INNOVATIONS IN ENERGY EFFICIENCY MANAGEMENT: ROLE OF PUBLIC GOVERNANCE

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Abstract: *The article summarizes the arguments and counter-arguments within the scientific debate on the influence of state administration on innovations in energy efficiency management of the national economy. The main goal of the conducted research is to form and prove a hypothesis regarding the effectiveness of the methodological toolkit for assessing the impact of the level of government efficiency on the divergent energy efficiency subindex of the national economy. The systematization of literary sources and approaches to solving the problem of the role of state administration in the context of the formation of innovations in energy efficiency management proved that active discussions are currently underway on this topic. The urgency of solving this scientific problem is to develop an effective mechanism for finding additional determinants of influence on the level of energy efficiency for the further possibility of harmonizing domestic and European energy policies. The study of the role of state management of the innovative component of energy efficiency development in the article is carried out in the following logical sequence: at the first stage, the initial data array was formed, which was checked for multicollinearity (Pearson's correlation coefficient) and normality of distribution (graphic quantile method of comparing two probability distributions) using statistical analysis tools at the second and third stages; at the fourth stage, a quantile regression OLS model was built, which allows taking into account the heterogeneity of the studied factors. Methods of bibliometric and comparative analysis, correlational and quantile methods became the methodological tools of the conducted research, the years from 2000 to 2020 were chosen as the research period. Ukraine and the EU countries (27) were chosen as the object of the study, because they allow us to compare the level of energy efficiency of countries and their positions in the world ranking of the quality of public administration. The article presents the results of an empirical analysis and found that for Ukraine, the diffusion of green innovations leads to a slight increase in the level of energy efficiency of the national economy by 0.7%, while for the countries of the European Union – by an average of 3%. The experience of the countries of the European Union shows that the multiplier effect in increasing the energy efficiency of the national economy is provided by the growth of green innovations and the activation of the green investment market. Increasing the efficiency of public administration to the level of reference countries will allow to increase the divergent energy efficiency sub-index for Ukraine by 16.1% for the rule of law, 18.9% for the government's ability to openly implement policies and regulatory measures, and 10.7% for corruption control. The results of the conducted research may be useful for further research in the field of energy efficiency of the national economy.*
Keywords: innovations, energy efficiency, public governance, energy conservation, energy governance, process innovation, national economy, carbon-free economy.
JEL Classification: O31; Q40; Q48

Introduction. The full-scale invasion of the Russian Federation on the territory of Ukraine and its intentions to destroy the energy infrastructure dictate the relevance of research on the chosen topic. Today, Ukraine and EU countries are aware of the need to strengthen the energy front both through technological and innovative management solutions. This is demonstrated by the refusal of European countries from the energy resources of the terrorist country, emphasis on increasing the share of alternative/renewable energy sources and increasing the level of energy efficiency and energy saving of the national economy.

At the same time, discussions on the issues of reducing the carbon load on the environment, working to achieve the goals of sustainable development and environmental stability of the world remain relevant. But today, amid the recent COVID-19 pandemic, military conflicts, and the war in Ukraine, the world is experiencing one of its biggest economic, energy, and social crises. At this time, the scientific community faces questions that require detailed research, in particular, the search for additional determinants of the impact on the level of energy efficiency and independence of countries, for the stabilization of the ecological state and energy security.

Literature Review. For the purpose of a bibliometric analysis, the publications of the scientometric databases Scopus, Web of Science and Google Scholar were selected for the search terms "energy efficiency", "innovations" and "public governance". Thus, more than 100 scientific publications were processed according to this filter. It should be noted that the first publications on this topic date back to 1986, and are focused on the analysis of the prospects of the processing industry as an innovative tool for increasing the level of energy efficiency of the national economy. Authors from China (36 publications), USA (21 publications) and Great Britain (10 publications) publish the most on this topic. Let's note the TOP-5 publications with more than 100 citations (table 1).

Table 1. TOP-5 most cited publications by the keywords "energy efficiency", "innovations" and "public governance" in the scientometric database Scopus

Title of the article	The authors	Journal	Year of publication	Number of citations	FWCI
Institutional quality, green innovation and energy efficiency	Sun H., Edziah B.K., Sun C., Kporsu A.K.	Energy Policy	2019	272	16,14
Dynamic relationship among environmental regulation, technological innovation and energy efficiency based on large scale provincial panel data in China	Pan X., Ai B., Li C., Pan X., Yan Y.	Technological Forecasting and Social Change	2019	192	21,2
Energy efficiency: The role of technological innovation and knowledge spillover	Sun H., Edziah B.K., Kporsu A.K., Sarkodie S.A., Taghizadeh-Hesary F.	Technological Forecasting and Social Change	2021	170	33,76
Do regulations encourage innovation? - The case of energy efficiency in housing	Gann D.M., Wang Y., Hawkins R.	Building Research and Information	1998	146	2,75
Impact of technological innovation on energy efficiency in industry 4.0 era: Moderation of shadow economy in sustainable development	Chen M., Sinha A., Hu K., Shah M.I.	Technological Forecasting and Social Change	2021	100	18,73

Note: *FWCI – Field-Weighted Citation Impact*

It should be noted that the largest number of publications on this topic falls on the period of 2020-2022, while the articles of 2019 and 2021 have the highest citation rates. This indicates the high interest of the scientific community in the impact of innovative state regulation on the level of energy efficiency of the national economy. The authors (Sun et al., 2019) consider the need to work on increasing the level of energy efficiency of the country at the expense of innovative solutions, while according to scientists, such innovative measures should be financed and to be implemented by state authorities. The research (Pan et al., 2017) built on DAG analysis confirms the existence of three behavioral pathways among environmental regulation, technological innovation, and energy efficiency. The main conclusions of the authors are that in order to achieve high levels of energy efficiency, a clear algorithm for the implementation of innovative solutions and control and financing of state authorities is necessary. Sun et al. (2021) shows the results of research on the effectiveness of implementing innovative solutions at the country level. In doing so, the authors conclude that their research findings have policy implications for sustainable energy management and environmental sustainability, emphasizing the need to develop domestic research and development capacity that augments

innovation-based infrastructure. Gann et al. (1998) suggest reviewing the regulatory documents on the construction of residential buildings for further individual design to increase the level of energy efficiency in the country. Chen et al. (2021) which closes the list of the top-5 most cited publications on the studied subject, it is proved that technological innovations and structural transformation of the economy have a positive effect on energy efficiency, while the growth of the shadow economy negatively affects energy efficiency. Also, it is appropriate to pay attention to the work that examines the impact of clustering as a tool for improving the energy efficiency and security of the country (Tvaronavičienė, 2017), and the possibilities and feasibility of promoting energy-efficient innovations with the help of marketing, management, and legal support tools (Panchenko et al., 2020).

There are many discussions about the positive impact of green investments on the level of energy efficiency of the national economy (Vanickova, 2020), and they also analyze the prospects and challenges in the process of transforming the economy into a green and carbon-neutral. The issue of energy efficiency gaps (Pavlyk, 2020) and the formation of methods to combat this phenomenon are being actively investigated by domestic and foreign scientists. Also the search and analysis of possible determinants of influence on the level of energy efficiency, in particular: institutional determinants (Pavlyk, 2020), innovative determinants and environmental determinants (Sotnyk et al., 2018; Dkhili and Dhiab, 2019).

Methodology and research methods (for research and theoretical papers). On the one hand, inefficient state governance provokes a slowdown in the transformation processes of the transition to a carbon-neutral model of the development of the national economy (where the growth of energy efficiency is a key target), on the other hand, increasing the efficiency of state governance contributes to the growth of the country's economic development, its openness and involvement in global globalization processes, which is a catalyst for the diffusion of green innovations and investments in the energy sector of the national economy.

In order to test this hypothesis, the work proposes a methodical toolkit for assessing the influence of the level of government efficiency on the divergent energy efficiency subindex of the national economy. Therefore, to study the influence of institutional and investment-innovative determinants on the level of energy efficiency and the calculated divergent sub-index of energy efficiency of the national economy (Ziabina, 2021), the input array of statistical data of the study was formed:

$$k^d = f(EP, GI, RUL, REQ, CC), \qquad (1)$$

where k^d – divergent subindex of energy efficiency of the national economy; RUL – rule of law; REQ – the government's ability to openly implement policies and regulatory measures; CC – control of corruption; GI –green investments in the energy sector of the national economy; EP – the number of patents for green technologies.

At the second stage, with the help of correlation analysis (Pearson correlation coefficient), the power of influence and dependence of institutional and investment-innovative determinants on the level of energy efficiency of the national economy in the context of the divergent subindex of energy efficiency of the national economy was revealed.

The third stage of the study was the multicollinearity check of institutional and investment-innovative determinants for the divergent energy efficiency subindex of the national economy and the check of indicators for normality of distribution using the Q-Q plot model (graphic quantile method of comparing two probability distributions) which made it possible to reveal the future model for assessing the influence of institutional and investment-innovative determinants on the divergent subindex of energy efficiency of the national economy.

The fourth stage of the study of the influence of institutional and investment-innovative determinants on the divergent energy efficiency subindex of the national economy is the construction of a full quantile OLS model.

$$Q_{k^d_{i,t}}(\tau) = \alpha_{1,\tau} EP_{i,t-1} + \alpha_{2,\tau} GI_{i,t} + \alpha_{3,\tau} RUL_{i,t} + \alpha_{4,\tau} REQ_{i,t} + \alpha_{5,\tau} CC_{i,t} + \mu_t, \qquad (2)$$

where i – the number of studied countries; τ – order quantile; $\alpha_{1,..,5}$ – evaluation parameters; μ_t – the standard error.

Indicators of the rule of law, the government's ability to openly implement policies and regulatory measures, and corruption control were chosen as parameters of the effectiveness of state regulation, as their

impact on increasing the divergent sub-index of energy efficiency for Ukraine is the most statistically significant.

Results. The analysis of scientific publications and the results of previous studies (Ziabina, 2021) made it possible to reveal the power of the influence of institutional and investment-innovative determinants on the level of energy efficiency of the country as a whole and, accordingly, on the divergent subindex of energy efficiency of the national economy (Ziabina, 2021). Thus, it is necessary to conduct an analysis of the development of the main determinants of increasing the level of energy efficiency of the national economy and to formulate the main possible tools for ensuring the established conditions for the transition to a carbon-neutral model of the national economy. In order to further analyze the influence of public administration on the level of energy efficiency, we analyzed the components of Worldwide Governance Indicators for the last twenty years.
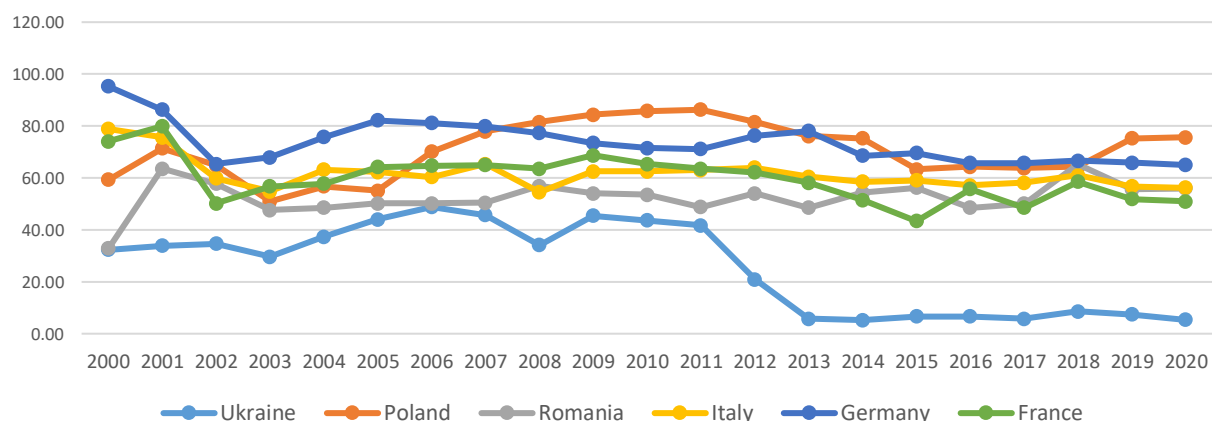

Figure 1. The level of political stability and the probability of unconstitutional political destabilization in Ukraine and the countries of the European Union, 2000–2020.

Sources: systematised by the authors on the basis of   (WGI, 2022; European Statistical Office, 2022; National Institute for Strategic Studies, 2022; NationMaster, 2022)

The identification of significant disparities in the socio-ecological and economic development of the national economy necessitates a comparative analysis of the level of political stability and the probability of unconstitutional political destabilization in Ukraine and the countries of the European Union, the graphic interpretation of which is shown in Figure 1 Taking into account the existing socio-ecological-economic and political trends, it can be concluded that Ukraine has been a politically unstable state for the past ten years with a high probability of unconstitutional political destabilization, which is a rather negative indicator compared to other EU member states. This, accordingly, characterizes the presence of the last two large-scale revolutions, the temporary loss of territories (Donetsk, Luhansk Oblasts and the Autonomous Republic of Crimea), the decline of the country's investment potential, and today's war on the territory of the country is unlikely to have a positive effect on this indicator. One of the key indicators of a country's ability to function effectively is the level of government efficiency (Figure 2).
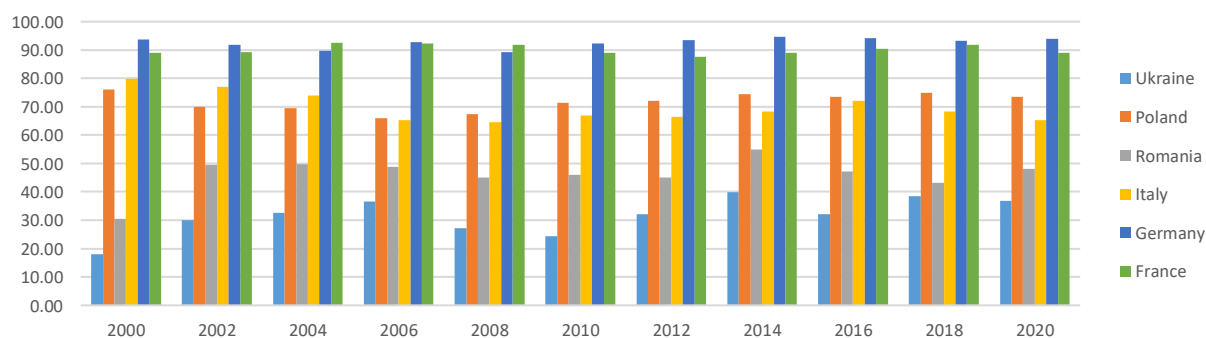

Figure 2. The level of government efficiency in Ukraine and the countries of the European Union, 2000–2020.

Sources: systematised by the authors on the basis of (WGI, 2022; European Statistical Office, 2022; National Institute for Strategic Studies, 2022; NationMaster, 2022)

According to the graph, we can conclude that the level of government efficiency has increased over the past twenty years, but still remains one of the lowest among the countries of the European Union.

According to calculations regarding the study of the influence of the effectiveness of state governance on the divergent subindex of the energy efficiency of the national economy (Ziabina, 2021) – the level of government efficiency, as well as political stability and the probability of unconstitutional political destabilization has a moderate impact on the level of the divergent energy efficiency subindex of the national economy, which makes it necessary to consider the relevant determinants as integral components of the formation of tools for increasing the energy efficiency of the national economy during the transition to a carbon-neutral model of its development.

Table 2. Dynamics of the level of rule of law and control of corruption in Ukraine and the countries of the European Union

Year	Level of rule of law					Control of corruption				
	Germany	France	Poland	Romania	Ukraine	Germany	France	Poland	Romania	Ukraine
2002	1,66	1,45	0,63	0,05	-0,76	1,76	1,44	0,45	-0,26	-1,04
2004	1,63	1,52	0,68	0,05	-0,81	1,78	1,47	0,50	-0,23	-1,03
2006	1,62	1,45	0,77	0,06	-0,82	1,74	1,53	0,56	-0,21	-1,05
2008	1,66	1,45	0,78	0,04	-0,78	1,83	1,46	0,66	-0,26	-1,08
2010	1,65	1,43	0,82	0,13	-0,80	1,81	1,33	0,60	-0,19	-1,13
2012	1,86	1,47	0,84	0,17	-0,79	1,84	1,31	0,64	-0,11	-0,99
2014	1,79	1,41	0,80	0,16	-0,81	1,84	1,31	0,67	-0,02	-0,98
2016	1,62	1,41	0,64	0,36	-0,77	1,84	1,40	0,74	-0,02	-0,81
2018	1,61	1,44	0,47	0,39	-0,71	1,84	1,26	0,72	-0,03	-0,78
2020	1,63	1,44	0,43	0,33	-0,72	1,95	1,32	0,64	-0,12	-0,87

Sources: systematised by the authors on the basis of (WGI, 2022; European Statistical Office, 2022; National Institute for Strategic Studies, 2022; NationMaster, 2022)

The level of the rule of law in the process of calculations regarding the impact on the sub-index of the divergent component of energy efficiency of the national economy turned out to be one of the most influential. According to the data, we conclude that there is a possibility of increasing the sub-index of the divergent component of energy efficiency of the national economy by almost 16% due to raising the level of the rule of law to the level of France. After conducting analytical calculations, we can conclude that the state will make maximum efforts to reform or even revive the powerful institution of law for its further effective functioning and ensuring the growth of the energy efficiency of the national economy of Ukraine.

Taking into account the possible increase in the level of the divergent sub-index of energy efficiency (Ziabina, 2021), almost 10.7% is due to the increase in the level of corruption control in Ukraine to the indicators of France. At the same time, it is necessary to note the ineffectiveness of state policy in the field of corruption control throughout all the years of Ukraine's independence. The calculations of the correlative influence of institutional determinants on the level of the divergent component of energy efficiency of the national economy made it possible to reveal a high strength of connection (0.783), which determines the need to improve the relevant determinant for further increasing the level of energy efficiency of the national economy. Accordingly, by raising the level of the government's ability to openly implement policy and regulatory measures to the level of, for example, France, there are prospects for increasing the energy efficiency of the national economy by 18.9%. Of course, such forecasts are theoretical, and Ukraine will need decades to improve its institutional determinants and raise them to the level of Poland, Germany, or France, but the transition to updated standards and the development of the management system in a promising direction will allow Ukraine to form new political, economic, environmental and investment goals.

In particular, it is necessary to note two components of investment and innovation determinants of increasing the level of energy efficiency of the national economy - patents for ecological technologies and green investments. In the paper (Costa-Campi et al., 2015), the authors examine the ability of companies to innovate and improve their energy performance to contribute to mitigation goals climate change. The study confirms the increased interest among representatives of the private sector in the development of green innovative projects to improve the state of the natural environment. In the past studies (Chygrin and Pimonenko, 2011; Chygrin and Shcherbak, 2011) state priorities for the development of environmentally friendly production are discussed in detail, the three-stage model of implementation of ecologically clean production in the system of the national economy is proposed, as well as a detailed analysis of the structural and logical scheme of the stages of the production process, which will ensure the effective implementation of

ecologically clean production and the structured main benefits and advantages, first of all, for production in the process of introducing ecologically clean technologies and work mechanisms. For a comparative analysis of the development of patents for environmental technologies in Ukraine and the member states of the European Union, a graph was drawn (Figure 3), reflecting the development trends of this determinant.
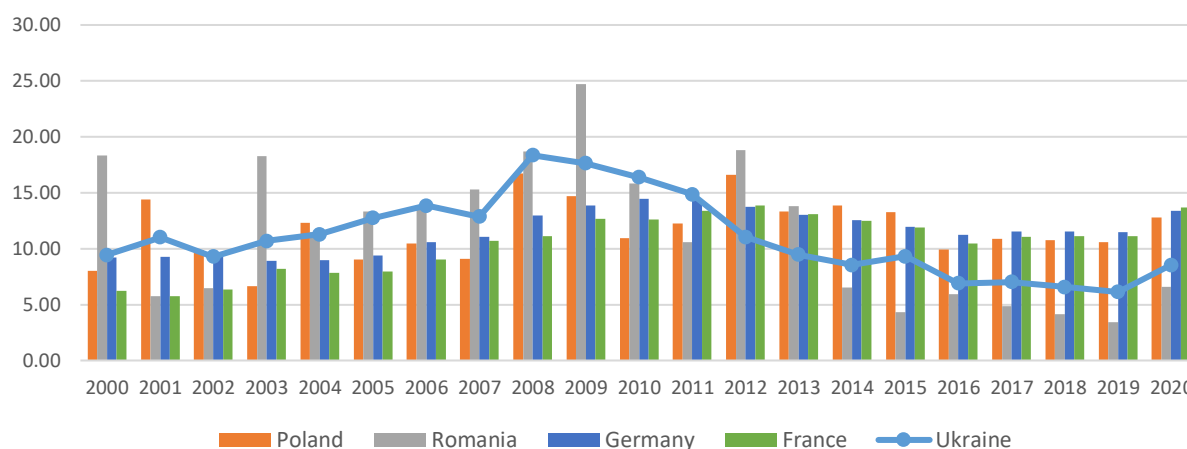

Figure 3. The volume of patents for environmental technologies in Ukraine and the countries of the European Union, 2000–2020.

Sources: systematised by the authors on the basis of   (WGI, 2022; European Statistical Office, 2022; National Institute for Strategic Studies, 2022; NationMaster, 2022)

It should be noted that Ukraine has a rather powerful innovative potential in the field of environmental technologies. In 2008, Ukraine surpassed Poland, France, and Germany on the same level as Romania, but since 2009, the volume of patents for environmental technologies began to decrease. The corresponding negative changes are caused by political instability, a decrease in state funding of scientific research centers, and the outflow of scientific potential abroad.
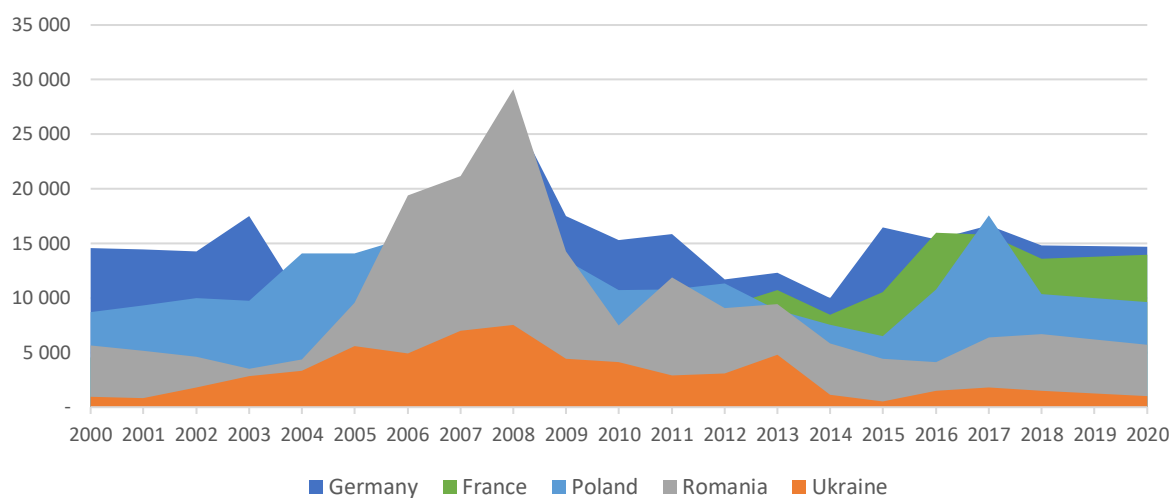
Figure 4. The volume of green investments in Ukraine and the countries of the European Union, 2000-2020.

Sources: systematised by the authors on the basis of (WGI, 2022; European Statistical Office, 2022; National Institute for Strategic Studies, 2022; NationMaster, 2022)

Trends in the development of green investment in the world are gaining momentum, but, unfortunately, the dynamics are declining in Ukraine (Figure 4). Today, compared to other countries of the European Union, the volume of green investments has almost halved, which is due to political instability, a high level of corruption and bureaucratic obstacles, an unstable financial situation, and to date, even war.

In view of the identified trend, the search for determinants of the growth of the divergent energy efficiency subindex of the national economy, which in various combinations can significantly increase its current level

and accelerate the speed of synchronization with the average European value, becomes more relevant. It should be noted that traditionally scientists have identified the following main indicators and factors that affect the level of energy efficiency: the structure of GDP, energy intensity of GDP, primary and final energy consumption, energy efficiency of buildings, the share of renewable energy sources in the country's energy balance, etc. At the same time, the transition to a carbon-neutral economy primarily depends on the efficiency of the energy sector, which is of strategic importance for the country (Ziabina et al., 2020). In this study, it was decided to select the following indicators as parameters of the effectiveness of state regulation: the rule of law, the government's ability to openly implement policies and regulatory measures, and corruption control, as their impact on increasing the divergent energy efficiency sub-index for Ukraine is the most statistically significant. Accordingly, a correlation analysis was conducted to check the multicollinearity of the studied determinants (table 3).

Table 3. Results of testing for multicollinearity of institutional and investment-innovation determinants on the divergent subindex of energy efficiency of the national economy

	RUL	REQ	CC	EP	GI
RUL	1	–	–	–	–
REQ	0,930	1	–	–	–
CC	0,959	0,902	1	–	–
EP	0,011	0,089	0,057	1	–
GI	0,069	0,096	0,095	–0,088	1

Sources: calculated by the authors

According to the results of the calculations, multicollinearity was found between three indicators of the effectiveness of public administration (RUL, REQ, CC), to eliminate multicollinearity or minimize it, it is necessary to form not only a complete model (all indicators are taken into account at the same time), but also its separate configurations (pairwise consideration of indicators of state governance efficiency).

To do this, first of all, it is necessary to check the indicators for the normality of the distribution using the Q-Q plot model, which will allow to reveal the future model for assessing the influence of institutional and investment-innovative determinants on the divergent energy efficiency sub-index of the national economy.

a) divergent subindex of energy efficiency of the national economy
b) the rule of law
c) the number of patents for green technologies
d) the government's ability to openly implement policies and regulatory measures
e) the volume of attracted green investments in the energy sector of the national economy
f) control of corruption

Figure 5. Results of the normal distribution of the divergent energy efficiency subindex of the national economy

Sources: developed by the authors

From Figure 5a, we can conclude that the calculated divergent subindex of energy efficiency of the national economy does not correspond to a normal distribution, and therefore can be used in the calculation of panel quantile regression to build a research model. The calculations showed that the rule of law indicator (Figure 5b) does not correspond to a normal distribution, and therefore can be used when calculating a panel quantile

regression to build a research model. The results showed (Figure 5c) that the indicator of the number of patents on environmental technologies does not correspond to a normal distribution, and therefore can be used when calculating a panel quantile regression to build a research model. According to Figure 5d, we can see that the indicator of the government's ability to openly implement policies and regulatory measures does not correspond to a normal distribution, and therefore can be used when calculating a panel quantile regression to build a research model. Calculations have shown that the green investment indicator does not correspond to a normal distribution, and therefore can be used when calculating a panel quantile regression to build the research model (Figure 5e). According to Figure 5f, we can see that the corruption control indicator does not correspond to a normal distribution, and therefore can be used when calculating a panel quantile regression to build a research model. That is, all six variables (kd, RUL, REQ, CC, GI, EP) do not correspond to a normal distribution, since the scatter plots of each plot are deviated from the diagonal lines (marked in red), which necessitates the use of panel quantile regression to build the research model. Identified patterns (combinations of indicators) that, cumulatively accumulating over a long period of time, formed "weak spots", "critical points" and attractors of changes in energy efficiency, which will inhibit the dynamics of harmonization of domestic and European energy policies in the forecast period.

Table 4. Summary results of the calculation of the assessment of the impact of institutional and investment and innovation determinants on the divergent energy efficiency subindex of the national economy
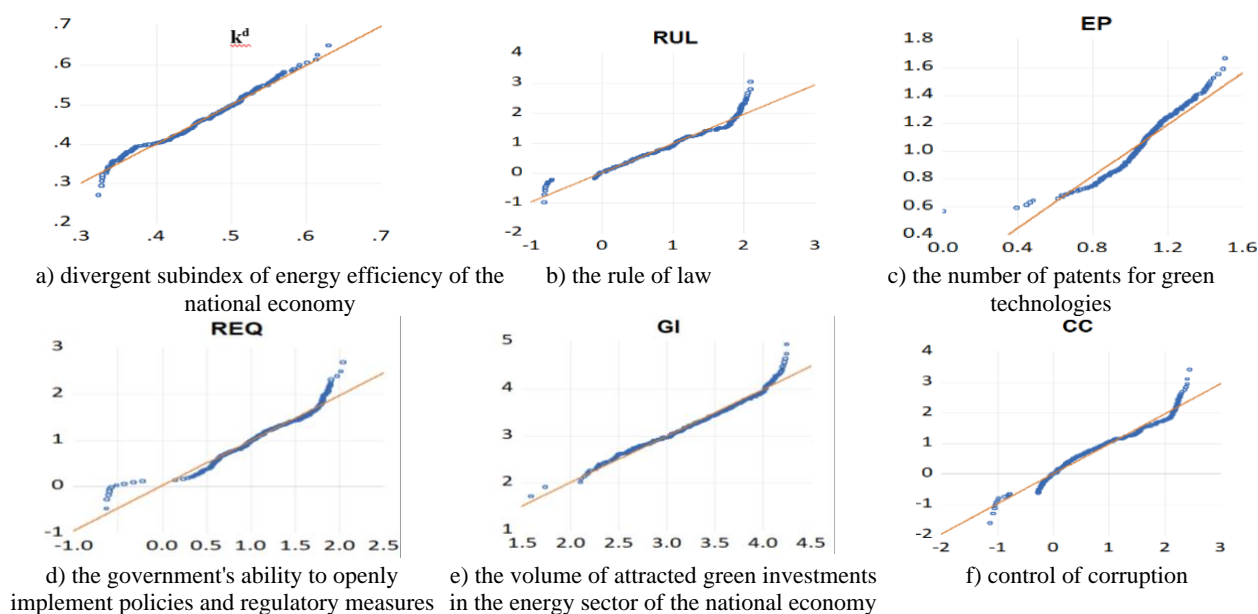
Determinants / type of model		Quantile								
		10th	20th	30th	40th	50th	60th	70th	80th	90th
1		2	3	4	5	6	7	8	9	10
EP	(1)	0,03906 (0,0000)	0,03284 (0,0000)	0,02695 (0,0000)	0,02299 (0,0000)	0,01904 (0,0000)	0,01873 (0,0000)	0,01646 (0,0000)	0,01179 (0,0000)	0,00742 (0,0000)
	(2)	0,03687 (0,0000)	0,03018 (0,0000)	0,02171 (0,0000)	0,01403 (0,0000)	0,01266 (0,0000)	0,01238 (0,0000)	0,01137 (0,0000)	0,00888 (0,0000)	0,00557 (0,0001)
	(3)	0,04321 (0,0000)	0,03864 (0,0000)	0,03296 (0,0000)	0,02995 (0,0000)	0,02527 (0,0000)	0,02140 (0,0000)	0,01838 (0,0000)	0,01667 (0,0000)	0,01023 (0,0000)
GI	(1)	0,0682 (0,0000)	0,0646 (0,0000)	0,0650 (0,0004)	0,0540 (0,0105)	0,0599 (0,0025)	0,0592 (0,0769)	0,00666 (0,0860)	0,00441 (0,2597)	0,00227 (0,6135)
	(2)	0,0541 (0,0036)	0,0445 (0,0095)	0,0819 (0,0000)	0,0778 (0,0001)	0,00864 (0,0001)	0,00782 (0,0013)	0,00448 (0,1549)	0,00108 (0,7278)	0,0001 (0,2158)
	(3)	0,001 (0,0000)	0,00111 (0,0000)	0,0091 (0,0000)	0,00856 (0,0001)	0,00828 (0,0021)	0,00563 (0,0556)	0,00524 (0,1215)	0,00534 (0,3750)	0,00232 (0,0921)
RUL		0,16113 (0,0000)	0,13107 (0,0000)	0,12100 (0,0000)	0,12610 (0,0000)	0,13686 (0,0000)	0,13902 (0,0000)	0,12584 (0,0000)	0,11263 (0,0000)	0,11849 (0,0000)
REQ		0,18937 (0,0000)	0,185200 (0,0000)	0,17021 (0,0000)	0,18239 (0,0000)	0,20194 (0,0000)	0,21046 (0,0000)	0,18338 (0,0000)	0,15570 (0,0000)	0,16070 (0,0000)
CC		0,10749 (0,0000)	0,06990 (0,0000)	0,08344 (0,0000)	0,08363 (0,0000)	0,07755 (0,0000)	0,07131 (0,0000)	0,08020 (0,0000)	0,06664 (0,0000)	0,03029 (0,1502)

Note: the statistical significance of the corresponding indicators is shown in parentheses; (1) – model with consideration of RUL; (2) – a model with consideration of REQ; (3) is a model taking into account CC
Sources: calculated by the authors

It was established that for Ukraine, the diffusion of green innovations leads to a slight increase in the level of energy efficiency of the national economy by 0.7%, while for the countries of the European Union, on average, by 3%. The experience of the countries of the European Union shows that the multiplier effect in increasing the energy efficiency of the national economy is provided by the growth of green innovations and the activation of the green investment market. Increasing the efficiency of public administration to the level of reference countries (the lowest quantile is Denmark, Sweden, Austria, Finland and France) will allow to increase the divergent sub-index of energy efficiency for Ukraine by 16.1% of the rule of law, by 18.9% – the ability of the government to openly implement policies and regulatory measures and 10.7% – control of corruption.

Conclusions. In view of the identified trend, the search for determinants of the growth of the divergent energy efficiency subindex of the national economy, which in various combinations can significantly increase its current level and accelerate the speed of synchronization with the average European value, becomes more relevant. The analysis of the experience of the countries of the European Union proved that effective state governance contributes to increasing the energy efficiency of the national economy. The use of correlation-regression analysis tools for Ukraine for 2000–2020 made it possible to empirically substantiate the

statistically significant influence of the following indicators on the divergent energy efficiency sub-index of the national economy: the rule of law, the government's ability to openly implement policies and regulatory measures, and control corruption. The logical continuation of the study is the determination of the influence of green investments and innovations in the energy sector on the divergent energy efficiency subindex of the national economy, taking into account the level of efficiency of state governance. Indicators of the rule of law, the government's ability to openly implement policies and regulatory measures, and corruption control were chosen as parameters of the effectiveness of state regulation, as their impact on increasing the divergent sub-index of energy efficiency for Ukraine is the most statistically significant. Patterns (combinations of indicators) were identified, which cumulatively accumulated over a long period of time and formed "weak spots", "critical points" and attractors of changes in energy efficiency, which will inhibit the dynamics of harmonization of domestic and European energy policies in the forecast period.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "conceptualization, Y.Z. and V.N.; methodology, Y.Z. and V.N.; software, Y.Z.; validation, Y.Z. and V.N.; formal analysis, Y.Z. and M.O.; investigation, Y.Z. and V.N.; resources, Y.Z. and V.N.; data curation, Y.Z. and V.N.; writing-original draft preparation, Y.Z. and V.N.; writing-review and editing, Y.Z. and V.N.; visualization, Y.Z. and V.N.; supervision, Y.Z. and V.N.; project administration, Y.Z. and V.N.; funding acquisition, V.N.

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Інновації в управлінні енергоефективністю: роль державного врядування

Стаття узагальнює аргументи та контраргументи в межах наукової дискусії з питання впливу державного управління на інновації в управлінні енергоефективністю національної економіки. Основною метою проведеного дослідження є формування та доведення гіпотези щодо ефективності методичного інструментарію оцінювання впливу рівня ефективності державного урядування на дивергентний субіндекс енергетичної ефективності національної економіки. Систематизація літературних джерел та підходів до вирішення проблеми ролі державного управління в контексті формування інновацій в управлінні енергоефективністю засвідчила, що на сьогоднішній день ведуться активні дискусії щодо цієї тематики. Актуальність вирішення даної наукової проблеми полягає в тому, щоб розробити дієвий механізм пошуку додаткових детермінант впливу на рівень енергоефективності для подальшої можливості гармонізувати вітчизняну та європейську енергетичні політики. Дослідження питання ролі державного управління інноваційною складовою розвитку енергоефективності в статті здійснено в наступній логічній послідовності: на першому етапі сформовано вихідний масив даних, який на другому та третьому етапах з використанням інструментарію статистичного аналізу перевірено на мультиколінеарність (коефіцієнт кореляція Пірсона) та нормальність розподілу (графічний квантильний метод порівняння двох розподілів ймовірностей); на четвертому етапі побудовано квантильну регресійну OLS-модель, що дозволяє врахувати гетерогенність досліджуваних факторів. Методичним інструментарієм проведеного дослідження стали методи бібліометричного та компаративного аналізу, кореляційний та квантильний методи, періодом дослідження обрано роки з 2000 по 2020. Об'єктом дослідження обрана Україна та країни ЄС(27), оскільки саме вони дають змогу порівняти рівень енергоефективності країн та їх позиції в світовому рейтингу якості державного управління. В статті представлено результати емпіричного аналізу та встановлено, що для України дифузія зелених інновацій призводить до незначного збільшення рівня енергетичної ефективності національної економіки на 0,7 %, тоді як для країн Європейського Союзу – в середньому на 3 %. Досвід країн Європейського Союзу свідчить, що мультиплікативний ефект у підвищенні енергетичної ефективності національної економіки забезпечується зростанням обсягів зелених інновацій та активізацією ринку зеленого інвестування. Підвищення ефективності державного управління до рівня еталонних країн дозволить підвищити дивергентний субіндекс енергетичної ефективності для України на 16,1 % для верховенства права, 18,9 % – здатність уряду відкрито реалізовувати політики та регуляторні заходи, та 10,7 % – контроль корупції. Результати проведеного дослідження можуть бути корисними для подальших досліджень в сфері енергоефективності національної економіки.

Ключові слова: інновації, енергоефективність, державне управління, енергозбереження, енергетичне управління, інновації процесів, національна економіка, безвуглецева економіка.