

The Evolution of Efficiency Indicators in the Economies of European Countries

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Abstract— This study includes an analysis of resource and energy productivity indicators over ten years. Through these indicators it was possible to obtain the evolution of these indicators during the years studied as well as the differences between countries because of the achievements in those economies. The comparative analysis of the two indicators shows that the evolution trend is similar during 2019. Subsequently, a ranking of countries was made according to 5 indicators: Energy productivity, Resource productivity, Greenhouse gas emissions per capita and Eco innovation index. According to this ranking, it can be seen which are the countries that registered high values for the productivity and eco-innovation indicators and countries where the Greenhouse gas emissions per capita indicator registered decreasing values.

Keywords — *efficiency; productivity; sustainable development.*

I. INTRODUCTION

Resource-intensive use has created problems in many countries. Thus, to reduce the depletion and degradation of the environment, the EU has undertaken a series of actions leading to a circular economy, imposing measures to create more resilient and sustainable production and consumption models. This transition, which would also contribute to the EU's achievement [1] of the goals of the UN 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 12 on "responsible consumption and production", would lead to opportunities for international cooperation, to efficient use of resources [2].

Some authors argue that there are benefits that can be obtained through intelligent production, which include: reduced costs, production flexibility, reduced marketing time, energy efficiency, reduced environmental impact and increased productivity [3]. Intelligent production can lead both to the capitalization of traditional performance indicators and to the addition to them of new attributes, such as: product personalization, flexibility, and reaction capacity [4]. Several authors in the literature show us that performance indicators must be focused on: energy efficiency and sustainability [5,6].

Increasing global competition is leading manufacturers to focus more and more on productivity and quality. To evaluate any industry, we reach the problem of energy efficiency,

which in the manufacturing industry has a proportion of up to 30% and we find negative effects on the environment in proportion of 90%, because of electricity consumed by machines and equipment [7-8]. Thus, these negative effects on the environment can be improved by reducing energy consumption [9,10]. In addition to the energy consumed, the processing performance also places greater emphasis on the use of advanced materials to obtain high production productivity that complies with health and environmental regulations [11] and technologies that allow efficient processing [12-14].

The purpose of this paper is to perform an analysis of the evolution of resource and energy productivity indicators, which captures the changes, in the 10 years studied. The comparative analysis registered at the level of 2019 allows us to see if the evolution trend is similar for the two indicators. Subsequently, a ranking of countries was made according to the indicators: Energy productivity, Resource productivity, Eco innovation index and Greenhouse gas emissions per capita.

II. MATERIAL AND METHOD

In this study, an analysis was performed using data provided by Eurostat over a period of 10 years [15].

The resource productivity indicator was used to be able to see the evolution of each country in terms of efficiency and to measure their progress. Resource productivity is defined as the ratio of gross domestic product (GDP) to domestic consumption of raw materials. When GDP increases, resource productivity improves, that country's economy becomes more efficient, and when GDP declines, the situation worsens. Resource productivity also depends a lot on the structure of the economy in each country, so industrial economies consume more resources than service-based economies. Resource productivity is a measure of the total amount of materials used directly by an economy in relation to GDP (measured as domestic consumption of materials (DMC)).

The Energy Productivity indicator was used to measure in terms of efficiency the energy productivity at the level of each country, respectively the progress registered. It is an indicator obtained from the breakdown of gross domestic product (GDP) to gross energy available for a given calendar year. It

measures the productivity of energy consumption and provides an image of the degree of decoupling of energy consumption from GDP growth. For the calculation of energy productivity, Eurostat uses GDP in the million-euro unit, in linked volumes, until the reference year 2010 (at 2010 exchange rates). The euro unit in chain-linked volumes allows the observation of energy productivity trends over time in a single geographical area, while the PPS unit allows comparisons between countries for the same year.

The indicator "energy productivity" was chosen for the study because it is considered that the increase of energy productivity leads to the improvement of the entire economy [16].

For the two indicators: resource productivity and energy productivity, a comparative analysis was performed to observe whether the two indicators follow the same evolution trend, for 2019.

According to the "Action Plan for a Circular Economy" presented by the EU Commission, the emphasis is on more efficient use of resources. To be able to capture this aspect, a comparative analysis of the indicators was performed: resource productivity, energy productivity, Greenhouse gas emissions per capita and the eco-innovation index. To this were added the statistical data recorded by the Greenhouse gas emissions per capita indicator (which shows the total national emissions of the so-called "Kyoto basket" of greenhouse gases) and the eco-innovation index (which shows the performance of eco-innovation in all states members, starting from means of production, activities, achievements to environmental results and socio-economic results). The eco-innovation index measures innovations that reduce the use of natural resources and the emission of harmful substances throughout the life cycle of products [17].

III. RESULTS AND DISCUSSIONS

Figure 1 shows the evolution of the resource productivity indicator during the ten years studied.

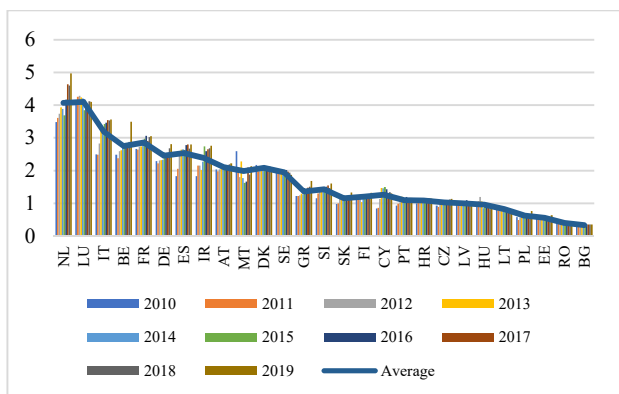


Fig. 1. Resource productivity.

From the analysis of Figure 1 the country with the best productivity of resources (measured in euros / kilogram) in 2019, is NL (4.97) followed by LU (4.1), IT (3.56), BE (3.49) and FR (3.06). The countries where the productivity of resources fell below the value of 2010 are MT (-0.46), HU (-0.21), RO (-0.14), SE (-0.12), DK (-0.08) and LU (-0.04). It can also be seen that in 2019 there are countries where resource productivity is above the average of 1.9% this year (NL, LU, IT, BE, FR, DE, ES, IR, AT, MT, DK, and SE),

while other countries record below average values (GR, SI, SK, FI, CY, PT, HR, CZ, LV, HU, LT, PL, EE, RO, and BG).

If we analyse the individual average of each country, during the 10 years it is found that there are countries that in 2019 exceeded their average: NL (0.9 EUR / KG), BE (0.75), IT (0.37), IR (0.37), DE (0.35), but also countries that registered values below the average of the 10 years: HU (-0.13), SE (-0.08), RO (-0.04), LT (-0.01).

Figure 2 shows the evolution of the energy productivity indicator.

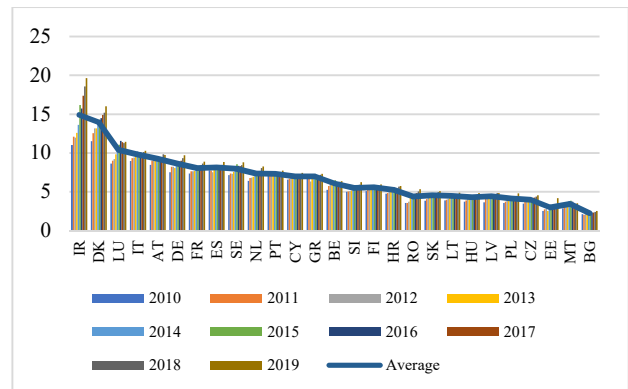


Fig. 2. Energy productivity.

From the analysis of Figure 2 the energy productivity indicator, measured in EURO / kilogram of oil equivalent (KGOE), in most countries registers increases in values from one year to another. The country with the best energy productivity in 2019 is: IR (19.64), followed by DK (16.02), LU (11.45), IT (10.27), AT (9.76) and DE (9.7). Values above the average of 2019 of 7.19 KGOE are registered by the following countries: IR, DK, LU, IT, AT, DE, FR, ES, SE, NL, PT, CY, GR and below average by the following countries: BE, SI, FI, HR, RO, SK, LT, HU, LV, PL, CZ, EE, MT, BG.

According to the individual average of each country during the 10 years, we can see that in 2019 in all countries there is an increase. The highest increase is registered by the following countries: IR (4.76), DK (2.09), EE (1.2), DE (1.08) and LU (1.06).

To see if there is any link between resource productivity and energy productivity, Figure 3 was constructed, using the data for 2019.

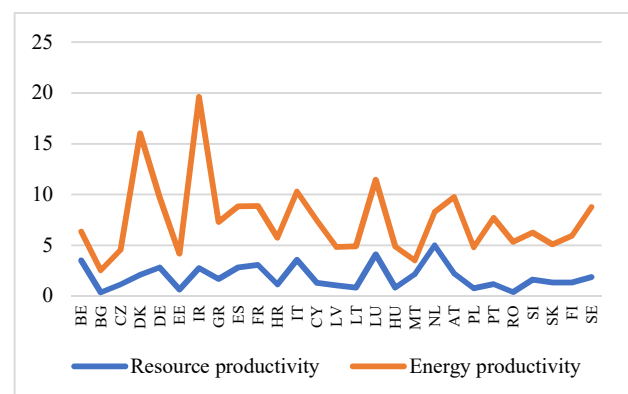


Fig. 3. Comparative situation of the evolution of productivity indicators.

From the analysis of Figure 3 the evolution trend of the resource productivity indicator is like that of energy productivity, the latter being more pronounced in certain countries such as: DK, IR, LU, IT, AT and SE. This suggests that the economic efficiency of EU Member States as measured by the two efficiency indicators is supported by the results obtained.

Figure 4 shows the evolution of the Greenhouse gas emissions per capita indicator.

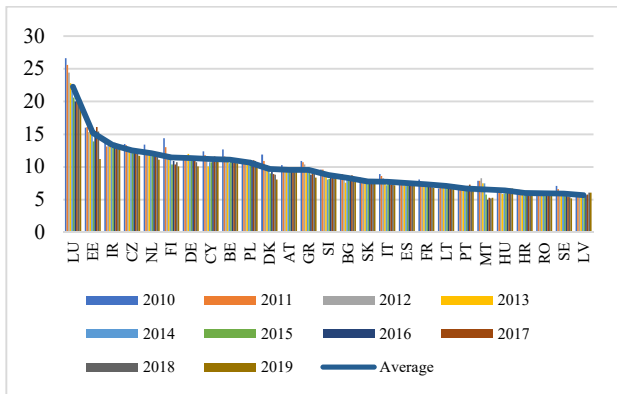


Fig. 4. Greenhouse gas emissions per capita.

From the analysis of the indicator, it can be said that the country with the highest level of this indicator is LU followed by EE, IR, and CZ. It is also observed that the trend of this indicator is decreasing, in most countries, from 2010 to 2019, except for the countries: LT (+ 1.10%), LV (+ 1.05%), and in HU and RO the percentage was maintained at the same value. The average of this indicator is 8.86% (in 2019) with the following countries: LU, IR, CZ, EE, CY, NL, BE, PL, FI, DE, AT, which have values above average and the following countries: GR, SI, BG, DK, SK, LT, IT, ES, FR, HU, PT, LV, HR, RO, MT, SE, which have below average values. We can say that in countries with above average values are located most developed countries (except for CZ and PL) while in countries with below average values are most countries with emerging economies, except for (DK, IT, ES, FR, PT, MT, SE).

Compared to its own average, recorded by each country over the 10 years, it is found that there are only three countries with above average values in 2019: LV (-0.39), HU (-0.29) and LT (-0.29). The biggest steps to reduce this indicator in the last 10 years, according to EU directives, are observed in the following countries: LU (6.3%), EE (4.8%), FI (4.3%), DK (3.8%), MT (2.6 %) and GR (2.5%).

In Table I, a ranking of EU countries was made based on the results obtained from the 4 indicators studied (according to the data in Table II, Appendix), with the data for 2019.

Table I. Ranking of EU countries.

Name of country	1	2	3	4
IR	1	8	11	22
DK	2	11	3	12
LU	3	2	1	23
IT	4	3	7	10
AT	5	9	3	15

DE	6	6	5	16
FR	7	5	5	8
ES	8	7	6	9
SE	9	12	4	1
NL	10	1	7	19
PT	11	18	8	6
CY	12	17	19	20
GR	13	13	13	14
BE	14	4	12	18
SI	15	14	9	13
FI	16	16	2	16
HR	17	19	17	4
RO	18	26	20	3
SK	19	15	18	11
CZ	20	20	10	21
LT	21	23	16	11
HU	22	22	21	7
LV	23	21	15	5
PL	24	24	23	17
EE	25	25	14	20
MT	26	10	22	2
BG	27	27	24	12

1 – Energy Productivity; 2 - Resource productivity; 3 - Eco innovation index; 4 - Greenhouse gas emissions per capita

According to Table I, we can see that the countries where the value, obtained from the indicators: energy productivity and resource productivity, is high also register high values at the Greenhouse gas emissions per capita indicator (IR, LU). We also notice that countries such as: NL, LU, IT and BE, have a high indicator of resource productivity, these being known as countries where services occupy a significant place in the economy. Noteworthy are the countries that recorded high values in the eco innovation index, such as: LU, FI, DK, AT, and SE. From the point of view of the Greenhouse gas emissions per capita indicator, we notice that the countries with the best values (the lowest emissions) are SE, MT, RO, HR, LV, PT.

IV. CONCLUSIONS

The analysis of the resource productivity indicator shows that it has increased every year in most of the countries studied. It shows us that over the years economies have become more efficient by reducing the absolute level of resources they consume, by reducing working hours or using advanced technologies. On the first three places at this indicator (in 2019) is NL (4.97) followed by LU (4.1) and IT (3.56).

The analysis of the energy productivity indicator allows us to observe the efficiency with which energy is produced and consumed. Because energy is used in any sector of activity, the problem of its efficiency is vital not only because of the danger of depletion of resources but also because of its share in all cost elements related to activities carried out in an economy. The analysis of this indicator shows that the best energy productivity in 2019 is: IR (19.64), followed by DK (16.02), LU (11.45).

The analysis of the Greenhouse gas emissions per capita indicator shows us the high or low level recorded by each country studied. From the analysis of this indicator, we notice that the highest values are registered by the countries: LU, IR and CZ and the lowest by the countries: SE, MT and RO.

The Eco innovation index analysis allows us to see which are the countries that have invested in eco-innovation, in which even if now the effects at the level of productivity are not seen, they will be advantageous in the long run. Among these countries we mention the countries with the best values: LU, FI, DK and AT.

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APPENDIX

Table II. The situation of the indicators from 2019

Name of country	1	2	3	4
IR	19,64	2,75	109	12,80
DK	16,02	2,10	150	8,10
LU	11,45	4,10	171	20,30
IT	10,27	3,56	124	7,20
AT	9,76	2,22	150	9,30
DE	9,70	2,81	133	10,10
FR	8,87	3,06	127	6,80
ES	8,85	2,80	125	7,10
SE	8,78	1,87	142	5,20
NL	8,26	4,97	124	11,10
PT	7,71	1,16	115	6,60
CY	7,44	1,30	79	11,20
GR	7,30	1,68	102	8,40
BE	6,36	3,49	107	10,60
SI	6,26	1,60	113	8,20
FI	5,95	1,32	157	10,10
HR	5,75	1,15	86	6,00
RO	5,33	0,37	71	5,90
SK	5,08	1,33	82	7,40
CZ	4,55	1,13	111	11,70
LT	4,90	0,82	88	7,40
HU	4,86	0,83	69	6,70
LV	4,84	1,04	90	6,10
PL	4,80	0,77	63	10,40
EE	4,17	0,64	97	11,20
MT	3,51	2,13	67	5,30
BG	2,52	0,36	50	8,10

1 - Energy productivity; 2 - Resource productivity; 3 - Eco innovation index; 4 - Greenhouse gas emissions per capita.