EFFICIENCY COMPARISON OF THE BULGARIAN FORESTRY AND FOREST BASED INDUSTRIES TO THESE IN EUROPEAN UNION COUNTRIES THROUGH DATA ENVELOPMENT MODELS

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Abstract: The economic efficiency of forestry has long been a leading issue in the sector's economic research. The wide variety of policies, goals and models in forests management makes researching the factors of economic efficiency a constantly relevant issue. Since 1978 Data Envelopment Models have provided a comprehensive approach without following particular assumptions for production function of the forests. Data Envelopment Analysis (DEA) models are quite suitable to estimate the efficiency and determine the weaknesses of forest policy measures. The current study is dedicated to the overall efficiency of economic sectors throughout the supply chain of wooden materials, i.e. forestry itself, wood-processing and paper industries in the EU countries. The study also suggests solutions for problems of small countries like Bulgaria in order to achieve better efficiency of the respective economic sectors.

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Introduction

Efficiency can be defined as the demand that the desired goals are achieved with the minimum use of the available resources (Martic et. al.,2009). Data Envelopment Analysis (DEA) was introduced by Charnes, Cooper and Rhodes (1978) for assessment of relative efficiency of similar economic units that use particular inputs to produce outputs. DEA is a well-known, linear-programming-based, nonparametric approach (Charnes et al., 1978) that is widely used to analyze the efficiency of a set of organizational units like a set of forest districts (Diaz-Balteiro, 2008). Models comprehensively describe, use and provide possibilities to distinguish different types of efficiency. Analysis provide great deal of opportunities for problems uncovering and establishing policy priorities, that make DEA more and more involved in the recent years. Liu et. al. (2013) estimated that until 2009 the cumulated share of DEA-based papers dedicated to Forestry is only 0,86%, in Industry 4,66%, but the growth of such papers is almost exponential. All these features of DEA define it like a current and reliable approach for efficiency assessment. According to the essence of the units included in DEA, i.e. Decision Making Units the measuring the efficiency of the Forestry and Forest-based industries is a kind preparation of policy recommendations. Narendra Chand et. al. (2015) state that the efficiency of the forest system will increase in result of intentional policy for human capital improvement. Hily et al. (2015) provide the cost-efficient policy for N2000 forest management considering economies of scale exploitation, which on their own can be successfully assessed by DEA.

In the recent years DEA is successfully implemented in Forestry and forest-based industries by many researchers. Alzamora and Apiolaza (2013) estimate efficiency of very particular and narrow subject like usage of pine logs for grade producing, until Susaeta et al. (2016) successfully calculate the efficiency of entire pine forest. Korkmaz (2011), Sporcic et. al. (2009 and 2014) use DEA to calculate efficiency of forestry units at the level of enterprises. In the same manner Boosari (2015) directly compare alternate plans for forestry management. Kovalcik (2018) compare the Slovak forestry

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efficiency to other European countries, which is the only direct comparative study using DEA approach throughout forestry of European Union countries. In forest-based industries, such as the wood-processing and furniture industry the existing studies are related mainly to enterprise level. Ma (2016) and Sari et. al. (2018) estimate the efficiency of furniture enterprises, mainly SMEs. Vahid and Sowlati (2007) conducted a study on DEA efficiency analysis throughout the wood supply chain. N. Salehirad and T. Sowlati (2005) directly implement the DEA efficiency model to Canadian primary wood producers that proves the applicability of the models to the forest subsectors. Trigkas et.al (2012) estimate the overall efficiency of the furniture sector.

The Bulgarian Forestry and forest-based industries have not been analyzed by DEA, but only by parametric approaches. Yovkov and Kolev (2007) estimate the Bulgarian Forestry efficiency implementing the Return on Investment method, based on transaction costs. Kolev (2017) also developed performance measurement, using investments assessment of forestry units. Many other authors analyze not the efficiency itself, but the respective influencing factors. R. Popova (2013 a,b, 2014, 2017, 2018) and Chobanova et. al. (2017)describes the innovations in furniture producing enterprises as one of the main determinants for economic efficiency improvement and an option for performance measurement. Petkov et. al. (2009, 2012), Neykov (2008, 2009) examined the efficiency estimation of wood working enterprises in Bulgaria by parametric approaches as relative indicators for allocation efficiency and profitability. However, all studies, related to the economic efficiency of Bulgarian Forestry and forest-based industries, are narrowly specialized in parametric estimations.

Materials and methods

In this study we applied the classical input oriented CCR model proposed by Charnes et. al (1978). Despite the BCC model, used by Korkmaz (2011) and preferred due to the more accurate pure technical forestry efficiency estimation, we aimed at assessing the common scale and pure factor efficiency (Martic et. al., 2009). Distinguishing the pure factor efficiency is needed to outline the problems in some of the resources involved, so we compared CCR to BCC in manner of Kovalcik (2018). Sporcic et. al (2009) also solve the trivial DEA task of assessing the efficiency or forestry organizational units, providing the comparison of CCR and BCC. The two step procedure, comprehensively described by Cooper et.al. (2007) was used in order to fill all the sufficient conditions for efficiency. Existence of constant returns to scale (CRS) of Forestry throughout European countries has not been proven in any previous research, despite the similar assumptions being made. Making the assumption on that could bias the results, so constant return to scale (VRS) model seems to be more appropriate for the purpose of the current study, in order to take into account effect of scaling. The model is used in following envelopment form (dual model):

Step 1 – estimation of efficiency

$$\min \theta \,, \tag{1}$$

Subject to: $\sum_{i=1}^{n} \lambda_j x_{ij} - \theta x_0 \leq 0$ (2)

$$\sum_{i=1}^{n} \lambda_i y_{ij} - y_0 \geq 0 \tag{3}$$

Step – 2 estimation of slacks:

$$\max \sum_{i=1}^{n} s^- + \sum_{r=1}^{s} s^+ \,, \tag{4}$$

Subject to:

$$\sum_{i=1}^{n} \lambda_i x_{ij} - \theta^* x_0 = -s^- \tag{5}$$

$$\sum_{i=1}^{n} \lambda_i y_{ij} - y_0 = s^+ \tag{6}$$

Where λj are individual DMU coefficients in dual form of j-th Decision Making Unit (DMU) which in this study are European Countries included. Θ is so called efficiency scores and Θ* is optimal efficiency, delivered by de first step. Notations s+ and s- are slacks that approved the efficiency existence and measure shortage of production (notated as y0 for the particular DMU being estimated) or surplus of resources (xij i-th type of resource of j-th DMU) involved to the optimal level of production.

Many of studies dedicated to DEA of Forestry include additional models for revealing some of the reasons to be efficiency at estimated value. Some additional DEA estimations in order to answer the questions about influence of different factors like main value adding determinants – labor and capital; intermediate consumption, consumption of fixed capital, have been conducted in the present study.

The approach, proposed in analitical form by Cooper et. al. (2007) and successfully implemented in many papers like Zadmirzaei et. al. (2016), has also been used in the present paper. It is called scale efficiency (SE) and is expressed by the following equation:

$$SE = \frac{\theta^*_{CCR}}{\theta^*_{BCC}} \quad (7)$$

Where Θ* are the optimal efficiency scores by the CCR and BCC models. SE is always less or equal to 1. In the second case the DMU is optimal. The fraction directly pesents the effect of the scale to DMU performance.

The model of inputs and outputs close to the basic one proposed by Kovalcik (2018) was also applied in this paper, but focused on the capabilities for adding value, similar to the research of Korkmaz (2011). In order to compare different sectors some of the specific outputs or inputs were omitted, due to the Eurostat Structural Business Statistic and Statistic for Forestry. The analysis was decomposed into two branches: basic models and capital models. Basic models would reveal the trivial results for DEA efficiency and the second ones the capabilities for capital formation.

A grouping procedure for the EU countries, similar to the research of Rametseiner et. al (2006) and Kovalcik (2011) was performed. The EU countries were grouped according to the involvement of the forest sector in manner of contribution to the overall added value of the respective country. This is a major criterion and derives common indicators for each group. In this way a profile that facilitates the country analysis was elaborated. Throughout this approach all the strengths and weaknesses are visible, and policy measures are easier to be proposed. Each obtained group is compared to another by nonparametric tests, utilizing all the advantages (Singh et. Al. 2013) of such testing. The applied test is Friedman Tests, suitable for three or more samples that have equal population means.

Grouping was created by one guiding criterion and all others were subsecuted. This criterion was „Gross Value Added (GVA)“ in . Countries were devided in following categories:

- share of Forestry above the average and share of industries below the average (FAIB);
- share of Forestry below the average and share of industries above the average (FBIA);
- share of Forestry below the average and share of industries below the average (FBIB);
- share of Forestry above the average and share of industries above the average (FAIA);

Results and Discussion

Analyzes were made between the specified groups and within them. The groups included the following countries:

- (FAIB): Slovakia; Bulgaria.
- (FBIA): Austria.
- (FBIB): Belgium; Croatia; Cyprus; Denmark; France; Germany; Greece; Hungary; Ireland; Italy; Netherlands; Romania; Spain; United Kingdom.
- (FAIA): Czech Republic; Estonia; Finland; Latvia; Poland; Portugal; Slovenia; Sweden.

Friedman's test proved that the groups are statistically significantly different. The relevant data is presented in Table 1.

Table 1: Freidman statistics for differences testing between groups

Indicators	Industries	Forestry
N	7	4
Chi-Square	17,914	9,3
df	3	3
Asymp. Sig.	0	0,026
Exact Sig.	0	0,012
Point Probability	0	0,005

Source: Neykov et.al.

The groups were arranged by the place of each indicator from 1 to 4. The 4-th place is taken by Slovakia and Bulgaria. The 4-th place reveals small scale of Forestry and subsequent industries. Despite its comparative small scale level, each country represents its own efficiency and in many cases it is efficient in both – forest and forest-industry manner. Slovakia, Bulgaria and Austria were compared with two large groups - (FBIB) and (FAIA) for further analysis. The efficiency estimation between groups, based on the average indicators, is 1. Each group, compared to another is efficient, achieving the level of resource usage and scale, sufficient to successful functioning of sectors. The situation is not the same when comparing countries in each group with those of another. All efficiency characteristics inside the groups in Forestry are shown in Table 2.

Table 2: Efficiencies of forestry

Group	Efficiency		Standard Deviation		Scale efficiency
	CRS	VRS	CRS	VRS	
FAIB	1	1	0	0	1,00
FBIA	0,86	0,87	NO		0,98
FAIA	0,89	0,97	0,17	0,07	0,91
FBIB	0,71	0,77	0,26	0,27	0,92
FAIA with SK, BG, A	0,86	0,93	0,17	0,11	0,93
FBIB with SK, BG, A	0,75	0,80	0,25	0,26	0,93

Source: Neykov et.al.

The only effective group is Slovakia and Bulgaria. Pure technical efficiency and global performance in both countries are effective when compared to each other. This situation varies when they compare with other countries. Bulgarian forestry remains sustainably effective while Slovakia's efficiency is reduced by about 13% - 15%. Forestry of all groups suffers from decreasing economies of scale, while Bulgaria and Slovakia have constant, but under the condition that they do not compare with other countries, but only with the average values of the groups. The meaning can be translated to economic terms by the market transactions between countries of forest products. When countries from group FAIB appeared in the markets where countries from FAIA or FBIB participate all the consequences would be results of decreasing economies and lack of efficiency. All efficiency characteristics inside the groups in industries are shown in Table 3.

Table 3: Efficiencies of industries

Group	Efficiency		Standard Deviation		Scale efficiency
	CRS	VRS	CRS	VRS	
FAIB	1,00	1,00	0,00	0,00	1,00
FBIA	1,00	1,00	0		1,00
FAIA	0,99	1,00	0,00	0,00	0,99
FBIB	0,99	0,99	0,03	0,03	0,99
FAIA with SK, BG, A	0,99	1,00	0,03	0,00	0,99
FBIB with SK, BG, A	0,99	0,99	0,03	0,03	1,00

Source: Neykov et.al.

Countries succeed in achieving much higher efficiency in creating added value for the industry. Efficiency remains high even after Bulgaria, Austria and Slovakia inclusion. The efficiency between groups is also equal to 1. Moreover, the effectiveness of the groups is also much more sustainable than the one of the forestry sector. It is impressive that the inclusion of the three countries in the other groups does not lead to a decrease in efficiency (Table 3.) as in the previous analysis. That reveals the feature of the industries, that they are much more capable for adding value than Forestry sector. It can be concluded that the observed countries face constant returns to scale.

Bulgaria and its interaction with other countries

Against the backdrop of other countries, Bulgaria is effective until it enters markets with countries like Poland, Sweden and the Baltic countries. Including the country in the forest industry group above the EU average immediately lowered the industry's efficiency by 0.01 points. The products of the Bulgarian forestry sector would be competitive in terms of value added in trade with EU countries. At the same time, there is a problem with the scale of the industries. In general, the country suffers from a lack of qualified labour force but this is not the main problem. The energy consumption should be significantly reduced, at about 75%. In addition to requirement for reducing the investments in tangible goods this presents the hidden mistake in type of the purchased goods. In fact, the adoption of new energy saving technologies is the more serious problem for the efficiency.

Conclusion

It can be stated that the EU forestry is less efficient than forest-based industries, in terms of value added. Countries with involvement in national economy below the average for the EU suffer more serious problems due to their inhomogeneity. It is interesting that big countries with large amount of value added like Germany or Italy are among the inefficient ones. The main problems which are typical to DEA models appear due to returns scales. There are 35% of increasing returns in FAIA and 37% in FBIB. Decreasing have smaller share which is optimistic. Many European countries have problems with exploiting the resources properly, i.e. pure technical efficiency. The countries from the FAIA have to reduce Compensation of employees in about 11%, Consumption of fixed capital – 20% and Intermediate consumption – 30% to achieve the proper scale. The countries from the FBIB have to reduce Compensation of employees in about 32%, Consumption of fixed capital – 46% and Intermediate consumption – 42% to achieve the proper scale. But here appears a precedent from the practice – Consumption of fixed capital is something good for the economic sectors. This means that the scale of value adding in production is more likely to be the result of labour force than of the equipment and machinery. In fact, almost 90% of the required economy of resources are due to low technical efficiency. That determines the EU forestry to be more efficient as a result of resource improvement in a qualitative manner.

Industries (woodprocessing, production of furniture and paper production) are much more effective. Recources can be reduced in ebergy products and purchases of goods and services. Models provide recomendations in creating capacity – scale to create more value added – in about 1,3% for woodworking to 4,5% for producing furniture. Production of paper is efficient. In general, European forest industry needs scale to add more value and reduce the value transferred in the price of products sold.

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