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THE INFLUENCE FEATURES OF INDIVIDUAL FACTORS ON EU COUNTRIES' ENERGY MARKETS

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The energy consumption impact is an important factor in the development of countries' economies. The European region is energy-dependent due to a significant shortage of energy carriers and an energy crisis. The energy dependence weakens the energy market and increases its vulnerability to external influences. The subject of research in the article is the characteristics, objective laws, and trends of the development of energy factors that are relative to other influence factors on the economic development of European countries. And the purpose is to analyze and assess important factors influencing the energy markets on the modern economic development of European countries. The task is to analyze the current state of traditional energy resource consumption, to determine the specifics of the impact of energy markets on macroeconomic indicators. To assess the influence degree of energy market indicators on macroeconomic development, which allows to identify the important factors for analysis and to indicate the general position of energy markets in the economy there are used following general scientific methods: systematic, logical and descriptive; analysis and synthesis; statistical; economic-mathematical modeling, namely the construction of a correlation-regression model. Based on the conducted analysis, it was established that the energy markets of the EU have a general feature of increasing dependence, and therefore their sensitivity on external factors, which is associated with a significant decrease in domestic production, as well as a weak differentiation of markets. The production of the main energy resources in Europe has a downward trend for all energy markets, which leads to the increased importance of imports. The influence of energy market factors on the macroeconomic indicators of EU countries is determined. The conducted correlation analysis confirmed the significant impact of the oil market on the GDP growth rate in the EU. The high energy dependence of the EU countries indicates the increased dependence on external factors but no direct correlation between energy dependence and economic development was found. The high dependence of the EU on the import of energy resources is a significant problem, and the energy security factor is also important for investors in the EU. Conclusions: energy factors do not have a significant impact on the development of EU GDP at the current stage, and the quality use of energy resources is more important than their consumption, which emphasizes the importance of efficient use of resources for the further development of the EU economy.

Key words: *energy markets, energy resources, macroeconomic development, EU countries, development of energy markets, gas, oil, coal.*

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Formulation of the problem. Energy supplies and their markets are an important factor in the overall macroeconomic development of countries and regions. Each energy market is not only a part of the world economic system but also a separate and unique factor in the implementation of geopolitical and geoeconomic goals and plans. Over the last decade, the economic and energy dependence of many European countries was formed on Russia that for a long time used the energy resource for economic and political influence in the EU. The energy crisis in the EU countries, artificially created by Russia in 2022 in connection with the Russian aggression against Ukraine, showed a low level of differentiation of importers with the emphasis on several indicators over qualitative ones, showed the significant sensitivity and vulnerability of the energy markets of the EU countries. However, with the achievement of a certain level of development of the economic system, energy market factors are able to change the intensity and direction of their influence. Therefore the study of the problems of the influence of energy indicators on the economy of the EU countries and the understanding of their role in the modern development trends of the European Union states is quite pressing.

The purpose of the article is to analyze the peculiarities, regularities, and trends in the development of energy factors in the EU countries, and their impact on the main macroeconomic indicators.

Analysis of recent research and publications. Among the studies and publications on this issue, it is worth noting the works of Kurt Yeager [1], who investigates the state of energy markets in different regions of the world and their impact on the economic

development of groups of countries. Peter Zweifel [2] focuses on the study of the main economic forces that influence the formation of prices for energy resources, as well as on the relationship between energy consumption and internal economic processes. M. V. Muzychenko [3], emphasizes the EU gas markets and their structural changes. O. Yu. Chygrin [4] focuses on the analysis of the features of the development of the world energy market and its structural elements, O. I. Kohut-Ferens [5] analyzes the world energy market and its impact on regional development and interaction with other markets. Quite interesting sources on this issue are the magazine “Statistical Review of World Energy” for 2023 [6] and World Bank analytics, the analytical and information site Our World in Data, and the Eurostat site.

An overview of the research material and its main results. When analyzing the state of the energy markets, we focused on the study of three main energy markets, namely the gas, oil, and coal markets. One of the most important indicators that influence the development of these markets and shape certain trends is the consumption of the relevant energy resources. World consumption is determined by the general tendency of increasing in terms of main energy resources, as indicated by the dynamics of consumption of main energy resources (Fig. 1).

It should be noted that the main global trend of oil and gas consumption for the near future is upward with significant growth dynamics. Thus, gas consumption has the largest approximation coefficient, which shows a high probability of further growth. As shown, oil has a lower probability, what can be explained as its sensitivity

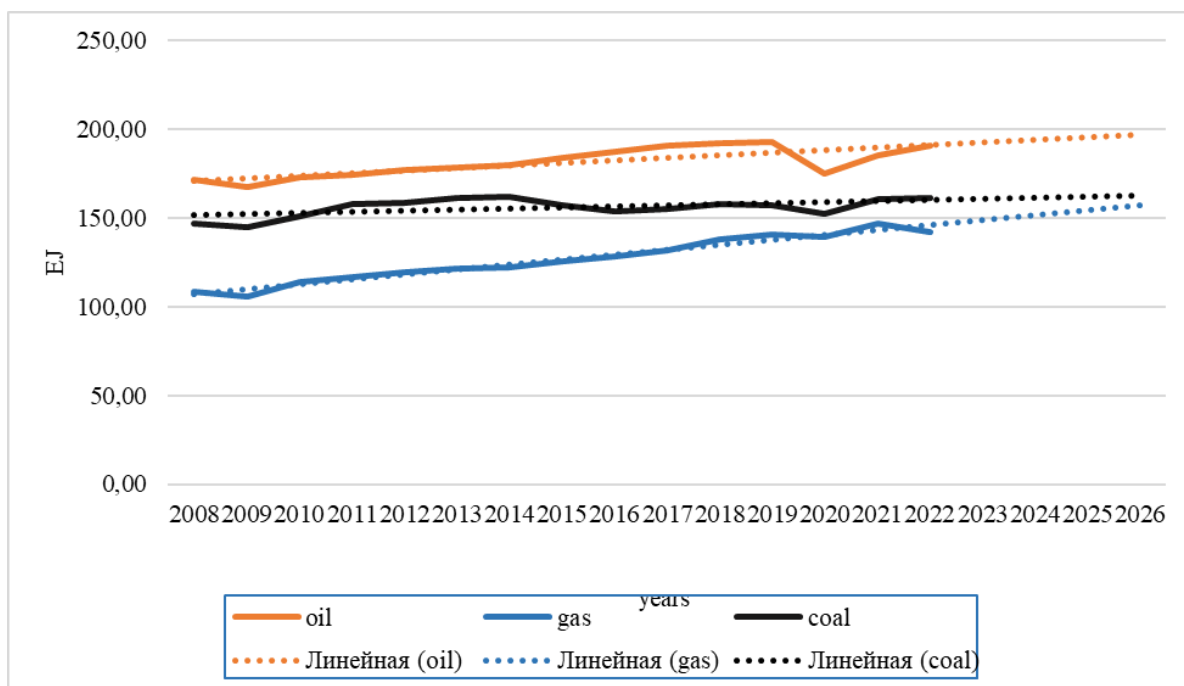


Fig. 1. Consumption of the main energy resources in the world for the period of 2008-2022, EJ
 Created by the authors based on: [8]

to global crises. Fig. 1 clearly shows that its consumption is steadily increasing with minor fluctuations. Regarding coal, it is worth noting that this energy resource shows the lowest growth dynamics, which can be associated with its lowest energy efficiency among the others. The actual increase in consumption compared to 2008 was 15 EJ, with a corridor between 144 EJ and 161 EJ. Such a narrow corridor shows the weak interest of the world in increasing the consumption of coal relative to other energy resources.

Trends in the consumption of gas, oil, and coal in the EU countries differ from the global trends, so the general dynamics indicate a gradual decrease in the consumption of these energy resources, which is shown in Fig. 2.

In the European Union, there is a clear tendency to decrease the consumption of the main energy resources, except oil, as the level of approximation indicates significant fluctuations in consumption and the sensitivity of the European oil market to external and internal factors. This was a consequence of the adoption by the European Union of the "Energy Strategy 2020", which defined the priorities of EU policy for the period from 2010 to 2020, and aimed to:

- reduction of greenhouse gas emissions by at least 20%;
- increasing the share of renewable energy in the EU consumption portfolio to at least 20%;
- increase in energy efficiency by at least 20%.

A comparison of the main trends in the consumption of primary energy resources in the world and the EU demonstrates that the economic potential of the EU countries allows them to consistently reduce the consumption of primary energy resources, in contrast to world trends, where the role of the consumption of developing countries and resource states remains significant.

The decrease in the consumption of primary energy resources in the EU is related to the overall energy efficiency of various sectors of the economy. Thus, according to the study of energy consumption in the agricultural sector [10], the total consumption was reduced, although the authors noted different reasons for such changes in different countries, and they also emphasize that consumption in the agricultural sector remains significant, especially the dependence on oil products. Regarding the manufacturing sector, according to Eurostat, a significant decrease in consumption began in 2005 and continued until 2015 (for different energy sources, the years may differ in the context of several years), but since 2015, no significant changes in the consumption of the manufacturing sector are noticeable [11].

Summarizing such trends, it is worth noting that they are objectively related to the growing level of energy efficiency of various enterprises and industries. Energy efficiency, in turn, is an indicator of highly developed countries, therefore the main difference in trends in the

consumption of major energy resources in the world [12] and the EU is based on the level of development of individual countries and their economic sectors.

Analyzing the main features of the oil, gas, and coal markets in the EU countries, it is noted that the gas market was characterized by a steady decrease in domestic gas production, and therefore the formation of a deficit domestic market, which created dependence on imports, which, according to Eurostat [13], had no significant differentiation over the past 10 years. The main gas importers were Norway, Russia, and Algeria. Among these countries, Algeria consistently ranked third with a volume of 15–20% of all gas imports. Russia consistently accounted for a third of all gas imports to the EU, while Norway ranked first in import volumes, close to 40% each year. However, this situation changed drastically in 2022 due to Russian aggression against Ukraine and Russia's attempt to create a gas crisis in the EU by sharply limiting the supply of Russian gas to European countries. After that EU countries began to more actively use and expand the network of liquefied natural gas (LNG) terminals, through which they began to massively purchase gas from the USA, Kuwait, and other countries.

The oil market in the EU countries is also characterized by a significant level of internal deficit due to the insignificant level of production [14], which is covered by imports from third countries. An important difference between the oil market and the gas market is its greater diversification in the imports geography; however Russia was the main importer with a share of 30-25%, which has been unchanged since 2008, while second-best in terms of import in different years were Norway, Libya, and Kazakhstan. At the same time, it should be noted that these countries practically did not change their share and shared the second and third places for a long time. However, in recent years, the USA has gained a significant share of this market and its influence is gradually expanding. It is worth to note that the share of the three largest oil importers to the EU was 45-50% [15], which formed a significant level of dependence on them with corresponding risks. Since the beginning of Russia's full-scale aggression against Ukraine, the geography of the oil market in the EU has begun to change significantly. The main change can be considered as the loss of the Russian Federation position as the main supplier of oil to the EU and the replacement of its share by other players. However, the share of the largest importers for 2022, although decreased, continued to be around 40%. At the same time, the share of small importers increased significantly due to their quantitative expansion, which can be considered a positive variable from the point of view of energy security [16].

The EU coal and solid fuel markets are characterized by a significant surplus. The reasons for this phenomenon were mentioned above. In 2008, the

largest importer of coal in the EU was Australia with a share of 24.1%, however, by 2020, the largest importer was Russia with a share of over 40%, and the combined share of the top 3 importers reached over 80%.

The factors listed above testify to the high level of EU risks in the energy field as a result of the insufficient differentiation of suppliers of energy resources. In this regard, it is advisable to consider the level of energy dependence of the EU and individual European countries (Fig. 3).

The level of energy dependence is not a metric that directly affects the macroeconomic development of countries, since the calculation methodology does not include any direct monetary metrics and is calculated as follows: $(\text{import} - \text{export}) / \text{gross available energy volume}$. If we compare the indicator of energy dependence with the level of GDP of the countries represented, we will not see the regularity under which the logic works: the lower the energy dependence, the higher the GDP per capita. So, for example, Germany has

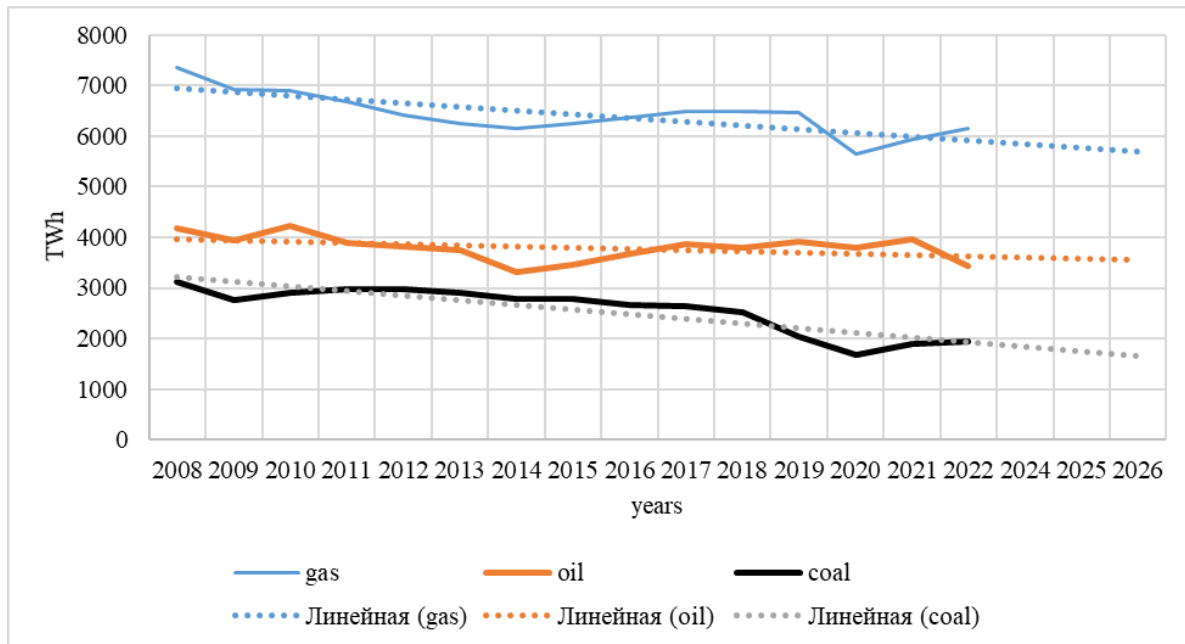


Fig.2. Consumption of the main energy resources in the EU for the period 2008-2022, TWh
 Created by the authors based on: [9]

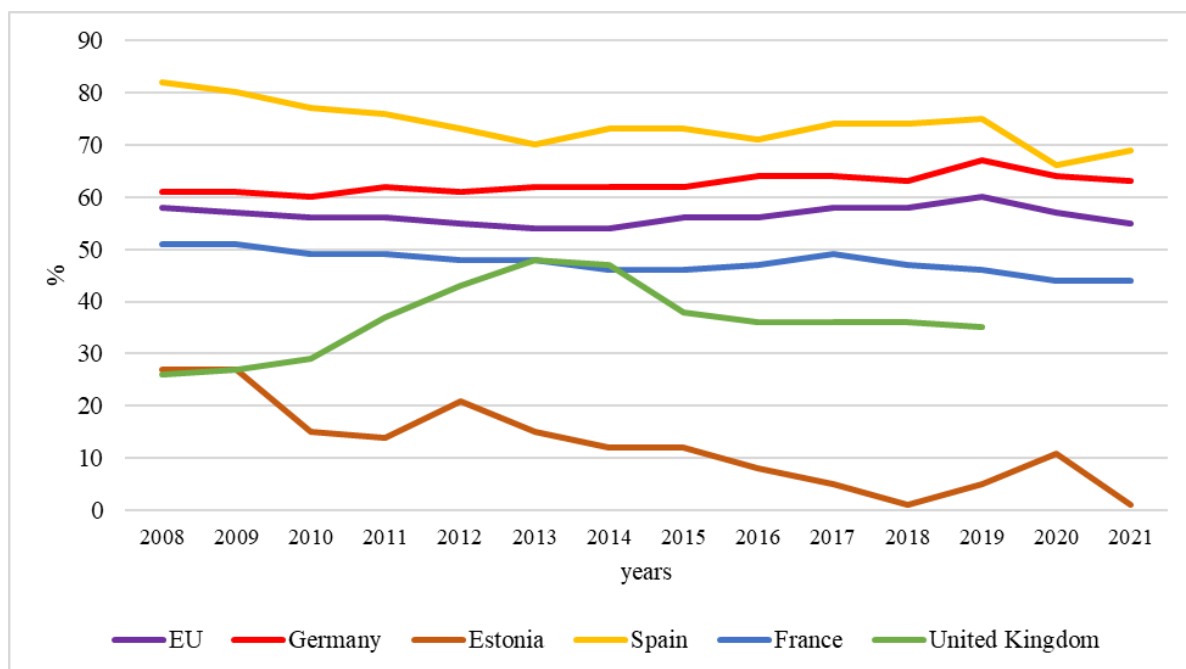


Fig. 3. The level of energy dependence in the EU countries for the period 2008-2021, %
 Created by the authors based on: [17]

high energy dependence, and the largest GDP per capita among European countries for 2021 (\$51,203) [18], while Spain has an even higher level of dependence, but is significantly inferior to Germany in terms of GDP, in 2021, Spain's GDP was \$30,103 per capita [18].

In addition, we can see that most EU countries have a high energy dependency, with an average value exceeding 50%, and for Germany and Spain, this value is greater than 60%. However, we do not see the impact of energy dependence on the macroeconomic development of the direction, noting that a high level of dependence is an objective risk for the energy security of the country, which carries significant risks for the economic system.

Thus, speaking about the state of the energy markets and regular energy indicators influence, we can state that the dynamics of the EU energy markets indicate a tendency towards a gradual decrease in consumption and the importance of quantitative market factors, with the exception of the oil market, which has a large number of fluctuating factors and with the exception of crisis factors periods has a relatively stable line of development. Europe's primary energy production tends to decline in all energy markets, creating a situation where imports become more important.

Considering the possible level of the energy factors influence on macroeconomic development, it is necessary to consider the possible correlation between indicators of economic growth (both qualitative and quantitative)

and energy factors. To do this, we conducted a correlation analysis, the data are presented in Table 1.

We have selected some multi-directional quantitative and qualitative indicators with the key indicator in the form of GDP per capita, since not all indicators are as of 2022 and 2023, the correlation analysis is carried out until 2021.

According to the data in Table 1, calculations were made according to formulas 1 and 2 to find the deviation using the Microsoft Excel calculation program.

$$r = \frac{\frac{1}{n} \cdot \sum |X - \bar{X}| \cdot |Y - \bar{Y}|}{\sigma_X \cdot \sigma_Y}, \quad (1)$$

де $|X - \bar{X}| \cdot |Y - \bar{Y}|$ – сум центральних відхилень;

n – кількість спостережень;

σ_X і σ_Y – середні квадратичні відхилення X і Y обчислені за формулою 2:

$$\sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{n}}, \quad (2)$$

де σ – знак середнього квадратичного відхилення.

Using Microsoft Excel, the following formula 3 is used to calculate this amount of data:

$$f(x) = \text{correl}(\text{massive1}; \text{massive2}) \quad (3)$$

Table 1

Quantitative and qualitative indicators of impact on EU's GDP

Year	GDP, tn dols.	Oil cons, k TWh	Gas cons, k TWh	Coal cons, k TWh	Tech develop., number of patents, k	Energy prod., euros per kg of oil equivalent	The import of energy resources (all types of mineral fuel, petroleum products and their distillation products, B dols)	Provision of qualifications. spec., % of population with higher education	Human Development Index (HDI)	Brand oil price, 2010 index = 1
	1	2	3	4	5	6	7	8	9	10
2008	16,3	7,4	4,2	3,12	62,72	6,83	211	20,1	0,856	3,97
2009	14,8	6,9	3,9	2,77	62,165	6,96	131	20,9	0,856	2,52
2010	14,6	6,8	4,2	2,90	63,953	6,84	149	21,6	0,86	3,25
2011	15,8	6,70	3,9	2,98	65,487	7,17	203	22,4	0,864	4,55
2012	14,6	6,40	3,8	2,97	64,321	7,22	214	23,2	0,865	4,56
2013	15,3	6,20	3,7	2,91	63,796	7,30	213	24	0,871	4,44
2014	15,6	6,10	3,3	2,78	63,926	7,68	196	24,5	0,874	4,04
2015	13,5	6,20	3,5	2,77	63,474	7,75	129	25,2	0,878	2,14
2016	13,9	6,30	3,7	2,66	63,378	7,83	107	25,7	0,881	1,78
2017	14,8	6,50	3,8	2,57	64,098	7,89	131	26,4	0,884	2,21
2018	16	6,50	3,8	2,51	63,69	8,09	159	27,1	0,887	2,91
2019	15,7	6,40	3,9	2,02	62,281	8,37	143	27,9	0,894	2,62
2020	15,4	5,60	3,8	1,66	62,2267	8,59	101	28,9	0,895	1,71
2021	17,2	5,90	4,0	1,87	62,1724	8,54	193	29,7	0,89	2,90

Created by the authors based on the materials: [8, 13, 19-23]

Table 2

The results of correlation analysis

	1	2	3	4	5	6	7	8	9	10
1										
2	0,00622									
3	0,359428	0,5581216								
4	-0,34353	0,6900712	-0,00067							
5	-0,24377	0,1661419	-0,21118	0,622698						
6	0,258502	-0,775054	-0,28816	-0,90442	-0,41728					
7	0,509915	0,2610689	0,100111	0,466997	0,38157	-0,40835				
8	0,242329	-0,80459	-0,26815	-0,87925	-0,3454	0,984749	-0,36322			
9	0,177276	-0,748347	-0,29133	-0,85746	-0,33886	0,980674	-0,44172	0,978592		
10	0,325974	0,3272999	0,068474	0,604512	0,554054	-0,57234	0,940602	-0,52884	-0,57773	

Compiled by the authors based on the results of correlation analysis

The results of correlation analysis calculations are presented in Table 2.

The main correlation pairs that have a strong and very strong relationship are: 7-1; 3-2; 4-2; 6-2; 8-2; 5-4; 6-4; 8-4; 9-4; 10-4; 10-5; 8-6; 9-6; 10-7; 9-8. Analyzing the relations, we can state that GDP has a significant correlation with only one factor, factor 2 (oil consumption) has 4 pairs, factor 4 (coal consumption) has 6 pairs, factor 6 (level of energy efficiency of the economy) has 4 pairs, 8 factor (skilled specialists) has 4 pairs, other factors have 3 or fewer pairs. It should also be noted here that the level of coal consumption, although it has a high parity, but this parity is reversed. A superficial analysis of the results allows us to conclude that oil consumption is the most important among consumption, as it has the most positive strong pairs among all other consumption factors (coal and gas). The GDP level has a medium and weak correlation to all the indicated indicators, except for the 7-1 relationship, which has a value of 0.51, which is insignificant in absolute terms, but we note that among the quantitative energy values, the value of the energy import level is the largest relative to the level of the country's GDP, but insufficient to establish dependence. In addition, highlighting the strongest correlation among other energy factors, we note that among the level of consumption, the level of gas consumption has the greatest impact on GDP with a level of 0.36, followed by an inverse correlation with coal consumption at the level of -0.34, the inverse of this result indicates the ineffectiveness of coal consumption for the development of the European economy. Oil consumption has the lowest correlation of all other markets, which requires a detailed study. Thus, when examining the influence of consumption level on other factors, we can see that metrics 2, 3, and 4 have significant correlations with metrics 6, 8, 5, 9, and 10.

So, in turn, indicator 2 has the strongest correlation with metrics number 3 and 4 (gas and coal

Table 3

Color legend to the table 2

	Positive	Negative
Very strong		
Strong		
Mid		
Weak		

Compiled by the authors

consumption), which is direct interdependence and mutual substitution, as well as a very strong inverse correlation with metric 6 (level of energy efficiency of the economy). The same situation with coal consumption, which tells us about the weak efficiency of the level of consumption of these energy resources and their impact on productivity, at the same time, gas consumption also has a negative value, but with an average strength. Evaluating the overall impact of gas and coal consumption on other metrics, we can note that for most correlations they have an inverse value, indicating their low efficiency, while oil consumption has more direct correlations, but most of them have medium and smaller power of influence, which also indicates the weak position of these metrics for macroeconomic development. Another important correlation, in our view, is the correlation between indicator 8 and indicator 6 (provision of qualified specialists and energy efficiency), as it shows the importance of the economy of quality mechanisms of influence. Also, metric 6 (level of energy efficiency of the economy) has the same very strong correlation with metric 9 (Human Development Index), which is also a qualitative and complex indicator with a very strong level of influence. So, we can state that all indicators have a moderate impact on the general macroeconomic metric of GDP per capita, and quantitative energy indicators have a lower degree

of influence than qualitative energy indicators and indicators of economic direction.

The similar state of economic metrics and their interaction indicates that it is more appropriate to focus on qualitative and deep-influencing factors of the given sector, such as the level of energy security, the level of energy poverty, the differentiation of energy suppliers, the state and modernization of energy infrastructure, and others, rather than on quantitative indicators.

Conclusions. Having analyzed the peculiarities of the influence of the studied factors on the energy markets of the EU countries, we can draw the following conclusions. The energy factors, which in this study are given as the main trends of the energy markets of classical energy resources and the main quantitative and qualitative metrics of these markets, showed that at this stage of the economic development of the EU countries, the quantitative energy factors have little influence on macroeconomic development, and the main trends of energy gas, oil, and coal markets correspond to this conclusion due to the tendency to decrease their consumption volumes by the EU

economies. In addition, the correlation analysis shows that the quantitative energy factors of classical energy markets have a negative correlation with the level of GDP and an insignificant effect on other macroeconomic indicators of development, which indicates their secondary nature at the current stage of development and the inefficient level of consumption of these energy resources, which is excessive. Qualitative energy factors, such as the level of energy dependence, also show an insignificant direct impact on macroeconomic development, while at the same time, they have a significant impact on the level of energy security, which in turn can create the risk of a crisis. Among quantitative energy factors, the degree of import of energy resources is a significant factor affecting the GDP of EU countries, according to the correlation analysis of economic and energy parameters. This highlights the problem of significant dependence of the EU economy on the import of energy resources since energy dependence itself does not correlate with different EU economies due to the lack of a unified influence.

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ОСОБЛИВОСТІ ВПЛИВУ ОКРЕМИХ ФАКТОРІВ НА ЕНЕРГЕТИЧНІ РИНКИ КРАЇН ЄС

Вплив споживання енергоресурсів є вагомим фактором для розвитку економік країн. Європейський регіон є енергетично залежним через значний дефіцит енергоносіїв та енергетичну кризу. Енергозалежність послаблює енергетичний ринок та підвищує його вразливість до зовнішніх впливів. Предметом дослідження в статті є особливості, закономірності та тенденції розвитку енергетичних факторів відносно інших факторів впливу на економічний розвиток країн Європи. Метою є аналіз та оцінка вагомих факторів впливу енергетичних ринків на сучасний економічний розвиток європейських країн. Завдання: проаналізувати сучасний стан споживання традиційних енергетичних ресурсів, визначити особливості впливу енергетичних ринків на макроекономічні показники. Використовуються загальнонаукові методи: системно-логічний та описовий; аналізу та синтезу; статистичний; економічно-математичного моделювання, а саме побудова кореляційно-регресивної моделі – для оцінки ступеню впливу показників енергетичних ринків на макроекономічний розвиток, що дозволяє виділити важливі фактори для аналізу та зазначити загальну позицію енергетичних ринків в економіці. На основі проведеного аналізу встановлено, що енергетичні ринки ЄС мають загальну особливість до збільшення залежності, а отже чуттєвості від зовнішніх факторів, що пов'язано із значною динамікою зниження власного видобування, а також слабкою диференціацією ринків. Видобуток основних енергоресурсів в Європі має спадну тенденцію для всіх енергетичних ринків, що призводить до підвищеної важливості імпорту. Визначено ступінь впливу факторів енергетичних ринків на макроекономічні показники країн ЄС. Проведений кореляційний аналіз підтвердив значний вплив ринку нафти на показник ринку ВВП в ЄС. Висока енергетична залежність країн ЄС вказує на підвищену залежність від зовнішніх чинників, але не виявлено прямої залежності між енергозалежністю та економічним розвитком. Висока залежність ЄС від імпорту енергетичних ресурсів є суттєвою проблемою, також фактор енергобезпеки є вагомим для інвесторів в ЄС. Висновки: енергетичні факто-

ри не мають привалюючого впливу на розвиток ВВП ЄС на поточному етапі, а якісне використання енергоресурсів виявляється важливішим за їхню кількість споживання, що підкреслює важливість ефективного використання ресурсів для подальшого розвитку економіки ЄС.

Ключові слова: *ринки енергоресурсів, енергоресурси, макроекономічний розвиток, країни ЄС, розвиток енергетичних ринків, газ, нафта, вугілля.*

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