determines the point on the frontier of efficient farms: and θ is the technical efficiency (TE).

As mentioned before, the DEA method involves the liner programming method and thus has no statistical properties or accounts for measurement error. In order to account for both the bias and serial correlations of efficiency scores, we have used the double bootstrap procedure (Algorithm 2) suggested by Simar and Wilson (2007) which allows for valid inference. By using a specific bootstrap procedure in the first stage, the DEA efficiency estimator is corrected for the bias. A parametric bootstrap procedure has also been applied, in the second stage analysis, to the truncated regression of DEA bias-corrected efficiency scores on explanatory variables. These variables are viewed as possibly affecting the production process, but are not under the control of managers. Determining the effect of these variables on efficiency is essential for determining performance improvement strategies.

The truncated regression model used in the second stage in our study is specified as follows:

$$(2) \qquad \delta_j = \beta Z_j + \varepsilon_j$$

where δ_j is the dependent variable ($\delta_j = \frac{1}{TE_j}$ is the reciprocal of technical efficiency scores of arable farms in Serbia estimated in (1)), β is a vector of parameters to be estimated, Z_j is a vector of individual farm characteristics assumed to affect the choice and use of inputs and output, and ε_i is the statistical noise.

Since the reciprocal of technical efficiency scores of arable farms in Serbia (input-oriented BCC DEA model) is chosen as the dependent variable, there is a positive relationship between an arable farm specific variable and technical efficiency if the sign of the coefficient is negative, whereas a relationship is negative if the coefficient is positive.

3.2. *Data and variable selection*

Data used in this paper were derived from the Serbian FADN database for the 2014-2015 period. The FADN database is harmonised with the EU FADN database. The FADN is a European system of sample surveys that take place each year and collect structural and accountancy data on farms. In total, there is information about 150 variables on farm structure and yield, output, inputs, costs, subsidies and taxes, income, balance sheet, and financial indicators. The Serbian FADN sample covers approximately 1,000 agricultural farms annually. For the period 2014-2015 they represented almost 32% of farms, covering approximately 90% of the total utilised agricultural area and accounting for more than 90% of the total agricultural production in Serbia. Farm-level data are confidential and, for the purposes of this paper, they were accessed under a special agreement.

Farms are selected to take part in the survey on the basis of sampling plans established at the level of each region in Serbia. The FADN survey does not, however, cover all farms in Serbia, but only those which are of a size allowing them to rank as commercial holdings. According to the data of the agricultural census carried out by Statistical Office of the Republic of Serbia, there were 631,552 agricultural holdings in Serbia in 2012 (SORS, 2013). Around 203,665 holdings exceed the threshold of the economic size of EUR 4,000 and these holdings form the base for field survey of the Serbian FADN.

In this paper we have used a subsample of arable farms specialized in cereals (other than rice), oilseeds and protein crops (COP), which are the most significant contributors to the output of the agricultural sector in Serbia. The crop sector represented 65% of the total gross agricultural output (GAO), while arable farms represented 36% of GAO in 2015 (SORS, 2016). Arable farms represented 20% of the total number of farms and used 46% of the total Utilised Agricultural Area (UAA).

Methodologically, the assumption of a common frontier across different farm types is a sensitive issue in DEA. In general, management practices and the technology differ between farm types, especially if the farms under investigation have different production specialisation.

Estimating a common production function may lead to biased estimates of the efficiency scores. This is a second reason for using specialised subsample of arable farms.

Overall, the dataset used in this paper includes 143 (179) COP farms out of the total 930 (1,130) farms available in the FADN database for 2014 (2015). Thus, the final sample consists of 322 COP farms out of total 2,060 farms participating in the FADN survey during the 2014-2015 period.[1]

Input and output variables used in previous studies to explain the efficiency varied depending on the research objectives and availability of data. The most commonly used output variable is the total agricultural production (expressed in monetary values). Several studies also consider non-agricultural output (e.g. revenue from non-agricultural activities such as rural tourism, rural service, forestry and other outputs) expressed in monetary terms (Bojnec and Latruffe, 2008; 2013; Latruffe *et al.*, 2008a; Latruffe and Fogarasi, 2009; Mamardashvili and Schmid, 2013). Most frequently used inputs in the literature are land, labour and intermediate costs (either aggregated intermediate inputs or disaggregated by type, e.g. fertiliser, seed, pesticides, energy, etc.) (Atici and Podinovski, 2015; Gunes and Guldal, 2019).

For technical efficiency analysis, we have retrieved as much information as possible from the Serbian FADN database available for this paper. It should be noted that although the Serbian FADN database attempts to be fully harmonised with the EU FADN database, it is still under the process of full harmonisation of all quality standards applied by the EU FADN database. Considering the information available in the FADN database, we have considered one output variable which measures total production value of farms and associated crop-specific costs such as seeds, fertilisers and crop protection costs and three factor inputs (capital, labour and land). Non-agricultural outputs (e.g. obtained from rural tourism, rural service, forestry), as suggested by other studies (e.g. Bojnec and Latruffe, 2008; 2013; Latruffe *et al.*, 2008a; Latruffe and Fogarasi, 2009; Mamardashvili and Schmid, 2013), were not considered as they are not available in the Serbian FADN data given that most arable farms in Serbia are not involved in the non-agricultural activities. Regarding input variables, we have included ten categories: total labour input (AWU), UAA, seeds and plant costs, fertilisers, crop protection costs, farming overheads, depreciation, external costs, total assets and total liabilities (Table 1). These input and output variables have been chosen as they are expected to represent characteristics of the arable farms in Serbia, human capital and technology employed.

Following the literature (Davidova and Latruffe, 2003; Latruffe *et al.*, 2008a; 2008b; Bakucs *et al.*, 2010), we have considered the following variables as determinants of technical efficiency used in the second-stage in the regression model defined in equation (2): age of holder, farm size measured as total farm area expressed in hectares, the share of rented land in total farmland, the share of hired labour in total farm labour, capital to labour ratio, land to labour ratio, debt to asset ratio which is the percentage of total assets that were paid for with borrowed money, current ratio as financial ratio that shows the proportion of current assets to current liabilities (i.e. the indicator of a farm ability to meet short-term financial obligations), financial stress as ratio that reflects the interest and rent payments to the value of the farm output, agricultural subsidies implemented in Serbia which are relevant for arable farms (area payments, input subsidies, investment subsidies, and other subsidies), dummy variable for 2015 (it equals 1 if the year is 2015; zero otherwise) and interaction between subsidies and time dummy variable to account for possible effects of the change in policy implementation between 2014 and 2015.[2]

[1] Note that the final sample of 322 farms also takes into account observations excluded during the data cleaning in case errors were detected in the data.

[2] Note that running the estimation with the full sample by including time dummies and the interaction variables or splitting the sample by year are equivalent approaches. We have opted for the first approach as it allows us to test for the statistical significance of the change in the subsidy implementation between the two years (i.e. for the interaction variables) as well as it increases the number of observations, which causes estimates to be more precisely estimated.

It should be noted that the FADN database available for this paper has not included certain variables due to the confidentiality of individual farm data used in this paper. Hence, it was not possible for some explanatory variables (e.g. legal status of farms and education of a farm manager) used in previous empirical studies to be considered in the second-stage estimations.

In addition, it should be noted that the output variable in our paper does not include subsidies. Although some consider subsidies as an additional output to the traditional farm outputs used in the efficiency calculations (Silva *et al.*, 2004; Hadley, 2006; Rasmussen, 2010; Silva and Marote, 2013), in general subsidies are used in most studies as an explanatory variable of farm efficiency (e.g. Zhu and Lansink, 2010; Bojnec and Latruffe, 2013; Kumbhakar *et al.*, 2014; Sipiläinen *et al.*, 2014). One of the reasons is that if subsidies are included both as dependent and independent variables in the model (defined in equation 2), it will generate an endogeneity problem leading to biased regression coefficient estimates. The second reason for excluding subsidies from output variable is that the efficiency score of farms receiving subsidies might be biased in certain situations. For example, consider a hypothetical situation where two farms have the same output and input levels, but only the first farm receives decoupled payments (e.g. because only the first farm fulfils the eligibility criteria). The first farm will show higher efficiency than the second one if subsidies are included in the output measure although both farms are equally efficient. In this case, we would observe a positive relationship between subsidies and efficiency solely induced by the construction of the policy support (i.e. eligibility criteria). Indeed, this might be the case of Serbia where eligibility criteria for receiving subsidies changed substantially between 2014 and 2015 (e.g. the maximum area eligible for area payments reduced from 100 ha in 2014 to 20 ha in 2015). If accounting subsidies in the output variables it might generate biased estimated results. Table 1 shows descriptive statistics of output and inputs variables used in the DEA model and explanatory variables used in regression analysis.

4. Results

The DEA estimation results are reported in Table 2. The average technical efficiency of arable farms in both observed years was similar: 0.76 in 2014 versus 0.74 in 2015. The efficiency scores lower than one imply for the possibility of arable farms to improve their efficiency by reducing the input use (by 24% in 2014 and 26% in 2015) while producing the same quantity of output. These results suggest that arable farms faced greater challenges in 2015 in minimising the combination of inputs for the produced output level. In this regard, efficient farms (TE = 1) could sustain their efficiency unless there were major changes in the inputs/outputs. In addition, the efficiency of marginal inefficient farms (0.9 < TE < 1) could easily be increased to 1 while inefficient farms (TE < 0.9) could not easily be transformed into efficient ones in a short period and would remain inefficient unless there were major changes in inputs/outputs.

Table 3 compares the subsidies received by efficient and marginal inefficient farms on the one hand and inefficient farms on the other hand in 2014 and 2015. It can be seen that in both years efficient and marginal inefficient farms received higher subsidies than inefficient farms: 114.5 EUR/ha versus 90.1 EUR/ha in 2014 and 66.3 EUR/ha versus 44.8 EUR/ha in 2015. Regarding the subsidy type, efficient and marginal inefficient farms had higher area payments, input subsidies, and investment subsidies than inefficient farms in both years. For other subsidies inefficient farms received slightly higher values in 2014, while the reverse was valid in 2015.

When comparing changes in subsidies between years, we have identified a significant decrease in the total subsidies in 2015 compared to 2014. Furthermore, inefficient farms experienced a greater drop in subsidies than efficient and marginal inefficient farms: by 50.3% versus 42.1%, respectively. As explained above, the subsidy cut is driven by a decrease of area payments and input subsides. This holds for both efficient and marginal inefficient and inefficient farms. Area payments (input subsidies) decreased by 53.8% (42.5%) for efficient and marginal inefficient farms and 49.8% (50.1%) for inefficient farms

Table 1 - Descriptive statistics of arable farms.

	Unit	*2014*		*2015*	
		Mean	*Std. deviation*	*Mean*	*Std. deviation*
Output variable in DEA					
Total output	EUR	56,572.0	51,588.2	58,100.0	46,480.0
Input variables in DEA					
Total labour input	AWU	1.6	1.0	1.6	0.9
Utilised agricultural area	ha	60.9	52.8	63.9	51.2
Seeds and plant costs	EUR	5,109.7	4,961.8	5,572.8	5,502.2
Fertilisers	EUR	7,786.9	7,745.2	7,273.3	6,821.9
Crop protection	EUR	2,863.6	3,300.7	3,206.9	3.334,6
Farming overheads	EUR	10,569.4	9,755.4	10,522.3	9,927.1
Depreciation	EUR	2,527.7	5,539.4	4,536.1	9,279.1
External costs	EUR	8,916.2	9,534.3	8,976.9	9,802.8
Total assets	EUR	260,122.6	241,590.6	300,075.5	270,780.4
Total liabilities	EUR	7,720.5	27,007.8	7,222.8	24,760.4
Explanatory variables					
Age of holder	years	47.1	11.1	47.5	11.0
Farm size	ha	60.9	52.8	63.9	51.2
Share of rented land in total farmland	%[(a)]	0.5	0.3	0.5	0.3
Share of hired labour in total farm labour	%[(a)]	0.2	0.2	0.1	0.2
Capital to labour ratio	EUR/AWU	2,048.1	4,283.3	3,306.3	6,136.1
Land to labour ratio	ha/AWU	42.8	34.6	47.0	39.3
Debt to asset ratio	ratio	0.02	0.06	0.02	0.07
Current ratio	ratio	0.7	4.6	0.4	2.1
Financial stress	ratio	0.1	0.1	0.1	0.1
Area payments	EUR/ha	42.2	24.1	21.1	19.0
Input subsidies	EUR/ha	47.2	18.3	24.1	19.2
Investment subsidies	EUR/ha	1.9	18.1	1.9	20.9
Other subsidies	EUR/ha	0.7	3.4	0.2	1.1

Note: [(a)] *Percentages are expressed as decimals.*

Table 2 - Technical efficiency scores of arable farms in Serbia (input-oriented BCC DEA model).

Efficiency scores	*%*	*Mean*	*95% confidence interval lower*	*95% confidence interval upper*
2014				
All farms	100	0.76	0.69	0.85
Efficient and marginal inefficient farms	8.39	0.92	0.87	1.00
Inefficient farms	91.61	0.74	0.68	0.84
2015				
All farms	100	0.74	0.68	0.81
Efficient and marginal inefficient farms	11.73	0.93	0.87	1.00
Inefficient farms	88.27	0.71	0.66	0.78

Note: Efficient farms are those with TE = 1, marginal inefficient farms are those with 0.9 < TE < 1 and inefficient farms are those with TE < 0.9.

Table 3 - Subsidies received by efficient and inefficient arable farms in 2014 and 2015.

Indicators	*Type of farm*	*2014*		*2015*	
		Mean	*Std. deviation*	*Mean*	*Std. deviation*
Area payments (EUR/ha)	Efficient and marginal inefficient farms	46.8	31.8	21.6	21.1
	Inefficient farms	41.8	23.8	21.0	18.8
Input subsidies (EUR/ha)	Efficient and marginal inefficient farms	50.3	28.3	28.9	25.1
	Inefficient farms	46.9	17.2	23.4	18.3
Investment subsidies (EUR/ha)	Efficient and marginal inefficient farms	17.0	59.1	15.0	60.5
	Inefficient farms	0.5	6.4	0.1	1.8
Other subsidies (EUR/ha)	Efficient and marginal inefficient farms	0.4	1.3	0.7	2.3
	Inefficient farms	0.7	3.5	0.2	0.8
Total subsidies (EUR/ha)	Efficient and marginal inefficient farms	114.5	115.5	66.3	85.0
	Inefficient farms	90.1	40.	44.8	35.0

in 2015 compared to 2014. For other subsidy types, we have observed a mixed development. Investment subsidies decreased for efficient and marginal inefficient farms by 11.8%, while they decreased by 80.0% for inefficient farms in 2015 compared to 2014. Finally, for other subsidies efficient and marginal inefficient farms experienced an increase (75.0%), while inefficient farms experienced a decrease (71.4%) in their per hectare value over the same period (Table 3).

The second stage estimated results are reported in Table 4. We have estimated several models

Table 4 - Determinants of technical efficiency of arable farms in Serbia[(a)]: double bootstrap estimation.

Variable names	*Model 1 (M1)*	*Model 2 (M2)*	*Model 3 (M3)*	*Model 4 (M4)*
Costs	**1.39E+00**[**]	**1.35E+00**[**]	**1.54E+00**[**]	**1.57E+00**[**]
	(6.09E-01; 2.08E+00)	(6.35E-01; 2.01E+00)	(7.86E-01; 2.26E+00)	(7.53E-01; 2.39E+00)
Age of holder (years)	-6.30E-03	-5.29E-03	-6.24E-03	-7.06E-03
	(-1.73E-02; 4.86E-03)	(-1.53E-02; 4.84E-03)	(-1.66E-02; 3.71E-03)	(-1.76E-02; 2.92E-03)
Farm size_Total Utilised Agricultural Area (ha)	7.81E-03	**7.91E-03**[**]	**7.46E-03**[**]	7.32E-03
	(-3.42E-05; 1.70E-02)	(2.57E-04; 1.69E-02)	(2.14E-05; 1.60E-02)	(-5.14E-04; 1.63E-02)
Farm size_Total Utilised Agricultural Area Square (ha)	-2.57E-05	-2.65E-05	-2.43E-05	-2.38E-05
	(-7.45E-05; 8.77E-06)	(-7.40E-05; 7.97E-06)	(-6.91E-05; 8.82E-06)	(-6.95E-05; 1.01E-05)
Share of rented land (%)[(b)]	**-6.40E-01**[**]	**-5.38E-01**[**]	**-6.45E-01**[**]	**-6.80E-01**[**]
	(-1.23E+00; -7.71E-02)	(-1.10E+00; -4.41E-02)	(-1.19E+00; -1.41E-01)	(-1.24E+00; -1.76E-01)
Share of hired labour (%)[(b)]	2.95E-01	3.03E-01	2.76E-01	2.46E-01
	(-2.69E-01; 8.49E-01)	(-2.56E-01; 8.36E-01)	(-2.68E-01; 7.95E-01)	(-2.95E-01; 7.51E-01)

→

Variable names	*Model 1 (M1)*	*Model 2 (M2)*	*Model 3 (M3)*	*Model 4 (M4)*
Capital to labour ratio (EUR/AWU)	1.30E-05	9.16E-06	1.19E-05	1.16E-05
	(-2.04E-05; 4.02E-05)	(-2.33E-05; 3.56E-05)	(-1.90E-05; 3.72E-05)	(-2.00E-05; 3.74E-05)
Land to labour ratio (ha/AWU)	**-2.43E-02****	**-2.37E-02****	**-2.38E-02****	**-2.36E-02****
	(-3.39E-02; -1.67E-02)	(-3.25E-02; -1.67E-02)	(-3.34E-02; -1.64E-02)	(-3.25E-02; -1.63E-02)
Debt to asset ratio	-3.49E-01	-1.61E-01	-3.17E-01	-2.85E-01
	(-2.49E+00; 1.36E+00)	(-2.07E+00; 1.39E+00)	(-2.21E+00; 1.25E+00)	(-2.23E+00; 1.32E+00)
Current ratio	-4.20E-03	-5.47E-03	-4.54E-03	-4.00E-03
	(-7.02E-02; 3.36E-02)	(-6.77E-02; 3.05E-02)	(-6.54E-02; 3.22E-02)	(-7.27E-02; 3.32E-02)
Financial stress	**5.87E+00****	**5.30E+00****	**5.67E+00****	**5.71E+00****
	(4.30E+00; 7.54E+00)	(3.91E+00; 6.90E+00)	(4.28E+00; 7.27E+00)	(4.27E+00; 7.40E+00)
Area payments per ha (EUR)	-4.36E-03	**-3.96E-02****	-4.09E-03	-7.35E-03
	(-1.19E-02; 3.18E-03)	(-6.67E-02; -1.55E-02)	(-1.13E-02; 3.62E-03)	(-1.71E-02; 2.40E-03)
Input subsidies per ha (EUR)	-1.81E-03	**3.21E-02****	-3.08E-03	-1.08E-04
	(-1.10E-02; 6.44E-03)	(7.87E-03; 6.02E-02)	(-1.28E-02; 5.77E-03)	(-1.60E-02; 1.50E-02)
Investment subsidies per ha (EUR)	-1.90E-03	1.84E-02	-1.59E-03	-2.45E-04
	(-1.54E-02; 4.65E-03)	(-1.26E-02; 5.37E-02)	(-1.40E-02; 4.88E-03)	(-2.38E-02; 1.06E-02)
Other subsidies per ha (EUR)	-5.71E-03	-4.94E-03	-8.21E-03	-5.50E-03
	(-8.32E-02; 4.25E-02)	(-1.49E-01; 1.27E-01)	(-7.94E-02; 3.72E-02)	(-9.41E-02; 4.49E-02)
Area payments per ha Square (EUR)		**7.79E-04****		
		(2.97E-04; 1.37E-03)		
Input subsidies per ha Square (EUR)		**-7.37E-04****		
		(-1.34E-03; -2.64E-04)		
Investment subsidies per ha Square (EUR)		-1.62E-04		
		(-5.73E-04; 3.14E-05)		
Other subsidies per ha Square (EUR)		-3.88E-05		
		(-9.36E-03; 6.64E-03)		
Dummy variable "2015"=1			-6.63E-02	-5.77E-02
			(-3.15E-01; 1.81E-01)	(-6.65E-01; 4.71E-01)
Dummy variable "2015"=1 * Area payments per ha (EUR)				8.80E-03
				(-6.48E-03; 2.54E-02)

→

Variable names	*Model 1 (M1)*	*Model 2 (M2)*	*Model 3 (M3)*	*Model 4 (M4)*
Dummy variable "2015"=1 * Input subsidies per ha (EUR)				-7.28E-03
				(-2.73E-02; 1.24E-02)
Dummy variable "2015"=1 * Investment subsidies per ha (EUR)				-3.36E-03
				(-4.31E-02; 2.44E-02)
Dummy variable "2015"=1 * Other subsidies per ha (EUR)				-7.59E-03
				(-2.30E-01; 1.62E-01)

*Notes: *** significant at the 0.001 level, ** significant at the 0.05 level and * significant at the 0.10 level. Figures in parentheses indicate lower and upper bounds for 5 percent confidence interval.*
[(a)] Reciprocal of technical efficiency scores of arable farms in Serbia (input-oriented BCC DEA model) is chosen as the dependent variable. Therefore, the parameters with negative signs indicate sources of efficiency and vice versa.
[(b)] Percentages are expressed as decimals.

to account for possible effects of subsidies on farm efficiency. In the first specification (M1) we included all variables related to different types of subsidies. The second specification (M2) considered square terms for subsidies to account for possible nonlinearities. The third specification (M3) includes all subsidies (without square terms) and time dummy variable for 2015. The forth model (M4) was the same as the third model except that we added interaction between subsidies and time dummy variable to account for possible effects of the change in policy implementation between 2014 and 2015.

The double bootstrap estimation results show that three explanatory variables had a significant influence on technical efficiency of arable farms in all model specifications: share of rented land, land to labour ratio, and financial stress (Table 4).

The share of rented land and land to labour ratio positively influenced technical efficiency of arable farms in Serbia. These results imply that farms with more rented land and farms with less labour intensive production system could attain higher efficiency. Our estimates are consistent with Latruffe *et al.* (2004) who have also found that the share of rented land positively affects the technical efficiency of crop farms in Poland. Latruffe *et al.* (2004) argues that this effect could be due to the positive size-efficiency relationship. An alternative explanation could be that farms with a greater share of rented land achieve higher efficiency because they might be less credit-constrained and thus be able to invest in technology and new farm practices. This is because expanding farmland through renting is less financially demanding than expanding farm through land acquisition. Similarly to our finding, Latruffe *et al.* (2008a) have found that the land to labour ratio has a positive influence on technical efficiency. In addition, Bakucs *et al.* (2010) report positive relationship between the land to labour ratio and farm efficiency in Hungary. Latruffe *et al.* (2008a) argue that this could be caused by the fact that in some European countries agriculture has served as a shelter from industrial unemployment (or hidden unemployment) during the process of transition and/or economic crises leading to over-employment in the farming sector and thus lower efficiency of some farms.

The financial stress has a negative impact on the technical efficiency of arable farms in Serbia. The estimates of Latruffe *et al.* (2008a) also confirm that farms with high financial stress have lower technical efficiency which could be because of the obligation concerning the repayment of rentals and interest payment leaving less to pay for on-investments or variable inputs.

For subsidies, we found that area payments and input subsidies had a statistically significant impact on the technical efficiency of arable farms in Serbia, although the findings have not been consistently confirmed across all estimated models. Area payments had a positive impact on technical efficiency, while input subsidies were found to have a negative effect. The estimates also provided some evidence that there might be nonlinear relationship between area payment and technical efficiency on one side and between input subsidies and technical efficiency on the other. This indicate that farm efficiency gains increase as farms get higher area payment per hectare, but the gain decreases and even becomes negative if area payments per hectare increase significantly. On the other hand, farm efficiency gains decrease as farms get higher input subsidies per hectare, but the gain increases and even becomes positive if input subsidies per hectare increase significantly (Table 4).

The possible explanation for the positive relationship between subsidies and farms efficiency could be found in the literature on credit constraints and risk behaviour in agriculture (e.g. Blancard *et al.*, 2006; Ciaian and Swinnen, 2009; Kumbhakar and Bokusheva, 2009; Hüttel *et al.*, 2010). If farms are credit-constrained, then subsidies may provide an additional source of finance either directly by increasing farms' financial resources or indirectly through the improved access to formal credit. In other words, for credit-constrained farms, subsidies may serve as a substitute for credit (Rizov *et al.*, 2013).

Regarding the investment subsidies, Minviel and Latruffe (2017) have found, on the basis of extensive literature review, that there are examples of both positive and negative impacts of investment subsidies on farm efficiency, but there is also the example of a neutral effect. Similar results were found by Pechrová (2015), who has demonstrated that the effect of investment subsidies on technical efficiency of organic and conventional farms in the Liberecký region (Czech Republic) is negligible. However, the impact of investment subsidies on improved farm efficiency should be reflected in long-term rather than short-term analysis as captured in our analysis. This might explain why the investment subsidies were found to have statistically insignificant impact on the technical efficiency in our estimations. That is, because our paper considers rather a short period (only 2 years), the coefficients associated with investment subsidies and their square value are statistically insignificant because their effect might not have materialised within the period covered in the paper in terms of improving farm efficiency.

Finally, other subsidies and the interaction term between subsidies and time dummy variable for 2015 are statistically insignificant. Other subsidies might have insignificant impact on technical efficiency because this variable encompasses different subsidy types, the impact of each might offset each other in impacting the technical efficiency. The insignificant coefficient for the interaction variable seems to suggest that the change in the subsidy implementation between 2014 and 2015 did not affect the technical efficiency of farms in Serbia.

5. Conclusions

The agricultural policy reform in Serbia, similar to other transition countries, is undergoing a series of distinct adjustment phases, largely reflecting the orientation of government political agenda towards their harmonisation with the EU CAP, at the same time taking in consideration the internal political constraints. However, this reform process needs to be supported by evidence-based assessments of the impact of alternative policy options in order to support the policy decision making. This also applies to analysis of the effects of agricultural policy reforms on farm performance where empirical evidence-based micro data is missing. The empirical literature is inconclusive on how agricultural subsidies affect technical efficiency of farms, while there is no empirical evidence available for Serbia. Only some limited and highly fragmented insights have been provided for different sub-sectors using simple methods and farm samples of varying quality.

The objective of this paper was to fill the gap in this area by analysing the technical efficiency of arable farms in Serbia. We have applied a two-stage double bootstrap DEA on a sample of

322 arable farms derived from FADN database from the 2014-2015 period to examine whether and how the agricultural subsidies implemented in Serbia impacted their technical efficiency.

The results show that the average technical efficiency of arable farms in Serbia was similar in 2014 and 2015 (0.76 and 0.74 respectively). The average technical efficiency score indicates that inefficient arable farms could have reduced the use of inputs by 24% in 2014 and 26% in 2015 without suffering output loss. In other words, the results suggest that arable farms faced challenges in using efficient combination of inputs in the production process. These results further imply that there is scope for extension service providers to address the need for strengthening farmers' knowledge and managerial skills particularly in the area of input use and their allocation.

The variables comprising the share of rented land, land to labour ratio, and financial stress were found to be main determinants of arable farm efficiency in Serbia in the period 2014-2015. The share of rented land and land to labour ratio positively influenced the technical efficiency of farms, while the financial stress had a negative impact on the efficiency. These results suggest that, access to credit might be a factor at play and thus policy action might be oriented in this area to boost technical efficiency of farms in Serbia.

Regarding the subsidies, we found that area payments and input subsidies had a statistically significant impact on the technical efficiency of arable farms in Serbia, although the findings were not consistently confirmed across all estimated models. Area payments had a positive impact on technical efficiency, while input subsidies were found to have a negative effect. In contrast, investment and other subsidies were found to have an insignificant impact on farm technical efficiency. Our results also suggest that the change in the subsidy implementation between 2014 and 2015 did not affect the technical efficiency of farms in Serbia. It is important to emphasize that evidence presented here on the influence of subsidies on farm technical efficiency must be understood in the given context. Namely, in this paper we have estimated the effects of area payments, input subsidies, investment support and other subsidies allocated from the national budget. However, other types of measures, like investment support from local and regional authorities and international donors are not included as data were not available to account for them in the analyses.

The results presented here provide evidence that there might be nonlinear relationship between area payment and technical efficiency on one side and between input subsidies and technical efficiency on the other. These results suggest that the future potential reform of the Serbian agricultural policy towards the CAP-like payments (i.e. area based payments) could have insignificant impact or rather small positive impact on farm technical efficiency depending on the magnitude of the support change. This could be partially explained by the fact that both area subsidies and input subsidies were found to affect technical efficiency to some extent but their impact is reverse when their size increases (i.e. the coefficient associated with square term is positive for area payments and negative for input subsidies). As a result, the potential future reform of coupled subsidies (particularly input subsidies) may lead to a (small) increase in farm technical efficiency in Serbia; for example, this would be the case if the past trend of subsides shift from the input support to the area and animal payments will continue in future. Note that the estimated impact of area payments and input subsidies on farm technical efficiency was not robust across all estimated model and thus this result needs to be taken in consideration when interpreting the estimates of this paper.

During 2010s Serbian agricultural policy has been reformed in order to bring it closer to the CAP principles. The main policy instruments of the Serbian agricultural policy are the area payments and input subsides, whereas one of the key policy objectives is the promotion of on-farm investments in modern technologies in order to stimulate productivity growth of the agricultural sector. Although modern inputs and technologies can help farmers to improve farm performances and increase the productivity and profitability, if they are not efficiently applied, they may generate small or insignificant productivity gains. This paper has confirmed concerns that the significant increase in certain types of farm subsidies may not give the right incentives to arable farmers in Serbia to make their decisions on input and output so as to increase farm efficiency. Therefore, given the limited understanding of effects of different policy instruments on farmers' performance particularly related to the Serbian agricultural policy, the results of this paper can contribute to better understanding factors affecting technical efficiency of the largest sub-sector of the Serbian agricultural sector.

Despite the comprehensiveness of the analyses, the findings of this paper have to be considered with some caution on account of the data limitations. First, although the Serbian FADN database attempts to be fully harmonised with the EU FADN database, it is still under the process of full harmonisation of all quality standards applied by the EU FADN database. Second, although the objective of the FADN sampling is to achieve a high degree of representativeness of the Serbian farming sector, some farm types are under-represented in the FADN database. These include small non-commercial farms, which are excluded from FADN by construction of sampling plans, and large farms which are often reluctant to participate in the FADN survey. Third, the FADN database available for this paper did not include some variables due to the confidentiality issue. Hence, it was not possible for some explanatory variables (e.g. legal status of farms and education of a farm manager) used in previous empirical studies to be considered in the second stage estimations. Third, we were not able to capture long-term effects of subsidies (in particular investment subsidies) on farm efficiency due to the availability of data for a short period (i.e. for 2014 and 2015). Despite these limitations, the paper shows the potential implications of the effects of agricultural subsidies on efficiency on arable farm in Serbia, which provides valuable ideas that can guide further research, can provide insights into agricultural policy making and can raise awareness about the need for evidence based policy making in the study region.

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