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Pattern of Energy Productivity and Gross Domestic Product Among European Countries

Wzór produktywności energetycznej i produktu krajowego brutto wśród krajów europejskich

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Abstract

The first part of the study performs a comparative analysis over a period of 5 years between countries grouped by regions and regions through the energy intensity indicator using the data available in the Eurostat database. A statistical analysis was carried out using one-way ANOVA and post-hoc analysis using the Tukey test, and the three indicators surveyed (energy productivity, energy intensity of the economy, gross domestic product at market prices) allowed comparisons between countries. Thus, groups that differ in average have been highlighted. Using the Tukey test, all comparisons were made between the analyzed countries, taking two in two of each region, for each indicator, allowing the determination of homogeneous groups by checking the null hypothesis.

Key words: economic growth, development country, significant differences

Streszczenie

W artykule przeprowadzono analizę porównawczą odnoszącą się do okresu 5 lat między krajami pogrupowanymi według regionów oraz regionów pogrupowanych za pomocą wskaźnika intensywności energii, korzystając z danych dostępnych w bazie Eurostatu. Analizę statystyczną przeprowadzono za pomocą jednokierunkowej analizy wariancji ANOVA i analizy post-hoc przy użyciu testu Tukeya, a trzy analizowane wskaźniki (wydajność energetyczna, energochłonność gospodarki, produkt krajowy brutto po cenach rynkowych) umożliwiły dokonanie właściwych porównań pomiędzy wybranymi krajami. Wyróżniono grupy, które różnią się średnią. Korzystając z testu Tukeya, dokonano wszystkich porównań między analizowanymi krajami, biorąc po dwa z każdego regionu, dla każdego wskaźnika, umożliwiając określenie homogenicznych grup poprzez sprawdzenie hipotezy zerowej.

Słowa kluczowe: wzrost ekonomiczny, rozwój kraju, znaczące różnice

1. Introduction

The second industrial revolution has created, among other things, the global dependence on fossil fuels, the dependence that has increased as a result of rapid electrification, mass production and infrastructure development in transport and telecommunications (Allen, 2009; Berndt, 1990). According to economic theory, the dependence of an economic system on certain resources can be removed either by substitution (finding substitutes) or by investing in technology (infrastructure). The issue of substitution has been the subject of wide-ranging debates and controversies as to how substitution and complementarity would characterize the relationship between the energy production process and national capital inflows (Daly 1997a, b; Solow 1997; Stiglitz 1997). This concern has led to the conclusion that energy and energy resources are factors that have a limiting role, or they can influence the economic growth of a nation (Abosedra et al., 2009). Studies in China present the results of the production function estimation and state that, in the current state of the economy, production will increase with the growth of the econ-

omy, which will implicitly increase energy consumption and increase pollution (Yanqing and Mingsheng, 2011; Wang et al., 2011). These studies argue that rising incomes lead to increased pollution and energy consumption, and the rise in capital stock will continue to generate the pollution of large industries, with governments alone being able to produce policies that allow for conservation, sustainable development and energy security (Yanqing and Mingsheng, 2011; Wanga et al., 2015; Chalvatzis and Ioannidis, 2017).

The latest studies show that access to energy determines the welfare of a country, and that the use, production or delivery of most consumer goods cannot be achieved without the use of energy, and as a result of world population growth, demand for Energy will be inevitable (Chalvatzis, 2009; Martchamadol and Kumar, 2012; Topping, 2013). Other studies have stopped using primary energy that has been studied alongside renewable and non-renewable energy use. It was found that there is a feed-back relationship between the source of consumption and growth (Narayan and Wong, 2009; Tugcu et al., 2012; Apergis and Payne, 2012).

Energy dependence has also been a widely-discussed indicator of specialists who have found that energy imports have a negative impact on growth and sustainable development, as the price check for that country is a difficult task that is hampered by how volatile the country is political or social viewpoints (Gan et al., 2007). Another approach to energy dependency is given by the link that exists between different industrial branches and energy consumption in some countries, considering that these countries are economically dependent on energy consumption and energy conservation could contribute to reducing / slowing down economic growth as a result of slowing progress (Murry and Nan, 1996; Wolde-Rufael, 2006; Chen et al., 2007).

Other studies have looked at the difference between GDP and Sustainable Economic Growth (ISEW) indicators when it comes to energy consumption versus economic growth, highlighting some differences that exist between the two indicators (Marques et al., 2016).

Energy intensity and energy productivity are indicators debated in many studies in the literature, and they are considered to be energy efficiency indicators (Patterson, 1996; Nel & Van Zyl, 2010). Some researchers have decomposed the productivity index taking into account the contractions of the elements that determine the inputs and the extensions of the elements that determine the outputs (Luenberger, 1992; Chambers et al., 1998) and others have compared the Luenberger index to the Malmquist index (Boussemart et al., 2003; Managi, 2003).

Recent studies show that in some countries there is a tendency to improve energy intensity as a result of lower energy consumption in large industries (through upgrading, use of renewable energy or limiting activity), while in others worsening for example in Germany there has been an increase (in 2013) and then a slight decrease in 2014-2015 as a result of switching to biomass fuels that are less energy efficient but eliminating waste and reducing carbon emissions, energy expenditure and dependency of imported fuels (OECD / IEA, 2015).

The aim of this paper is to determine the significant differences between countries and geographic regions in Europe with 3 indicators: energy productivity, energy intensity of the economy and gross domestic product. The analysis consists of two parts: the study of the evolution of energy intensity on countries and regions and the statistical analysis using one way ANOVA and can be analysed on three indicators: energy productivity (EP), energy intensity of economy (EI), gross domestic product at market prices (GDP).

2. Material and method

The Eurostat database was used to collect the following data starting with 2011: energy productivity (EP), energy intensity of the economy (EI) and gross domestic product at market prices (GDP). Data collection was done February 09, 2017 and all data available till that date were included in the analysis. The country with data available for all years of interest (2011-2015) was included in the analysis along with abbreviation and region are presented in Table 1.

It has been chosen to study the Gross Domestic Product as it provides macroeconomic information on the efficiency of each country as a means of measuring well-being and quality of life. The energy productivity indicator was chosen because it is an indicator of efficiency that allows us to identify the countries producing the most energy at the lowest cost (the value being given both by the existing resources and by the way energy production is obtained: by reducing energy losses, increasing plant efficiency, etc.). The energy intensity indicator has been taken into account because it allows us to determine at country level qualitative assessments related to the structure of the economy which ultimately determine the level of development and, in the secondary plan, the energy use efficiency.

The five-year comparative analysis of the energy intensity indicator in the countries grouped by regions is done to identify energy-efficient countries both in the region and within the region. The increased level of energy intensity is important to study because it can have multiple causes: the effect of urbanization (increasing population density – increasing production – increasing consumption), the effect of industrialization (the increase in production in subsectors of the high-energy consumption economy) or the combined effect of both (Sadorsky, 2014). The existence of a five-year data series has allowed comparisons to be made over time and across regions for

Table 1. Regional breakdown of countries, sources: www.mapsofworld.com/europe/country-groupings/, publications.europa.eu/code/ro/ro-5000500.htm

Country	Abb	Region
Austria	AT	W
Belgium	BE	W
Bulgaria	BG	E
Croatia	HR	S
Czech Republic	CZ	E
Denmark	DK	N
Estonia	EE	N
Finland	FI	N
Republic of Macedonia	MK	S
France	FR	W
Germany	DE	W
Greece	GR	S
Hungary	HU	E
Iceland	IS	N
Ireland	IR	N
Italy	IT	S
Country	Abb	Region
Latvia	LV	N
Lithuania	LT	N
Luxembourg	LU	W
Malta	MT	S
Montenegro	ME	S
Netherlands	NL	W
Norway	NO	N
Poland	PL	E
Portugal	PT	S
Romania	RO	E
Serbia	RS	S
Slovakia	SK	E
Slovenia	SI	S
Spain	ES	S
Sweden	SE	N
United Kingdom	UK	N

Abb=abbreviation; N: North; W: West; S: South; E: East.

the average energy intensity. The average energy intensity was obtained as the arithmetic mean of the results recorded by the countries of each region. Also, the total average for all countries surveyed has been calculated by providing a ranking of the regions and a comparison of these with the average recorded in the countries.

The exploratory analysis of energy productivity (EP), energy intensity of economy (EI), and Gross Domestic Product at market prices (GDP) was done using the Statistics program (v. Soft, USA). ANOVA analysis was used in one direction to compare regions and countries in the same region and Post-hoc analysis using the Tukey test for comparisons between countries taken two in two. The significance threshold was 5%.

In order to evaluate the association between the values taken in the study, variance analysis (ANOVA) was used, which was extremely useful in the exploration and confirmation data analysis (Gelman, 2005), and the following were established:

- The measured variables (Y) represent the values for the countries surveyed for 2011-2015.
- Category variables (X) represent the studied indicators (EP, EI and GDP).

The Variance Analysis (ANOVA), being an exploratory test, identified the existence of statistically significant differences between groups, and then there was sufficient evidence to estimate the magnitude of these differences between pairs of environments using post-hoc analysis (Floyd, 2010; Black, 2010).

The statistical hypotheses investigated were fixed as:

- Null hypothesis (H_o): There is no statistically significant difference between indicator averages (Y) for countries grouped by regions (k);
  $1 = 2 = \ldots = k$; Where: μ = group average and k – group number.
- Alternative hypothesis (H_a): At least two environments are significantly different.

ANOVA has identified significant differences between different regions and countries in the same region. Application of the ANOVA test was necessary because it allowed the rejection of the equation of the media. Because after the ANOVA test it is not possible to determine which countries (of those taken in the study) have different environments (in order not to risk rejecting the null hypothesis even if this could be true) was used as a multiple comparison technique, post-hoc, which allows the identification of countries that differ as average.

Among the multiple comparison methods, the Tukey test was chosen, which is a statistic based q method and is preferable when it is desired to perform group comparisons taken two by two. Although it is considered a conservative method, the Tukey test was chosen because it allows for a high level of comparisons compared to Bonferroni (using a test sequence t) or Scheffe (based on the F test) which although allows for many comparisons the risk of errors is also high (Seltman, 2015; Maxwell and Delaney, 2003).

The energy productivity index (EP), as described in the Eurostat database, resulted from the split of Gross Domestic Product (GDP) to Gross Domestic Energy Usage for a given calendar year. It measures the productivity of energy consumption. Gross domestic energy consumption is calculated as the sum of the gross domestic consumption of five types of energy: coal, electricity, oil, natural gas and renewable energy sources. Since GDP is measured in millions of euros and gross domestic consumption in thousands of tons of oil equivalent, it results that energy productivity is available in EUR per kg of equivalent oil.

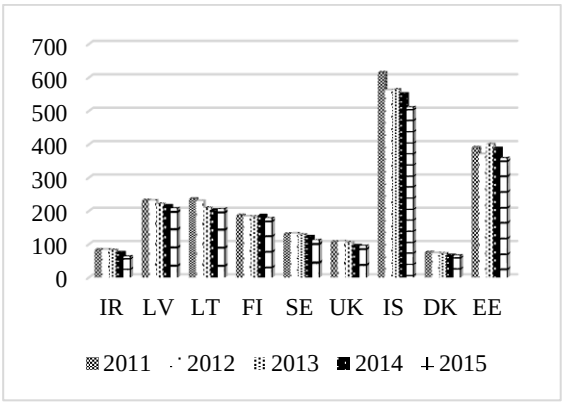
Another indicator used in the study is the energy intensity indicator (EI), which has been used in the existing form in the Eurostat database. It was calculated as a ratio between domestic energy consumption to produce a unit of gross domestic product. Measuring the energy consumption of an economy and its global energy efficiency, this indicator primarily characterizes the economic efficiency of energy use and, to a lesser extent, its technical effi-

ciency. The value of this indicator depends on the value of the gross domestic product and the existing industries in each country. The share of certain industries (chemical, metallurgical, etc.) in the manufacturing industry in a country may lead to an increase in this indicator when consumption does not correspond to an increase in added value that can be obtained at the level of results.
Gross domestic product at market prices – at current prices (GDP), is an indicator for the economic situation of a nation. It reflects the total value of all goods and services produced minus the value of the goods and services used for intermediate consumption in their production.

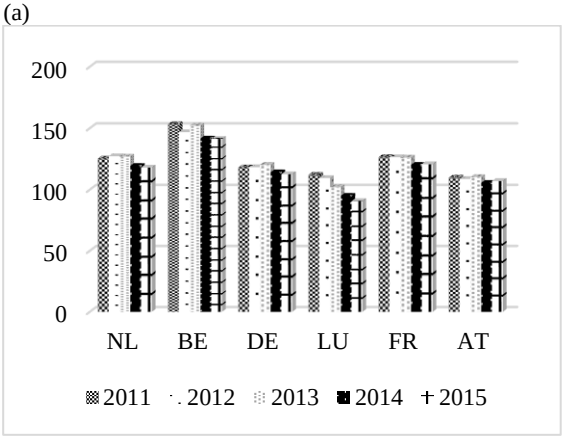
3. Results and discussions

3.1. Energy intensity analysis for countries in Europe grouped by regions

Figure 1 (a-d) graphically shows the values obtained for the energy intensity indicator for countries under study, grouped on four distinct regions.
The analysis of the data in Figure 1 (a) shows that the best performances in 2015 for the northern region were recorded by the following countries: Ireland (62 kg of oil equivalent / 1,000 EUR), Denmark (65.1 Kg of oil equivalent / 1,000 EUR) and Norway (85.5 kg of oil equivalent / 1,000 EUR), being the top three countries with the best values. Figure 1 (b) shows that the first three countries in 2015 for the western region are: Luxembourg (90.7 kg of oil equivalent / 1,000 EUR), Austria (107.1 kg of oil equivalent/ 1,000 EUR) and the Netherlands (118 kg of oil equivalent / 1,000 EUR). In Figure 1 (c), for the southern region, the top three countries are Malta (90.3), Italy (100.5) and Spain (113.7). In Figure 1 (d), for the Eastern region, the countries: Slovakia (215.1), Hungary (224) and Romania (226.7) are in the top three places.
The structure of the national economy decisively influences the value of the energy intensity due to the added value resulting from the economy on the one hand and the share of energy consumption on the other. It can be said that the number of inhabitants has a high contribution because if we speak in terms of efficiency then we know that the human factor can contribute to the improvement of productivity and implicitly to the economic growth. Energy consumption also plays a decisive role, which can be influenced by the internal policy of each state (economic leverage: price regulations, fuel type, pollution, CO_2 emissions, etc.) that can lead to encouraging or restricting activity with economic effects in some industries where the cost of energy is high (chemical, metallurgical, construction, transport, etc.). The high gross domestic product is due to both economic and political effects in a country (economies of scale because of serial production, with the possibility of retechnology that allows for cost reductions, efficient economic environment (well-organized enterprises) Consistent policies that support economic activity in the private environment, etc.).



(a)



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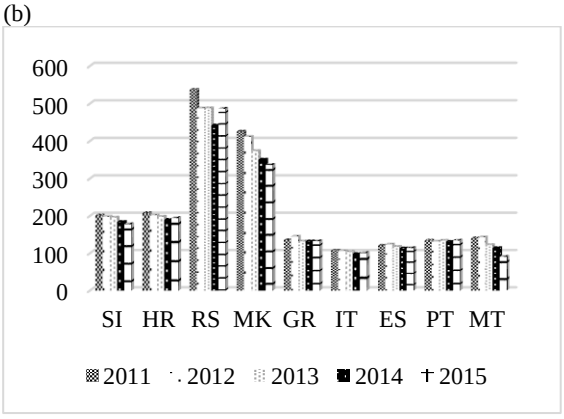

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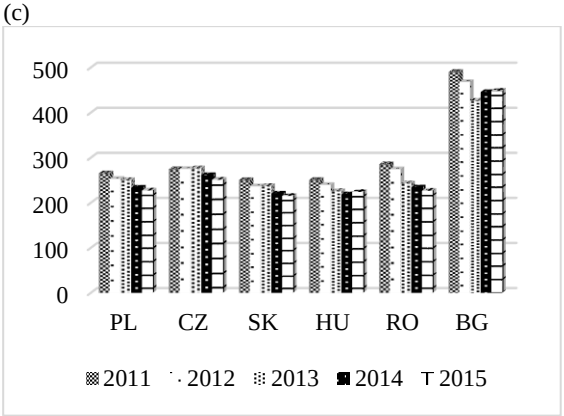

Figure 1. Energy intensity of the economy (kg of oil equivalent per 1,000 EUR)

Table 2. Energy intensity by regions (kg of oil equivalent per EUR 1 000)

Regions	2011	2012	2013	2014	2015	Ranking 2015
N	214.14	206.16	206.02	198.43	187.57	II
W	124.20	105.27	105.39	99.43	98.63	I
S	264.62	253.82	240.09	226.85	232.38	III
E	302.67	290.95	276.45	268.73	265.40	IV
Average regions	223.92	215.77	208.75	199.65	197.49	

Table 3. Summary of indicators by regions

Indicator	EP (Mean±Std. Dev.)	EI (Mean±Std. Dev.)	GDP (Mean±Std. Dev.)
North (n=50)	7.57 ±4.29	202.46±151.51	35,292 ±18,712.32
West (n=30)	8.45 ±1.05	120.21±15.31	44,270 ±19,017.89
South (n=45)	6.31 ±2.62	207.35±129.83	15,613.64 ±7,270.44
East (n=30)	3.77 ±0.79	280.84±82.19	10,506.67 ±3,403.54

Table 4. Distribution of the indicators studied by regions according to confidence intervals

Regions	EP		EI		GDP	
	-95.00%	+95.00%	-95.00%	+95.00%	-95.00%	+95.00%
N	6.77	8.38	169.75	235.17	31,323.43	39,260.57
W	7.41	9.49	7.98	162.43	39,146.60	49,393.40
S	5.46	7.16	172.87	241.83	11,383.13	19,844.15
E	2.73	4.81	238.61	323.07	5,383.26	15,630.07

The average energy intensity indicator was calculated by calculating the region-by-region average of country-by-country values for each year surveyed, as shown in Table 2.

From the data presented in Table 2, the average values recorded by the EI indicator for each region and for all countries are decreasing from one year to the next, which is a positive aspect. At the level of 2015, the following ranking was achieved: West region (W), North region (N), South region (S), and East region (E). These results are predictable because the southern and eastern areas of Europe comprise most countries falling under the *emerging markets* category, i.e. countries that are developing because of the fall of the communist bloc. The explanation is that these countries start with a limited return on capital. They should return a higher profit for each sector with new investments. The gap in the northern region of Europe, which surpasses the western region, is due to the existence of three emerging and border markets (Estonia, Latvia and Lithuania). This gap also remains in the southern region (Slovenia, Croatia, and Serbia) and the East (Romania, Bulgaria) where most of the countries are with the emerging market and the border (MIGA, 2010; IMF, 2015; Cogman et al., 2015). Although all the countries of the former communist bloc have gone through the same period in the market economy, there are some economic differences that can be found also in the indicators computed in this study.

From Table 2 we can see that the first two regions record the lowest values, below the average recorded, and the latter two regions record values above the average, which again shows the economic efficiency gap recorded by these countries. Getting lower values of energy intensity is a target that all countries are targeting. This implies achieving higher economic performance from one year to another owing to both the rising values of the gross domestic product and the technologies used to be more efficient (lower consumption). The decrease in energy intensity can be achieved both economically by increasing the energy efficiency, respectively the increase of the gross domestic product as well as from the technical point of view through the modernization of the technologies and the restructuring of the economy.

3.2. Exploratory analysis of differences between regions and between countries

As expected, significant difference has been observed between investigated regions for EP, EI and GDP (see Table 3).

However, the post-hoc analysis identified significant differences are between: North and East regions ($p=8.0x10^{-6}$) which is maintained at the same value and between West and East regions and South and East regions, West and South regions (p=0.0087), for EP. The smallest EI was observed in West region, the values being significantly lower compared with North (p=0.0126), South (p=0.0086), and East ($p=8.0\times10^{-6}$). Moreover, the North region proved significantly lower EI compared with South (p=0.0086) and East ($p=8.0x10^{-6}$) while EI proved also significantly lower in South as compared with East (p=0.0387).

As expected, the North and West regions had higher values of GDP (see Figure 1). The values are significantly higher when North is compared with West (p=0.0315), South ($p=8.0x10^{-6}$) or East ($p=8.0x10^{-6}$). The same holds true when comparing the South with West and West with the East.

Analyzing the distribution of each indicator surveyed according to the confidence interval of 0.95 it

Table 5. Differences between North and West regions using confidence intervals

Regions	Country	EP		EI		GDP	
		-95.00%	+95.00%	-95.00%	+95.00%	-95.00%	+95.00%
NORTH	IR	12.50	13.82	63.41	90.71	39,315.26	45,604.74
	LV	3.84	5.16	207.59	234.89	8,055.26	14,344.74
	LT	3.96	5.28	202.93	230.23	8,595.26	14,884.74
	FI	4.82	6.14	169.43	196.73	34,175.26	40,464.74
	SE	7.38	8.70	111.33	138.63	41,455.26	47,744.74
	UK	9.16	10.48	88.29	115.59	30,575.26	36,864.74
	IS	1.14	2.46	546.37	573.67	34,615.26	40,904.74
	NO	10.72	12.04	74.57	101.87	70,655.26	76,944.74
	DK	13.64	14.96	56.55	83.85	43,035.26	49,324.74
	EE	1.98	3.30	367.67	394.97	10,995.26	17,284.74
WEST	NL	7.74	8.54	118.61	128.11	37,563.87	40,516.13
	BE	6.42	7.22	142.27	151.77	34,003.87	36,956.13
	DE	8.20	9.00	111.93	121.43	33,763.87	36,716.13
	LU	9.46	10.26	97.13	106.63	84,183.87	87,136.13
	FR	7.66	8.46	119.23	128.73	30,623.87	33,576.13
	AT	8.84	9.64	103.57	113.07	36,623.87	39,576.13

Table 6. Differences between South and East regions using confidence intervals

Regions	Country	EP		EI		GDP	
		-95.00%	+95.00%	-95.00%	+95.00%	-95.00%	+95.00%
SOUTH	SI	4.67	5.77	173.97	208.47	17,185.10	18,694.90
	HR	4.53	5.63	180.87	215.37	9,545.10	11,054.90
	RS	1.55	2.65	470.53	505.03	3,885.10	5,394.90
	MK	2.13	3.23	362.11	396.61	3,006.00	4,694.00
	GR	6.87	7.97	117.87	152.37	16,225.10	17,734.90
	IT	9.19	10.29	85.65	120.15	26,085.10	27,594.90
	ES	7.99	9.09	100.09	134.59	21,765.10	23,274.90
	PT	7.01	8.11	115.35	149.85	15,825.10	17,334.90
	MT	7.89	8.99	104.43	138.93	17,765.10	19,274.90
EST	PL	3.86	4.34	228.96	262.56	9,998.63	10,881.37
	CZ	3.48	3.96	250.80	284.40	14,898.63	15,781.37
	SK	4.06	4.54	214.98	248.58	13,298.63	14,181.37
	HU	4.10	4.58	214.80	248.40	9,978.63	10,861.37
	RO	3.74	4.22	235.86	269.46	6,798.63	7,681.37
	BG	1.92	2.40	438.84	472.44	5,418.63	6,301.37

is noticed that the western region recorded the best values for all three indicators studied and the eastern region has the most serious values (see Table 3).

For EP, Table 3 shows the existence of a North, West and South cluster against which the East is isolated at an EP domain close to being statistically significantly inferior to the cluster value of the other 3 regions. The outcome is expected, given that most of the countries in the last enlargement waves of the EU are covered in the East. On the opposite side, there is the EI indicator (Table 3) against which the East is again detached from the cluster of the other 3, this time in a positive difference, reflecting the trend of recovering the economic gap. The latter indicator, GDP (Table 3), can be viewed again through clustering, and shows the formation of North with West and South with East clusters, respectively.

From the statistical analysis it is observed that at the EP in the North region the best average value is recorded by Denmark (14.3) and the weakest Iceland (1.8) while in the region West's best value is registered by Luxembourg (9.86) and the lowest value is obtained by Belgium (6.82). In Figure 3 (c) and (d), the EI indicator shows that in the North region the best value is recorded by Denmark (70.2) and Iceland's weakest value (560.02), while in the West region. Good value is recorded by Luxembourg (101.88) and the lowest value is obtained by Belgium (147.02). In figure 3 (e) and (f) the GDP indicator shows that in the Northern region the best value is recorded by Norway (73,800) and the weakest Latvia (11,200) while in the West's best value is recorded by Luxembourg (85,660) and the lowest value is obtained by France (32,100).

Table 5 shows the confidence intervals obtained from statistical calculations by each country in the North and West regions.

Table 5 shows that for the EP indicator the best position is occupied in the North region: DK (13.64÷14.96) and in the western region: LU (9.46÷10.26) and the lowest value is recorded in the North region: IS (1.14÷2.46) and in the South region: BE (6.42÷7.22). Thus, by comparing the countries of the two regions, the best confidence interval is given

by DK (in the Northern region), although the West region has average confidence values higher than the North region.

From the analysis of the results obtained by the EI indicator, for each country surveyed according to the confidence intervals, it is observed that the best values are recorded by DK (56.55÷83.85) and LU (97.13÷106.63). However, from the region's comparative analysis, the Western region is superior to the North.

From the analysis of the GDP index results for the North and West countries, according to the confidence intervals, we can see that the best values are recorded by NO (70,655.26÷76,944.74) and LU (84,183.87÷87,136.13). And to this indicator, the comparative analysis on the whole region tells us that the Western region has values superior to the North.

From statistical analyses shows that the best EP indicator value in the southern region is recorded by Italia (9.74) and Croatia's weakest value (2.1), while in the eastern region the best value is registered by Hungary (4.34) and the poorest value is obtained by Bulgaria (2.16). From EI indicator shows that in the southern region the best value is recorded by Italy (102.9) and the lowest value of Serbia (487.78) while in the eastern region the best value is registered by Hungary (231.6) and the lowest value is obtained by Bulgaria (455.64). The GDP indicator shows that in the southern region the best value is registered by Italy (26,840) and the lowest value of Republic of Macedonia (3,850) while in the Eastern region the best value is registered by Czech Republic (15,340) and the lowest value is obtained by Bulgaria (5,860). Table 6 shows the confidence intervals obtained from statistical calculations by each country in the South and East regions.

From the analysis of the results obtained by the EP indicator taking into account the countries of the South and East region, according to the confidence intervals, it is observed that the best values are recorded by IT (9.19÷10.29) and by HU (4.10÷4.58) and the smallest by RS (1.55÷2.65) and BG (1.92÷2.40).

At EI, the results for countries in the South and East region, according to confidence intervals, show that the best values are registered by IT (85.65÷120.15) and by HU (214.80÷248.40) and the worst by RS (470.53÷505.03) and BG (438.84÷472.44).

At the GDP indicator, the results for countries in the South and East region, according to confidence intervals, show that the best values are recorded by the countries: IT (26,085.10÷27,594.90) and CZ (14,898.63÷15,781.37) and the weakest by MK (3,006÷4,694) and BG (5,418.63÷6,301.37).

From the post-hoc analysis with the Tukey test (Table 7 and 8) it can be observed that at the level of each indicator taken in the study there are statistically significant differences between pairs of countries (bold values) but also insignificant statistical differences.

From the probability analysis (Table 7) for the Northern region it is observed that the insignificant statistical differences are recorded at the EP indicator in the following countries: IS-EE, LV-LT, LV-FI, LT-FI, IR-DK. At the EI indicator, the probability analysis tells us that there are statistically insignificant values recorded in the following countries: IR-UK; IR-NO; IR-DK; LT-LV; SE-UK; UK-NO; UK-DK; NO-DK. The GDP indicator in the probability analysis shows that there are several static insignificant differences than those statistically significant. The insignificant statistical differences are recorded by comparison between the following countries: IR-FI, IR-SE, IR-IS, IR-DK, LV-LT, LV-EE, LT-EE, FI-SE, FI-UK, FI-IS, SE-IS, SE-DK, UK-IS. From the average (central or all-year mean) value recorded in the northern region, it is noticed that at the energy productivity indicator, Denmark has an average value of 7.94 times the Iceland lowest value. From the analysis of the standard deviation to all three indicators in the North region it is observed that it takes values in 0.08 ÷ 1.0. The only country is IR (1.73) being more remote at the EP indicator; Then to EI, values between 3.85 ÷ 17 (IS being farther away taking 37) and values between 653.45 ÷ 7,241.06 for the GDP indicator. It can also be said that when we have small values, we are confronted with homogeneous values overall years (relatively constant increases / decreases), and the tops show us the possible leaps produced over the years studied (e.g. IR at the EP indicator, jump in year 2011 compared to 2012 from 12.1 to 12 and in year 2014 compared to 2015 from 13.4 to 16.1).

From the probability analysis (Table 7) for the western region it is observed that the insignificant statistical differences are recorded at the EP indicator at the following pairs of countries: NL-DE, NL-FR, DE-AT, LU-AT. At EI indicator, the probability analysis tells us that there are statistically insignificant values from the following countries: NL-DE; NL-FR; DE-FR; LU-AT. For the GDP indicator, from the probability analysis, statistically insignificant values are recorded in the following countries: DE-AT, BE-DE, BE-AT, NL-AT.

From the probability analysis obtained in Table 8 for the South region it is observed that most statistically insignificant differences are recorded in the EP indicator and the EI, same eastern region. In the Southern region, significant differences are recorded by Italia with all countries on the EP, EI and GDP indicators. For the Southern region observed that the insignificant statistical differences are recorded at the EP indicator in the following countries: RS-MK, SI-HR, GR-ES, GR-PT, GR-MT, PT-MT, ES-PT, ES-MT, IT-ES. At the EI indicator the probability analysis tells us that there are statistically insignificant values registered at: GR-IT; GR-ES; GR-PT; GR-

Table 7. Probabilities associated with post-hoc analysis with the Tukey test

North										West					
Energy Productivity (EP)															
Abb (Mean±Std. Dev.)	LV	LT	FI	SE	UK	IS	NO	DK	EE	Abb (Mean±Std. Dev.)	BE	DE	LU	FR	AT
IS (1.8±0.14)							**0.0002**	**0.0002**	0.7265	BE(6.82±0.28)		**0.0001**	**0.0001**	**0.0016**	**0.0001**
EE (2.64±0.11)										FR(8.06±0.22)					**0.0026**
LV (4.5±0.21)			10.5322	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0089**	NL(8.14±0.29)	**0.0008**	0.5452	**0.0001**	0.9997	**0.0054**
LT (4.62±0.34)			0.7000	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0043**	DE (8.6±0.24)			**0.0014**	**0.3740**	0.2085
FI (5.48±0.08)				**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	AT(9.24±0.17)					
SE (8.04±0.57)					**0.0143**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	LU (9.86±0.9)				**0.0001**	0.2365
UK (9.82±0.63)						**0.0002**	**0.0489**	**0.0002**	**0.0002**						
NO (11.38±0.77)								**0.0002**	**0.0002**						
IR (13.16±1.73)	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0143**	0.3235	**0.0002**						
DK (14.3±0.92)									**0.0002**						
Energy Intensity (EI)															
Abb (Mean±Std. Dev.)	LV	LT	FI	SE	UK	IS	NO	DK	EE	Abb (Mean±Std. Dev.)	BE	DE	LU	FR	AT
DK (70.2±4.38)									**0.0002**	LU(101.88±9.15)				**0.0001**	0.3820
IR (77.06±9.1)	**0.0002**	**0.0002**	**0.0002**	**0.0006**	0.2485	**0.0002**	0.9731	0.9993	**0.0002**	AT(108.32±1.97)					
NO (88.22±6.09)								0.6772	**0.0002**	DE(116.68±3.16)			**0.0017**	0.2553	0.1438
UK (101.94±6.43)						**0.0002**	0.9079	0.0531	**0.0002**	NL(123.36±4.34)	**0.0001**	0.3435	**0.0001**	1.0000	**0.0015**
SE (124.98±8.39)					0.3457	**0.0002**	**0.0136**	**0.0002**	**0.0002**	FR(123.98±3.23)					**0.0010**
FI (183.08±3.85)				**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	BE(147.02±5.64)		**0.0001**	**0.0001**	**0.0001**	**0.0001**
LT (216.58±15,19)			**0.0335**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**						
LV (221.24±10.39)		1.0000	**0.0091**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**						
EE (381.32±16.92)															
IS (560.02±37.27)							**0.0002**	**0.0002**	**0.0002**						
Gross domestic product (GDP)															
Abb (Mean±Std. Dev.)	LV	LT	FI	SE	UK	IS	NO	DK	EE	Abb (Mean±Std. Dev.)	BE	DE	LU	FR	AT
LV (11,200±961.77)		1.0000	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	0.9388	FR (32,100± 494.97)					**0.0002**
LT(11,740±1,035.86)			**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	0.9829	DE (35,240± 1370,4)			**0.0001**	**0.0488**	0.0870
EE(14,140±1,167.48)										BE(35,480± 801.25)		0.9999	**0.0001**	**0.0290**	0.1385
UK(33,720±3,804.21)						0.7093	**0.0002**	**0.0002**	**0.0002**	AT (38,100± 1,000)					
FI (37,320±653.45)				0.0551	0.8226	1.0000	**0.0002**	**0.0084**	**0.0002**	NL(39,040± 630.87)	**0.0193**	**0.0112**	**0.0001**	**0.0001**	0.9349
IS (37,760±5,069.81							**0.0002**	**0.0145**	**0.0002**	LU(85,660± 3,344.10)				**0.0001**	**0.0001**
IR(42,460±7,241.06)	**0.0002**	**0.0002**	0.3897	0.9923	**0.0097**	0.5147	**0.0002**	0.7941	**0.0002**						
SE(44,600±1,065.36)					**0.0007**	0.0882	**0.0002**	0.9993	**0.0002**						
DK(46,180±1,283.35)									**0.0002**						
NO(73,800±4,677.07)								**0.002**	**0.0002**						

From the average (central / all-year mean) analysis, it is noticed that, for the EP indicator, Italia (S) averages 4.64 times higher than Croatia (S) and Hungary (E) of 2.01 times against Bulgaria (E). From the GDP indicator, the average analysis, Italia (S) has a value of 6.97 times higher than Republic of Macedonia (S) and Czech Republic (E) of 2.62 times compared to Bulgaria (E).

From the standard deviation analysis to all three indicators in the South region it is observed that they take values between: 0.09 ÷ 2.68; 1.57 ÷ 38; 100 ÷ 2,029, the only Slovenia; Russia and Macedonia; and Malta again at the third indicator, with more remote values. In the Eastern region, the standard deviation analysis to all three indicators, take values between: 0.11÷0.24; 11÷26; 270÷626. The only country with the highest values for all three indicators is Romania. It can also be said that when we have small values, we are confronted with homogeneous values overall years, and winds (for example, Malta in the South region) show us the leaps over the years studied that may be due to some slippages in the economy, being shocks registered in certain branches of industry that caused chain changes to the three indicators (of different intensities).

The dispersed values recorded by the EP and EI indicators in the countries of the Eastern region show that although these countries had about the same de-

Table 8. Probabilities associated with post-hoc analysis with the Tukey test

South									East					
Energy Productivity (EP)														
Abb (Mean±Std. Dev.)	HR	RS	MK	GR	IT	ES	PT	MT	Abb (Mean±Std. Dev.)	CZ	SK	HU	RO	BG
RS (2.1±0,14)			0.8420	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	BG (2.16±0.11)					
MK (2.68±0,28)				**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	CZ (3.72±0.18)		**0.0162**	**0.0091**	0.5988	**0.0001**
HR (5.08±0,19)		**0.0001**	**0.0001**	**0.0002**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	RO (3.98±0.41)					**0.0001**
SI (5.22±2,68)	1.0000	**0.0001**	**0.0001**	**0.0002**	**0.0001**	**0.0001**	**0.0002**	**0.0001**	PL (4.10±0.24)	0.2113	0.8130	0.6745	0.9741	**0.0001**
GR (7.42±0,3)					**0.0002**	0.1170	1.0000	0.1979	SK (4.30±0.24)			0.9999	0.3796	**0.0001**
PT (7.56±0,09)								0.3709	HU (4.34±0.24)				0.2602	**0.0001**
MT (8.44±1,67)														
ES (8.54±0,34)							0.2402	1.0000						
IT (9.74±0,32)						0.0738	**0.0002**	**0.0398**						
Energy intensity (EI)														
Abb (Mean±Std. Dev.)	HR	RS	MK	GR	IT	ES	PT	MT	Abb (Mean±Std. Dev.)	CZ	SK	HU	RO	BG
IT(102.9±3.71)						0.9512	0.2803	0.8186	HU(231.60±13.05)				0.4673	**0.0001**
ES(117.34±4.42)							0.9340	1.0000	SK (231.78±14.2)			1.0000	0.4765	**0.0001**
MT(121.68±21.34)									PL(245.76±15.46)	0.4281	0.8258	0.8182	0.9901	**0.0001**
PT(132.6±1.57)								0.9911	RO(252.66±25.82)					**0.0001**
GR(135.12±5.56)					0.1915	0.8582	1.0000	0.9677	CZ (267.6±11.12)		**0.0481**	**0.0465**	0.7835	**0.0001**
SI(191.22±10.08)	0.9997	**0.0001**	**0.0001**	**0.0014**	**0.0001**	**0.0001**	**0.0008**	**0.0002**	BG(455.64±24.24)					
HR(198.12±6.85)		**0.0001**	**0.0001**	**0.0003**	**0.0001**	**0.0001**	**0.0002**	**0.0001**						
MK(379.36±38.24)				**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**						
RS (487.78±33.51)			**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**						
Gross domestic product (GDP)														
Abb (Mean±Std. Dev.)	HR	RS	MK	GR	IT	ES	PT	MT	Abb (Mean±Std. Dev.)	CZ	SK	HU	RO	BG
MK(3,850±191.49)				**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	BG(5,860±270.19)					
RS (4,640±151.66)			0.8840	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	RO (7,240±626.9)					**0.0017**
HR(10,300±100)		**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	HU(10,420±443.85)				**0.0001**	**0.0001**
PT(16,580±486.83)								**0.0192**	PL(10,440±517.69)	**0.0001**	**0.0001**	1.0000	**0.0001**	**0.0001**
GR (16,980±1,003.49)					**0.0001**	**0.0001**	0.9973	0.1164	SK(13,740±541.3)			**0.0001**	**0.0001**	**0.0001**
SI (17,940±522.49)	**0.0001**	**0.0001**	**0.0001**	0.6658	**0.0001**	**0.0001**	0.2287	0.9700	CZ(15,340±384.71)		**0.0004**	**0.0001**	**0.0001**	**0.0001**
MT (18,520±2,029.04)														
ES(22,520±506.95)							**0.0001**	**0.0001**						
IT 26,840±313.05)						**0.0001**	**0.0001**	**0.0001**						

Table 9. Summary of indicators by regions

Region/Indicator	EP (Mean±Std. Dev.)	EI (Mean±Std. Dev.)	GDP (Mean±Std. Dev.)
North + West (n=80)	7.90 ±3.47	171.62±126.22	38,658.75±19,211.5
South + East (n=75)	5.29 ±2,431.05	236.74±118.25	13,543.24±6,489.32

Table 10. Comparison between N+W versus S+E clusters

Regions	EP		EI		GDP	
	-95.00%	+95.00%	-95.00%	+95.00%	-95.00%	+95.00%
N+W	7.24	8.57	144.58	198.66	35,442.18	41,875.32
S+E	4.61	5.98	208.82	264.67	10,198.81	16,887.68

Table 11. Summary of indicators by regions

Region/Indicator	EP (Mean±Std. Dev.)	EI (Mean±Std. Dev.)	GDP (Mean±Std. Dev.)
North +West + South (n=125)	7.33±3.27	184.48±128.17	30,481.45±19,444.76
East (n=30)	3.77±0.79	280.84±82.19	10,506.67±3,403.54

Table 12. Comparison between N+W+S versus E clusters

Regions	EP		EI		GDP	
	-95.00%	+95.00%	-95.00%	+95.00%	-95.00%	+95.00%
N+W+S	6.81	7.85	163.13	205.83	27,366.83	33,596.07
E	2.70	4.84	237.27	324.41	4,174.46	16,838.88

velopment conditions until the 1990s (thanks to the communist block), these years have developed different. Hungary is the best performing country followed by the Slovakia and Poland at EI and EP indicators, and Czech Republic, Slovakia and Poland at GDP indicator.

From the analysis of the North + West versus the South + East cluster it can be noticed that in all three indicators the first region recorded the best values compared to second region (Table 9).

At the EP indicator: we can see that the North + West countries have values higher than those in the South-East region (the middle of mean value is 7.90 in North + West compared with 5.29 in South + East), at the EI indicator: the North + West (171.62) region registers more values small (better) than South + East (236.74) and GDP indicator: the average of the South + East region (13,543.24) is 2.85 times lower than the North-West region (38,658.75).

In Table 10 a grouping of regions was made in two clusters: North + West versus South + East, thus obtaining the three indicators surveyed (EP, EI and GDP).

From the analysis of Table 10 it is observed that the cluster (N + W) obtained higher values, according to confidence intervals, from the cluster (S + E) in all three indicators.

The post-hoc analysis identified significant differences are between: North + West and South + East regions ($p=9*10^{-6}$), for EP. The smallest EI was observed in North + West region, the values being significantly lower compared with South + East ($p=9*10^{-4}$) and the higher GDP was observed in North + West region ($p=9*10^{-6}$).

In Table 11 are presented the values obtained by the two clusters taken into study: N + W + S and E.

From the analysis of the North + West + South cluster versus the East, it can be noticed that the best values were registered in the first region. At the EP indicator, it is noticed that the average value obtained by North + West + South region (7.33) is 1.94 times lower than the average of the East Region (3.77); At the EI indicator, in the East region (280.84) the average is about 2.9 times higher than the average of North + West + South region (184.48) and at GDP indicator, the average of North + West + South region (30,481.45) has a value of about 2.9 times higher than the average of East region (10,506.67).

In Table 12 a grouping of regions was made in two clusters: North + West + South versus East.

From the analysis of the North + West + South versus the East cluster it can be noticed that in all three indicators the first region recorded the best values compared to the second region.

The post-hoc analysis identified significant differences are between: North + West + South and East regions ($p=9*10^{-6}$), for all three indicators.

4. Conclusions

Energy intensity is a synthetic indicator of efficiency that characterizes the economic efficiency of using energy at national level and depends on the performance of the national economy. The comparative analysis shows that in the developed countries the energy intensity indicator is below 120 kg of oil equivalent per 1 000 EUR, while in other emerging and border economies the value is over 200 kg of oil equivalent per 1 000 EUR.

From the ANOVA analysis by regions it is found that: the western region is ranked first in all three indicators followed by the northern region. Analyzing the results obtained within the regions, we find that in the northern region, the developed countries record the best values for all three indicators, except for Denmark, which shows the best values for the EP and EI, and the GDP: Denmark is located immediately after Norway. In the western region, Luxembourg also has good value for all three indicators, and in the southern region, Italy is the country recording the best values for the EP, EI and GDP indicators. In the eastern region, the values are quite close among countries, except for Hungary with the highest value for the EP and EI indicators, and for the GDP indicator, Czech Republic has the best value followed by Slovakia.

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