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OPINION
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Corporate Social Responsibility of Energy Companies: International Experience and Polycriterial Evaluation of Technological Innovations' Effectiveness

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INTRODUCTION

The fuel and energy complex is a system-forming element of the modern economy, determining both the opportunities for economic growth and the prospects for sustainable development (Cui et al., 2022; Li et al., 2022; Padmanabhan et al., 2022; Wen and Jia, 2022). This strategic role of energy companies covers two types of activities. First, the implementation of initiatives in the field of corporate social responsibility aimed at increasing the sustainability (universal accessibility and environmental safety/purity) of energy (Ahmed et al., 2022; Ates, 2022; Madaleno et al., 2022; Shukla and Geetika, 2022; Wang and Sun, 2022).

Second, the introduction of technological innovations that allow optimizing the business processes of energy companies. In the existing literature, authors such as Brizhak and Tolstobokov (2022), Dudukalov et al. (2021), Guo et al. (2022), Popkova et al. (2022), Qu et al. (2022), Shi et al. (2022), and Vanchukhina et al. (2016) consider technological innovations as a promising tool for corporate social responsibility of energy companies, as they have the potential to increase productivity and environmental safety of their activities. However, the extent to which this potential can be used in practice is insufficiently studied and unclear. This is a research gap that is being filled in this article.

This article is intended to demonstrate the contradictory impact of technological innovations on the corporate social responsibility of energy companies. The originality of the study lies in the fact that it goes beyond the usual framework of modernization of energy companies, taking into account the impact of the digital economy on their corporate social responsibility. The traditional focus on internal factors forms the idea of corporate social responsibility as a manifestation of the altruism of energy companies.

The article presents a new view on the corporate social responsibility of energy companies since it is heavily influenced by market pressure. In this vein, the article is aimed at studying international experience and conducting a polycriterial evaluation of the effectiveness of technological innovations of energy companies from the standpoint of corporate social responsibility.

The contribution of the article to the improvement of scientific knowledge consists in the development of a new scientific-methodological approach to assessing the compliance of energy companies with EnergyTech criteria. The novelty, peculiarity, and advantage of the new approach are that it involves determining the compliance of EnergyTech energy companies from the perspective of efficiency rather than from the perspective of costs (digital competitiveness)—for the first time, it takes into account the contribution of these costs to results—energy intensity level of primary energy, investment in energy with private participation, and renewable electricity output.

Place of Technological Innovations in the System of Corporate Social Responsibility of Energy Companies

The theoretical basis of the research conducted in this article is formed by the concept of EnergyTech, in which the system combination of high technologies and sustainability is defined as a priority of energy companies (Baur et al., 2022; Haoyang et al., 2022; Matsunaga et al., 2022; Wang and Hasani, 2022). In accordance with this concept, the corporate social responsibility of energy companies is interpreted as an activity carried out on their own initiative (going beyond meeting the requirements of the state) in support of the implementation of SDG 7: sustainable energy development (Ajagekar and You, 2022; Gebreslassie et al., 2022; Son Le et al., 2022; Tang et al., 2022).

In the works of Kurowski and Huk (2021), Madaleno et al. (2022), and Nguyen (2022), the corporate social responsibility of energy companies is identified with altruism—their non-profit support for sustainable energy development. The clearest and generally recognized indicators of corporate social responsibility of energy companies are offered and calculated annually by the World Bank (2022). Among these, indicators are the energy intensity level of primary energy (we will introduce the notation e_1, its reduction is assumed), renewable electricity output (we will introduce the notation e_2, its increase is necessary), and investment in energy with private participation (we will introduce the notation e_3; its increase is required).

Technological innovations of energy companies are interpreted as the use of advanced capabilities of scientific and technological progress (in support of the implementation of SDG 9). In the works of Asakereh et al. (2022), Buonomano et al. (2022), and Zhang and Fu (2022), breakthrough technologies such as robots, artificial intelligence, and Big Data are cited as key technological innovations at the present stage of the Fourth Industrial Revolution. In accordance with this, it is also indicated that technological innovations of energy companies are determined by internal factors—the successful introduction and active practical application of the aforementioned breakthrough technologies.

The existing scientific and methodological approach to assessing the degree of compliance of energy companies with the EnergyTech criteria involves the analysis of their technological innovations from the standpoint of digital competitiveness. This approach is described in the works of Cibinskiene et al. (2021), Li and Kimura (2021), Nagel et al. (2022), and Shuai et al. (2022). The problem lies in the fact that the current approach takes into account only high technological intensity, the relationship of which with the sustainability of energy is still poorly understood and not clearly defined, which is a gap in the literature. Because of this, the boundaries of EnergyTech remain blurred, and its scientific study is hampered by the uncertainty of the subject area to study. The identified gap is filled in this article through the study of the interdependence of corporate social responsibility and technological innovations of energy companies.

Polycriterial Evaluation of the Effectiveness of Technological Innovations of Energy Companies From the Standpoint of Corporate Social Responsibility

To determine the interdependence of corporate social responsibility and technological innovations of energy companies, this article provides a polycriterial evaluation of the effectiveness of technological innovations of energy companies from the standpoint of corporate social responsibility. The study is conducted on the example of a sample of countries representative of the global economy, covering both developed and developing countries from different parts of the world with the highest digital competitiveness in 2021 (included in the IMD World Competitiveness Center rating, 2022).

Using the hierarchical procedure of T.L. Saati (the Saati method), the contribution of various technological innovations available in the digital economy to the corporate environmental responsibility of energy companies is determined. The internal factors of technological modernization (the use of robots, AI, and Big Data) and external (market) factors of the digital economy (the level of development of the information society, e-government) are considered simultaneously according to the materials of the IMD World Competitiveness Center (2022). The basic statistics and evaluation results are given in **Table 1**.

It is essential to consider the calculations made in **Table 1** and their results in more detail using the example of Russia. In accordance with the Saati method, the values of indicators of technological innovation are transferred from places to percentages of the maximum possible values (the best value: 1^{st} place and the worst: 64^{th} place). For example, the value for world robots distribution is obtained as follows: ((64–51.56)/64) *100% = 51.56%.

Then, the correlation of indicators of technological innovation with each of the indicators of corporate social responsibility (for the entire sample) is calculated. For example, the correlation of world robots distribution with an energy intensity level of primary energy (e_1) was −0.02, with renewable electricity output (e_2): −0.13, and with investment in energy with private participation (e_3): −0.49. The arithmetic mean of the correlation coefficients was −0.22. A negative correlation value indicates the antagonism of technological innovations and corporate social responsibility.

The average correlation of corporate social responsibility indicators with the use of Big Data and analytics was 0.54, with e-participation: 0.06, and with e-government: 0.32. Next, weighted amounts are calculated, reflecting the contribution of each technological innovation to the corporate social responsibility of energy companies. For example, in Russia:

TABLE 1 | Polycriterial evaluation of the effectiveness of technological innovations of energy companies from the standpoint of corporate social responsibility in 2021.

Country	Energy intensity level of primary energy, megajoules per constant 2017 PPP GDP	Renewable electricity output, % of total electricity output	Investment in energy with private participation, thousand US$	World robot distribution		Use of Big Data and analytics		E-participation		E-government		Integral synthesis
				Place 1–64	%	Place 1–64	%	Place 1–64	%	Place 1–64	%	
United States	5	13.23	n/a	4	93.75	5	92.19	1	98.44	9	85.94	63.00
China	6	23.93	838.180	1	98.44	11	82.81	9	85.94	40	37.50	40.49
Australia	4	13.64	n/a	30	53.13	35	45.31	9	85.94	5	92.19	47.88
Spain	3	34.95	n/a	10	84.38	55	14.06	34	46.88	17	73.44	15.99
Kazakhstan	6	8.87	265.480	No data	0.00	6	90.63	25	60.94	27	57.81	71.01
Russia	8	15.86	486.950	31	51.56	31	51.56	26	59.38	33	48.44	35.80
Argentina	3	28.14	160.000	37	42.19	46	28.13	28	56.25	29	54.69	27.08
Brazil	4	73.97	6,242.530	18	71.88	56	12.50	18	71.88	47	26.56	4.08
Colombia	3	38.24	205.230	50	21.88	51	20.31	26	59.38	52	18.75	15.77
India	4	15.34	3,389.000	12	81.25	15	76.56	28	56.25	59	7.81	29.45
Correlation	c e_1	—	—	—	−0.02[a]	0.58[a]	0.24[a]	0.05[a]	—	—	—	—
	c e_2	—	—	—	−0.13	0.73	0.15	0.39	—	—	—	—
	c e_3	—	—	—	−0.49	0.30	−0.22	0.53	—	—	—	—
	On average	—	—	—	−0.22	0.54	0.06	0.32	35.05	—	—	—

[a]*Values with the opposite sign are indicated since CSR is indicated by a negative correlation with e_1.*
Source: calculated and compiled by the authors based on the materials of the IMD World Competitiveness Center (2022) and World Bank (2022).

– world robots distribution: 51.56%*(−0.22) = −11.10%;
– use of Big Data and analytics: 51.56%*0.54 = 27.68%;
– e-participation: 59.38%*0.06 = 3.48%;
– e-government: 48.44%*0.32 = 15.74%.

Integral synthesis is determined by summing weighted sums. For example, in Russia: −11.10 + 27.68 + 3.48 + 15.74 = 35.80 (moderate efficiency). The results obtained mean that in Russia, technological innovations of energy companies make a moderate contribution to their corporate social responsibility in 2021—energy companies correspond to EnergyTech by 35.80%. The largest compliance of EnergyTech energy companies was found in the United States (63%), China (40%), Australia (47.88%), and Kazakhstan (71.01%). In the whole sample (taking into account the representativeness, this can be extended to the global economy as a whole), the degree of compliance of EnergyTech energy companies is estimated at 35.05%.

DISCUSSION

The article contributed to the literature by clarifying the scientific provisions of the EnergyTech concept through the disclosure of the essence of the interdependence of corporate social responsibility and technological innovations of energy companies. Unlike Kurowski and Huck (2021), Madaleno et al. (2022), and Nguyen (2022), it was revealed that the corporate social responsibility of energy companies is not a "pure" manifestation of altruism but is carried out under significant market pressure—demand from society (consumers) and government incentives.

Unlike Asakereh et al. (2022), Buonomano et al. (2022), and Zhang and Fu (2022), it is proved that not only internal factors but also external market factors play an important role in the implementation of technological innovations by energy companies. Moreover, one of the internal factors—robotization—does not make a significant contribution to the corporate social responsibility of energy companies. The most significant was the internal factor of using Big Data and artificial intelligence for their analysis (0.54%). Among the external factors, the most significant is the development of the e-government system (0.32). The information society turned out to be a less significant external factor (0.06), but it also needs to be taken into account.

Unlike Cibinskiene et al. (2021), Li and Kimura (2021), Nagel et al. (2022), and Shuai et al. (2022), the article shows, on the basis of a review of international experience, that a high level of digital competitiveness does not guarantee that energy companies meet the criteria of EnergyTech. For example, India ((12 + 15 + 28 + 59)/4 = 29) and Spain ((10 + 55 + 34 + 17)/4 = 29) have a similar level of digital competitiveness from the positions of the considered indicators of the IMD World Competitiveness Center (2022). But in India (29.45%), the compliance of energy companies with the EnergyTech criteria turned out to be higher than in Spain (15.99%) since technological innovations are used to varying degrees in the implementation of corporate social responsibility in these countries. Based on the obtained conclusion, the article demonstrates a new scientific and methodological approach to assessing the degree of compliance of energy companies with the EnergyTech criteria, which involves analyzing their technological innovations from the standpoint of efficiency.

CONCLUSION

So, technological innovations occupy an important place in the system of corporate social responsibility of energy companies. But the impact of technological innovations on this responsibility is contradictory, which requires flexible management of energy companies. The scientific novelty of the research and its contribution to the literature are involved in the development of a new scientific-methodological approach to assessing the compliance of energy companies with EnergyTech criteria.

The novelty of the authors' approach is that it provides a transition from the single-criteria assessment of competitiveness prevailing in the existing literature to the multicriteria assessment of the efficiency of technological innovations of energy companies. This allows for the first time to take into account not only costs (digital competitiveness) but also results (energy intensity level of primary energy, investment in energy with private participation, and renewable electricity output), as well as the ratio of results and costs (efficiency). As a result, the suggested approach allows making the most accurate and reliable assessment of the contribution of corporate social responsibility of energy companies to EnergyTech.

The theoretical significance of the results obtained in this study is that they formed a systemic vision of the practical implementation of SDG 7 and SDG 9 in the activities of energy companies, clarified the conceptual boundaries of EnergyTech, and offered scientific and methodological recommendations to accurately quantify the degree of compliance of energy companies with the requirements of EnergyTech.

The practical significance of the obtained results lies in the fact that the application of the progressive Saati method allowed not only to systematize but also to rank the criteria according to the degree of significance. Based on the ranks assigned to the indicators, energy companies will be able to prioritize the development of technological innovations when managing them in their activities. This will improve the efficiency of technological innovation management from the standpoint of increasing their contribution to the corporate social responsibility of energy companies, as well as accelerate their transition to EnergyTech.

AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript contributed to the conception and design of the study revision, read, and approved the submitted version.

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