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DIFFERENCES IN THE VOLUME OF WOOD FOREST RESOURCES BETWEEN SERBIA AND OTHER EUROPEAN COUNTRIES

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ABSTRACT

The aim of the paper is to determine the influence of particular factors on the diversity of selected countries in terms of the volume of wood forest resources. Two factors affecting the variable have been analysed in the paper: 1) the growing stock per 1 ha of forest area and 2) the forest cover. Logarithmic method was used to assess the influence of the deviations of the said factors on the deviation of the amount of wood forest resources. Thirty five countries – including Serbia – have been examined. Data for 2015 have been used for calculations.

KEYWORDS

wood forest resources, forest growing stock, forest cover, causal analysis, logarithmic method

1. INTRODUCTION

A forest is an ecosystem (or assemblage of ecosystems) dominated by trees. The living parts of a forest include trees, shrubs, vines, grasses and other herbaceous plants, mosses, algae, fungi, insects, mammals, birds, reptiles, amphibians, and microorganisms living on the plants and animals and in the soil. These interact with one another and with the non-living part of the environment – including the soil, water, and minerals.

Forests not only provide valuable timber, but also a large variety of non-timber forest products, such as food, fodder, medicines, construction materials and tools. Non-timber forest products provide input to a wide range of industries, including food and beverages, pharmaceuticals, cosmetics and botanical medicines (Ros-Tonen, 2012, pp. 29, 33).

Forests have been considered public goods for a long time. As early as the Middle Ages, in many regions in Europe deforestation and forest degradation led to the introduction of game reserves for the nobility, the protection of forests on steep slopes to combat erosion, and active management of timber resources for the construction of naval ships (Umans, 1993). Later, after the onset of industrialisation in Europe, many national forest laws were introduced in the 19th century as a response to the rapid depletion and degradation of forest resources and as a means for gaining state revenues from forests through taxation and public land ownership (Arts, Visseren-Hamakers, 2012, p. 245). These laws required the use of forest management, with its sustainable yield principle and silvicultural methods and tools (monocultures of commercial species, forest zoning, rotational harvesting, replanting, afforestation, etc.) (Wiersum, 1995). For example, Belgium introduced a forest law in 1847 which provided for government subsidies to forest owners – both communities and individuals – in order to stimulate tree planting. The Netherlands introduced its first forest law in 1922, which in principle required that each tree that was felled had to be replaced by the planting of a new one. Also, many of these laws were meant to regulate forest ownership and forest-related conflicts (Arts, Visseren-Hamakers, 2012, p. 246).

Despite the diversity which characterises Europe, forest management has undergone a number of broad transformations common to the region as a whole. These have included expanding resource pressures, the growth of scientific industrial forestry, and the more recent interest in multi-purpose, sustainable forest management (Jeanrenaud, 2001, p. 2).

2. CONCEPT OF THE CONDUCTED STUDY

The aim of this paper is to answer the question how the selected European countries differ from Serbia in terms of the amount of wood forest resources. However, the absolute value may not be the basis for comparisons between the countries, as it would be difficult to assess if this value is large or small. Thus, any comparison shall be made solely on the basis of relative values. It is possible – for example – to relate the amount of wood forest resources to the land area of the given country, creating this way the quotient constituting the desired comparative value. Hence, the differences between the countries will be evaluated on the basis of the relative value named the wood forest resources indicator and the indicator will be expressed in m3 per 1 ha of land area. Two factors affecting the variable, namely the standing volume per 1 ha of forest area and the forest cover, shall be analysed in this paper. Those two explanatory variables are directly proportional to the response variable, thus the bigger the volume of growing stock in relation to the forest area (i.e. the growing stock indicator) and the higher the forest cover, the larger the amount of wood forest resources of the analysed country.

The difference between the value of the studied variable for a given country and the value of this variable for Serbia will be defined as a deviation. Such a deviation may be positive or negative. Thus, in each case the deviation is mentioned in this paper, it shall be assumed as positive or negative deviation from the value characterizing Serbia.

Shall the standing volume indicator and the forest cover be adopted as the variables affecting the value of the wood forest resources indicator, it seems important to assess – for each of the discussed countries – the influence of the deviations of those two factors on the deviation of the response variable. In order to do so, causal analysis shall be conducted, enabling the examination of the structure of the response variable deviations in the individual countries.

The following research tasks shall be carried out in this paper:

1. assessment of the wood forest resources indicator in the analysed countries against the value of this variable characterizing Serbia;
2. comparison of the forest growing stock indicatorin individual countries with the quantity in Serbia;
3. assessment of the proportion of the forest area in the total land area in the discussed countries in relation to the value of this fraction regarding Serbia;
4. causal analysis of the differences in the amount of wood forest resources in particular countries.

3. RESEARCH METHOD USED

The objective of the causal analysis is to determine how various factors affect a given variable, i.e. what the direction and degree of their impact is. Therefore, the causal analysis can answer the question whether a particular factor causes an increase or a decrease of the studied variable and enables to assess how big the impact of this factor is (Turczak, 2016a, p. 24).

Logarithmic method will be used to carry out the causal analysis. Implementation of this method will include the following calculation steps (Turczak, 2016b, p. 99):

- constructing ratio equality (i.e. presentation of the ratio calculated for the response variable as the product of the ratios calculated for variables affecting the response variable);
- taking logarithms of both sides of the constructed ratio equality;
- dividing both sides of the obtained equation by the logarithm of the ratio regarding the response variable.

In order to build the adequate ratio equality it was assumed that the examined variable X (the wood forest resources indicator) can be presented as a product of factors Y (the standing volume indicator) and Z (the forest cover). The value of variable X for Serbia will be the basis of reference and shall be marked by X_{RS}.

In turn, the value of this variable calculated for the i-th country will be denoted as X_i.

Ratio $r_{i;X}$ in the form of $\frac{X_i}{X_{\mathrm{RS}}}$ was constructed. Due to the fact that $X_i = Y_i Z_i$ and $X_{\mathrm{RS}} = Y_{\mathrm{RS}} Z_{\mathrm{RS}}$, when dividing X_i by X_{RS}, the obtained result is:

$$\frac{X_i}{X_{\mathrm{RS}}} = \frac{Y_i Z_i}{Y_{\mathrm{RS}} Z_{\mathrm{RS}}}, \tag{1}$$

where:

X_i, Y_i, Z_i – the values of variables X, Y, and Z referring to the i-th country;

X_{RS}, Y_{RS}, Z_{RS} – the values of variables X, Y, and Z referring to Serbia.

The same can be presented in a different way, namely:

$$\frac{X_i}{X_{\mathrm{RS}}} = \frac{Y_i}{Y_{\mathrm{RS}}} \cdot \frac{Z_i}{Z_{\mathrm{RS}}}, \tag{2}$$

and then:

$$r_{i;X} = r_{i;Y} \cdot r_{i;Z}, \tag{3}$$

where: $r_{i;X} = \frac{X_i}{X_{\mathrm{RS}}}$, $r_{i;Y} = \frac{Y_i}{Y_{\mathrm{RS}}}$, $r_{i;Z} = \frac{Z_i}{Z_{\mathrm{RS}}}$.

Thus, if the response variable X is a product of the variables Y and Z affecting the variable X, the ratio calculated for variable X is a product of ratios calculated for the respective factors: Y and Z.

From mathematical point of view, logarithms to any base can be taken of both sides of an equation, provided that the numbers that the logarithms have been taken of are positive. The values of ratios $r_{i;X}$, $r_{i;Y}$ and $r_{i;Z}$ are always greater than zero, hence the logarithms can be taken of both sides of the equation (3). The choice of the logarithm base has no effect on the final results of the causal analysis, but only on the partial results. The logarithm to the base 10 (i.e. the common logarithm) will be used in further calculations.

Taking the logarithms of both sides of the equation (3), the following expression can be obtained:

$$\lg(r_{i;X}) = \lg(r_{i;Y} \cdot r_{i;Z}). \tag{4}$$

Then, using the logarithm property stipulating that the logarithm of a product of two numbers is equal to the sum of the logarithms of these numbers, the equation presented below can be derived:

$$\lg(r_{i;X}) = \lg(r_{i;Y}) + \lg(r_{i;Z}). \tag{5}$$

The next step is to divide both sides of this equation by the term $\lg(r_{i;X})$. This results in the expression:

$$1 = \frac{\lg(r_{i;Y})}{\lg(r_{i;X})} + \frac{\lg(r_{i;Z})}{\lg(r_{i;X})}, \tag{6}$$

where:

$\frac{\lg(r_{i;Y})}{\lg(r_{i;X})}$ – the impact of the deviation of Y factor on the deviation of X variable;

$\frac{\lg(r_{i;Z})}{\lg(r_{i;X})}$ – the impact of the deviation of Z factor on the deviation of X variable.

The final step is to multiply both sides of the equation (6) by the value of deviation calculated for variable X. The result is:

$$X_i - X_{\mathrm{RS}} = (X_i - X_{\mathrm{RS}}) \cdot \frac{\lg(r_{i;Y})}{\lg(r_{i;X})} + (X_i - X_{\mathrm{RS}}) \cdot \frac{\lg(r_{i;Z})}{\lg(r_{i;X})} \tag{7}$$

where:

$(X_i - X_{\mathrm{RS}}) \cdot \frac{\lg(r_{i;Y})}{\lg(r_{i;X})}$ − the deviation of variable X caused by the change of factor Y;

$(X_i - X_{\mathrm{RS}}) \cdot \frac{\lg(r_{i;Z})}{\lg(r_{i;X})}$ − the deviation of variable X caused by the change of factor Z.

In this paper, the causal analysis will allow to answer the question how two selected factors influence the deviations of the amount of wood forest resources in thirty four countries compared to the value characterizing Serbia. The analysis will be conducted based on data from 2015.

4. ANALYSIS OF THE WOOD FOREST RESOURCES INDICATOR

The first task carried out is the evaluation of the volume of wood forest resources in each of the studied countries in relation to the volume in Serbia. Ratio $r_{i;X}$ was constructed by dividing the value X_i computed for the i-th country by the value X_{RS} referring to Serbia. The obtained results have been presented in Table 1.

Table 1. The amount of wood forest resources (in m3/ha of land area) and the ratio referring to it

Country	X_i	$r_{i;X}$	Bulgaria	63.33	1.174
Slovenia	212.89	3.946	Belgium	61.48	1.140
Austria	137.70	2.552	**Serbia**	**53.95**	**1.000**
Liechtenstein	109.38	2.027	Italy	45.84	0.850
Slovakia	108.51	2.011	France	45.17	0.837
Switzerland	107.05	1.984	Hungary	40.54	0.751
Estonia	105.31	1.952	Norway	35.74	0.662
Latvia	102.98	1.909	Macedonia	29.72	0.551
Germany	102.50	1.900	Denmark	29.16	0.541
Luxembourg	100.35	1.860	United Kingdom	26.23	0.486
Czech Republic	100.33	1.859	Spain	23.95	0.444
Montenegro	87.89	1.629	Netherlands	19.47	0.361
Poland	81.23	1.506	Turkey	19.22	0.356
Romania	80.98	1.501	Ireland	16.74	0.310
Lithuania	78.88	1.462	Greece	14.62	0.271
Croatia	73.32	1.359	Cyprus	12.02	0.223
Finland	68.55	1.270	Malta	2.54	0.047
Sweden	68.14	1.263	Iceland	0.05	0.001

Source: own computation based on Eurostat database (date of access: 27.03.2017).

There is a great diversity of the amount of wood forest resources between the European countries. The highest value of wood forest resources indicator has been observed in Slovenia – in 2015 it was on average 212.89 m3 of stocks per each hectare of the land area of the country. Thus, the value of the measure in Slovenia was nearly four times higher than in Serbia. The lowest value in 2015 was recorded in Iceland – at that time the relative measure of wood forest resources in Iceland equalled less than 0.1% of the value in Serbia.

5. ANALYSIS OF THE FOREST GROWING STOCK INDICATOR

The second task is the evaluation of the volume of forest growing stock in the discussed countries against the volume in Serbia. Ratio $r_{i;Y}$ was constructed by dividing the value Y_i computed for the i-th country by the value Y_{RS} referring to Serbia. Table 2 contains results of the relevant calculations.

Table 2. The volume of forest growing stock (in m3/ha of forest area) and the ratio referring to it

Country	Y_i	$r_{i;Y}$	Country	Y_i	$r_{i;Y}$
Switzerland	352.5	2.294	Denmark	204.5	1.330
Slovenia	345.8	2.250	Latvia	198.2	1.289
Germany	320.8	2.087	Bulgaria	182.8	1.190
Luxembourg	299.1	1.947	Hungary	182.2	1.186
Austria	298.5	1.943	France	168.3	1.095
Czech Republic	296.6	1.930	Ireland	154.9	1.008
Liechtenstein	282.3	1.837	**Serbia**	**153.7**	**1.000**
Romania	281.4	1.831	Italy	148.9	0.969
Belgium	274.7	1.787	Montenegro	146.8	0.955
Slovakia	274.3	1.785	Turkey	126.1	0.821
Poland	269.2	1.752	Sweden	106.5	0.693
Lithuania	236.2	1.537	Finland	104.4	0.679
Malta	228.6	1.487	Norway	95.5	0.622
Croatia	215.9	1.405	Macedonia	77.4	0.503
Netherlands	215.2	1.400	Spain	65.8	0.428
Estonia	213.4	1.389	Cyprus	64.4	0.419
United Kingdom	207.4	1.349	Greece	49.4	0.322
			Iceland	10.2	0.066

Source: as in Table 1.

A great diversity of standing volume exists in Europe. The largest amount of growing stock per 1 ha of forest land has been observed in Switzerland and in 2015 the standing volume in this country was more than twice the volume in Serbia. In turn, Iceland recorded the lowest level of the forest growing stock indicator at that time – the value of the measure in Iceland was over fifteen times smaller than in Serbia.

6. ANALYSIS OF THE FOREST COVER

The third task is the comparison of forest area in proportion to the land area in the studied countries. Ratio $r_{i;Z}$ was calculated by dividing Z_i value computed for the i-th country by the value Z_{RS} referring to Serbia. The results of the calculations have been presented in Table 3.

Table 3. Forest cover and the ratio referring to it

Country	Z_i	$r_{i;Z}$	Lithuania	0.334	0.951
Finland	0.656	1.870	Germany	0.320	0.910
Sweden	0.640	1.823	Italy	0.308	0.877
Slovenia	0.616	1.753	Switzerland	0.304	0.865
Montenegro	0.599	1.705	Poland	0.302	0.859
Latvia	0.520	1.480	Greece	0.296	0.842
Estonia	0.493	1.406	Romania	0.288	0.820
Austria	0.461	1.314	France	0.268	0.764
Slovakia	0.396	1.127	Belgium	0.224	0.638
Liechtenstein	0.388	1.104	Hungary	0.222	0.634
Macedonia	0.384	1.094	Cyprus	0.187	0.532
Norway	0.374	1.066	Turkey	0.152	0.434
Spain	0.364	1.037	Denmark	0.143	0.406
Serbia	**0.351**	**1.000**	United Kingdom	0.127	0.360
Bulgaria	0.346	0.987	Ireland	0.108	0.308
Croatia	0.340	0.967	Netherlands	0.091	0.258
Czech Republic	0.338	0.963	Malta	0.011	0.032
Luxembourg	0.335	0.955	Iceland	0.005	0.014

Source: as in Table 1.

In the examined year, the largest forest cover of all the studied countries was noted in Finland – forests occupied 65.6% of the territory of the country. In turn, the smallest forest area in relation to the land area was observed in the case of Iceland – in 2015 the quotient concerning this country equalled less than 1.4% of the value of the corresponding measure calculated for Serbia.

7. ESTIMATION OF THE IMPACT EFFECTS OF THE TWO ANALYSED FACTORS

The last task to be carried out is the evaluation of the influence of deviations of the two selected factors on the deviation of the value of the wood forest resources indicator. Calculations will be performed for each of the thirty four European countries taken into consideration.

It was established in this paper that the value of the response variable (X) may be calculated by multiplication of 1) the standing volume per 1 ha of forest area (Y) and 2) the quotient of the forest area and the total land area (Z). The (3) ratio equality was derived from this relationship.

Table 4 presents the values of ratios calculated for each studied country. The top right section of Table 4 contains the countries where $r_{i;Y}$ and $r_{i;Z}$ values were higher than 1. The bottom right section of Table 4 includes the countries where ratio $r_{i;Y}$ value was higher than 1, and ratio $r_{i;Z}$ – lower than 1. The top left section of Table 4 contains the countries where ratio $r_{i;Y}$ value was lower than 1, and ratio $r_{i;Z}$ – higher than 1. The bottom left section of Table 4 includes the countries where the values of ratios $r_{i;Y}$ and $r_{i;Z}$ were lower than 1.

Table 4. Quantity of wood forest resources and the factors affecting it

Larger forest cover	Montenegro:	**1.629** = 0.955 · 1.705	Slovenia:	**3.946** = 2.250 · 1.753
	Finland:	**1.270** = 0.679 · 1.870	Austria:	**2.552** = 1.943 · 1.314
	Sweden:	**1.263** = 0.693 · 1.823	Liechtenstein:	**2.027** = 1.837 · 1.104
	Norway:	**0.662** = 0.622 · 1.066	Slovakia:	**2.011** = 1.785 · 1.127
	Macedonia:	**0.551** = 0.503 · 1.094	Estonia:	**1.952** = 1.389 · 1.406
	Spain:	**0.444** = 0.428 · 1.037	Latvia:	**1.909** = 1.289 · 1.480
		SERBIA		
		1.000 = 1.000· 1.000		
			Switzerland:	1.984 = 2.294 · 0.865
			Germany:	1.900 = 2.087 · 0.910
			Luxemburg:	1.860 = 1.947 · 0.955
			Czech Republic:	1.859 = 1.930 · 0.963
			Poland:	1.506 = 1.752 · 0.859
			Romania:	1.501 = 1.831 · 0.820
			Lithuania:	1.462 = 1.537 · 0.951
			Croatia:	1.359 = 1.405 · 0.967
			Bulgaria:	1.174 = 1.190 · 0.987
			Belgium:	1.140 = 1.787 · 0.638
Smaller forest cover			France:	0.837 = 1.095 · 0.764
			Hungary:	0.751 = 1.186 · 0.634
	Italy:	0.850 = 0.969 · 0.877	Denmark:	0.541 = 1.330 · 0.406
	Turkey:	0.356 = 0.821 · 0.434	United King.:	0.486 = 1.349 · 0.360
	Greece:	0.271 = 0.322 · 0.842	Netherlands:	0.361 = 1.400 · 0.258
	Cyprus:	0.223 = 0.419 · 0.532	Ireland:	0.310 = 1.008 · 0.308
	Iceland:	0.001 = 0.066 · 0.014	Malta:	0.047 = 1.487 · 0.032

← **Smaller** forest growing stock in relation to the forest area

Greater forest growing stock in relation to the forest area →

Source: own compilation based on Tables 1, 2, and 3.

In the last part of this research the remaining stages of the logarithmic method will be performed. This will result in receiving information regarding the impact effect of the first factor and the impact effect of the second factor on the deviation of the analysed variable. The results obtained for 2015 are shown in Table 5.

Table 5. The occurring deviations of the value of X variable for i-th country from the value of this variable for Serbia and the causes of the deviations (all results in m3/ha of land area)

Country	1°	2°	3°
Slovenia	158.94	93.92	65.02
Austria	83.74	59.35	24.39
Liechtenstein	55.42	47.68	7.74
Slovakia	54.56	45.23	9.33
Switzerland	53.09	64.33	−11.24
Estonia	51.36	25.21	26.15
Latvia	49.03	19.28	29.75
Germany	48.54	55.67	−7.13
Luxembourg	46.39	49.80	−3.40
Czech Republic	46.37	49.16	−2.79
Bulgaria	9.38	10.17	−0.79
Belgium	7.53	33.47	−25.94
Serbia	**0.00**	**0.00**	**0.00**
Italy	−8.11	−1.56	−6.56
France	−8.79	4.51	−13.29
Hungary	−13.42	8.00	−21.41
Norway	−18.22	−21.03	2.81
Macedonia	−24.24	−27.89	3.65
Denmark	−24.79	11.50	−36.30
United Kingdom	−27.72	11.52	−39.24
Spain	−30.00	−31.34	1.34

Montenegro	33.94	−3.17	37.11	Netherlands	−34.48	11.39	−45.87
Poland	27.28	37.38	−10.10	Turkey	−34.73	−6.66	−28.08
Romania	27.02	40.25	−13.23	Ireland	−37.21	0.26	−37.48
Lithuania	24.93	28.22	−3.29	Greece	−39.34	−34.15	−5.18
Croatia	19.37	21.46	−2.10	Cyprus	−41.93	−24.29	−17.64
Finland	14.59	−23.56	38.15	Malta	−51.42	6.68	−58.09
Sweden	14.19	−22.31	36.50	Iceland	−53.90	−20.85	−33.06

1° – the deviation of the amount of wood forest resources: $X_i - X_{\mathrm{RS}}$;

2° – the part of the deviation caused by the bigger/smaller volume of forest growing stock per 1 ha of forest area: $(X_i - X_{\mathrm{RS}}) \cdot \frac{\lg(r_{i;Y})}{\lg(r_{i;X})}$;

3° – the part of the deviation caused by the larger/smaller forest cover: $(X_i - X_{\mathrm{RS}}) \cdot \frac{\lg(r_{i;Z})}{\lg(r_{i;X})}$.

Source: own computation based in Table 4 and Eurostat database(date of access: 27.03.2017).

As an example, the values obtained for Slovenia shall be interpreted. The amount of wood forest resources in Slovenia in 2015 was 158.94 m3/ha of land area greater than in Serbia. In 59 p.p. it was due to the fact that Slovenia has greater volume of standing stock per 1 ha of forest area (125.0% greater), and in the remaining 41 p.p. the reason being the larger forest cover (75.3% larger). Had the same volume of growing stock per 1 ha of forest area been in Slovenia in 2015 as in Serbia, the amount of wood forest resources in Slovenia would have been 65.02 m3/ha of land area greater than it was in the case of Serbia, only due to the larger forest cover. However, if the forest area in proportion to the total land area had been in Slovenia as little as in Serbia, the amount of wood forest resources in Slovenia would have been 93.92 m3/ha of land area greater than in Serbia, what would have been a result solely of the greater volume of forest standing stock.

8. CONCLUSIONS

For majority of the European countries forests are one of the most important renewable resources and provide multiple benefits to societies and economies. Forest governance – in its broadest sense – refers to steering the societies and economies towards sustainable forest management (Arts et al., 2012, p. 22). Apart from small areas of natural forest, much of Europe's forests are now managed and are subject to human activities (Jeanrenaud, 2001, p. 2).

The aim of the article was to compare thirty five selected European countries according to the three key forest indicators: the amount of wood forest resources per 1 ha of land area, the growing stock per 1 ha of forest area, and the forest cover. The research was conducted on the basis of data from 2015. The values relating to Serbia have been adopted as the basis for comparisons between countries.

It is very important to stress that the research carried out in this paper is only a certain contribution for the sake of conducting further studies on mathematical tools useful in making comparisons of countries in terms of different indicators describing their resources.

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