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The Economic and Financial Standing Assessment of Energy Sector Companies During the COVID-19 Pandemic

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Abstract:

Purpose: *This article aims to assess the financial standing of energy sector companies, specifically focusing on the effectiveness of selected corporate bankruptcy prediction models in evaluating the risk of corporate bankruptcy during the COVID-19 pandemic.*
Design/Methodology/Approach: *The study employs various methods, including theoretical review and the resource-based view (RBV), financial ratios analysis, discriminant models, and comparative and descriptive analysis.*
Findings: *The empirical results of the analyzed discriminant models of corporate bankruptcy prediction show that the F model presented a negative value in the case of company B in 2020 and the case of company D in the 2019-2020 period, and the G model indicates the risk of corporate bankruptcy in the case of company B in 2020. The findings not only point out that the selected energy sector companies survived during the COVID-19 pandemic but also provide valuable insights for future financial planning and corporate bankruptcy risk assessment in the energy sector.*
Practical Implications: *The lockdown of economic activity directly impacted the real sector of the economy. The energy market plays an essential role in the Polish economy. The research shows the crucial role of corporate bankruptcy prediction models for financial practitioners and governmental representatives in monitoring and evaluating the economic and financial standing of the energy sector companies.*
Originality/Value. *This article shows how the resource-based view (RBV) and discriminant models approach can overcome the knowledge gap of current conceptual and methodological attempts to evaluate energy sector companies' economic and financial standing during the COVID-19 pandemic. The analysed discriminant models are a valuable tool for assessing the risk of corporate bankruptcy. Finally, the results may also serve as a basis for further research in economics and finance.*

Keywords: *Economic and financial standing, discriminant models, economic outlook of energy sector companies, COVID-19.*

JEL codes: *E37, G30, G33, Q40.*
Paper Type: *Research article.*

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1. Introduction

Energy sectors play a crucial role in economic stability and global trade, and energy futures influence energy market dynamics. Much research on the energy sector has been conducted (Gielen *et al.*, 2019). Much of the existing research concentrates on the spot market (Algieri and Leccadito, 2017; Asl *et al.*, 2021; Rehman *et al.*, 2019) but fewer studies specifically examine the corporate financial standing in the energy sector. Energy market participants are exposed to substantial risk.

Sustainable finance will help ensure that investments support a resilient economy and a sustainable recovery from the impact of the COVID-19 pandemic (*Overview of sustainable…,* 2024). In the European Union's policy context, sustainable finance is understood as finance that supports economic growth while reducing pressures on the environment to help reach the European Green Deal's climate and environmental objectives, taking into account social and governance aspects.

On 11 December 2019, the European Commission presented the European Green Deal, a growth strategy to make Europe the first climate-neutral continent by 2050 (*Overview of sustainable…,* 2024).

In 2015, landmark international agreements were concluded by adopting the U.N. 2030 agenda, sustainable development goals, and the Paris Climate Agreement. This article refers to Goal No. 7: ensuring access to affordable, reliable, sustainable, and modern energy for all. The Paris climate agreement includes aligning financial flows with a low-carbon and climate-resilient development pathway (*United Nations…*, 2024).

The European Union strongly supports the transition to a low-carbon, more resource-efficient, and sustainable economy and has been at the forefront of efforts to build a financial system that supports sustainable growth. Transition finance is financing private investments to reduce today's high greenhouse gas emissions or other environmental impacts and transitioning to a climate-neutral and sustainable economy (*Overview of sustainable…,* 2024).

For instance, these could be investments in green production methods or reducing the environmental footprint as far as possible where no green technologies are available. Transition finance is urgently needed to reduce greenhouse gas emissions by 55% and our environmental impact by 2030 (*Overview of sustainable…,* 2024).

The European Commission presented on 17 September 2020 its 2030 climate target plan, with an increased emissions reduction target of 55% by 2030 compared to 1990. The E.U. needs to invest approximately € 350 billion more annually during the 2021-30 decade than during the previous decade to meet these 2030 climate and energy targets.

The topic is current and relevant because several measures are required to cope with the energy crisis and assess the financial standing of energy sector companies. Some companies act successfully in the market; on the other hand, some survive or go bankrupt because they can not implement innovation and adjust to the market conditions and regulations.

The negative consequences of the COVID-19 pandemic that affected economies in various countries to different extents highlighted the essential role of anti-crisis policy responses. Thus, the research significantly impacts the economy and society from recovery, resilience, and renewal perspectives.

One approach is to find out the current energy needs in the economy and explore the availability of energy resources to meet the current demand (Streimikiene *et al.*, 2020). The environmental and natural resources economics emphasize sustainable development (Manteuffel, 2013). According to Manteuffel (2013), "sustainable development means social progress combined with economic growth without entailing a rise in the entropy of the natural environment".

The research is pioneering and innovative, breaking with the dominant view in the literature that processes (especially in nature) are irreversible. The study fills the existing theoretical gap in economics and finance. Therefore, the research enables the acquisition of new knowledge about the occurrence and significance of the entropy phenomenon in economic and financial processes during the COVID-19 pandemic and the identification of new socio-economic mechanisms in the energy market and financial standing of energy sector companies, including the success, and bankruptcy processes.

The literature shows the research gap in exploring and evaluating selected energy sector companies' financial standing and the risk of corporate bankruptcy. This research contributes to energy sector companies' bankruptcy evaluation risk, including selecting, implementing, and adjusting proper methods.

The article's structure refers to the "IMRaD" format and includes four main sections: Introduction, Methods, Results, and Discussion. The "IMRaD" approach is extended in this study, and after the methodology part, it also presents the literature review and, at the end of the study, conclusions and recommendations.

2. Literature Review

The research focuses also on Max Planck's approach (Planck, 1897) which indicates as follows: a process is reversible if, at any stage of the process, it is possible to reverse the direction of its course and, together with the environment, return to the initial state of the system and its surroundings. There is a category of processes that are not reversible". Lars Onsager analyzed mathematical equations for various irreversible thermodynamic processes and, in 1931, found the connection that led him to formulate equations that came to be known as reciprocal relations. It allowed a complete description of irreversible processes. Irreversible thermodynamic processes go in only one direction and not in the reverse (Onsager, 2021).

Shannon introduced entropy in the frame of information theory. Shannon's entropy quantifies the expected value of the information contained in a message (Cánovas and Muñoz-Guillermo, p. 164). Information entropy is used in the so-called Social Entropy Theory (Bailey, 1990). Georgescu-Roegen (1971) tries to link thermodynamic entropy to economic processes and indicates that the economy as a process with different flows (mass and money) must also follow the principle of the second law of thermodynamics, i.e., that all economic activities are irreversible, and therefore also in an economy entropy is striving towards a maximum.

The literature discusses the economic and financial effects of the COVID-19 pandemic on the energy market and cases of energy sector companies. The global epidemic crisis related to the spread of the SARS-CoV-2 coronavirus would affect the long-run emergence and intensification of recession and economic situation. These economic crisis phenomena manifest as financial problems and, consequently, bankruptcies of enterprises and the resulting job liquidation. Global supply chains have been broken; rebuilding them is expensive and time-consuming.

Economic and social systems are exposed to scenarios of cascading outbreaks, whose impacts can ripple to enormous scales through their strong interdependencies, as recently shown by the pandemic spreading of COVID-19. As a result of people's isolation, many industrial and social systems have suspended or significantly reduced their production and services, with future effects still to be seen (Aven and Zio, 2021).

Recent studies on COVID-19's effects on economies indicate which sectors are affected mainly by the coronavirus and which countries, e.g., the U.S. electricity sector (Ruan *et al.*, 2020), the food and beverage sector (Bucak and Yiğit, 2021), and the water sector in Europe (Antwi, 2020). A few studies concentrate on the economic effects of COVID-19 on developing countries, (Workie, 2020; Grima *et al.,* 2020; Khan *et al.,* 2020; Nguyen *et al.,* 2022).

In developed economies, the consumption of energy has a direct impact on GDP growth. Energy resources are volatile and subject to depletion. Further, energy economics indicates that the future energy demand is also subject to change due to population growth, economic growth, and business variations.

One of Energy Economics's biggest challenges is estimating future energy requirements concerning variations in demography, financial activities, and infrastructure for transport and communication (Streimikiene *et al.*, 2020). Fluctuations in oil, natural gas, and other energy commodity prices impact economies worldwide (Brockway *et al.*, 2021; Gozor *et al.*, 2020; Pociovalisteanu *et* *al.*, 2010; Thalassinos *et al.*, 2022). Brockway *et al.* (2021) summarise the long-run, economy-wide rebound effects estimates from 21 CGE studies—seven studies model of household energy efficiency improvements.

Considering the business entity level, the resource-based view (RBV) is still recognized as one of the leading approaches in research (Sirmon, 2010; Barney *et al.*, 2011). The RBV perceives an organization as a bundle of resources and capabilities, a system of tangible and intangible assets and capabilities combining an internal perspective (phenomena within an organization) and an external perspective (competitive environment) (Barney, 2011).

As highlighted by Wernerfelt (1984), everything which can be considered a tangible or non-tangible asset and which affects the strength or weakness of an organization can be regarded as its resources, and both categories of assets can influence organizational success (Jancenelle, 2020).

As the fundamental basis of the resource approach (Wernerfelt, 1984; Barney, 2011; Grant 1991) such categories of resources are indicated as qualified personnel/human resources, knowledge, know-how, brand, reputation, a company's technical equipment, technology, and technological resources, practical procedures, information and information management systems, financial resources, physical resources, organizational processes, organizational attributes, and other elements that enable the development and implementation of strategies that increase efficiency (of resources). This study concentrates on energy sector companies' energy resources, financial resources, and financial standing.

3. Research Methodology

The literature review critically analyzes articles published mainly in Scopus and WoS databases, among other resources. This study presents the resource-based view (RBV) (Sirmon *et al.*, 2011), financial ratios analysis, methods of corporate bankruptcy prediction, and Max Planck's approach (Planck, 1897).

The study discusses the energy market in Poland, emphasizing the COVID-19 impact, its development and economic implications, and its major players. The study uses the financial data from publicly available financial statements of selected Polish energy sector companies.

The initial research sample included 14 companies representing the Energy-sector Index of the Warsaw Stock Exchange (WSE). Finally, 3 of these 14 companies were selected for further, in-depth analysis. These companies were codified as company A, company B, and company D. Additionally, one company (codified as company C) that does not listen to WSE was also analyzed because of its economic significance for the energy market in Poland. The research covers the 2018-2023 period.

The analysis focuses on the COVID-19 period and one year before the pandemic for comparison. The study reveals different scenarios of the energy sector companies' activity, namely survival, success, and bankruptcy, with particular attention to this last stage of the company life cycle. The article aims to present the effectiveness of selected corporate bankruptcy prediction models in evaluating the risk of corporate bankruptcy in the energy sector during the COVID-19 pandemic.

The research also includes the following specific research goals:

1. Interpretation of entropy mechanism in economic processes through the lens of the resource-based approach.
2. The overview of the impact and challenges of the COVID-19 pandemic on energy sector companies.

This study assumes the following hypothesis:

H1: The researched energy sector companies publicly listed on the Warsaw Stock Exchange were not threatened by bankruptcy during the COVID-19 pandemic.
H2: The evaluated energy sector companies' financial standing determines their bankruptcy threat during the COVID-19 pandemic.

The article uses the following scientific methods: financial ratios analysis and different discriminant models. The selected corporate bankruptcy prediction models were implemented to evaluate the risk of energy sector corporate bankruptcy during the COVID-19 pandemic.

In the first stage of the research, seven models developed at the Institute of Economic Sciences of the Polish Academy of Sciences by Mączyńska and Zawadzki (2006), based on Polish companies from various sectors were presented. In the next phase, two of them, the F and G models, were selected to assess the bankruptcy risk.

The financial ratios (variables) used in the models, coefficient weights, and definitions were presented in Tables 1 and 2.

Table 1. *Coefficients (variables) of estimated models and coefficient weights*

Ratios („x”)	**A Model**	**B Model**	**C Model**	**D Model**	**E Model**	**F Model**	**G Model**
	Weights of the ratios (w)						
II	5,577	5,837	5,896	6,029			
OROA	1,427	2,231	2,831	6,546	9,004	9,478	9,498
ROS	0,154	0,222					
AROA	0,310	0,496					
EC/A	1,937	0,945	0,539	1,546	1,177	3,613	3,566
(EC-IC)/A	1,598	2,028	2,538	1,463	1,889		

BP	3,203	3,472	3,655	3,585	3,134	3,246	2,903
OR/C	0,436	0,495	0,467				
CR	0,192	0,166	0,179	0,363	0,500	0,455	0,452
WC/NCA	0,140	0,195	0,226	0,172	0,160		
SI/A	0,386	0,030	0,168	0,114	0,749	0,802	
Log A	1,715						
Const (w_0)	–9,832	–0,392	–0,678	–0,593	–1,962	–2,478	–1,498

Source: *Mączyńska and Zawadzki, 2006, p. 21.*

The discriminant function (function Z) calculated in specific models is the sum of products of variables "x" (i.e., coefficients that characterize the financial standing of enterprises) multiplied by coefficient weights "w" and determined statistically in the model. The value of the discriminant function in each model is determined as follows:

$$Z=w_1*x_1 + w_2*x_2 + \ldots\ldots\ldots w_n*x_n + w_0 \quad (1)$$

The higher the discriminant function value, the lower the bankruptcy risk is, and vice versa. A negative value of the function in the case of companies that do not face bankruptcy and a positive value assumed for bankrupt companies points to a classification error.

Table 2. *Definition and designations of coefficients – variables of estimated discriminant functions*

Coefficient name	**Symbol**	**Numerator**	**Denominator**
Revenue growth rate	II	Sales revenues	Revenues in the previous year
Return on assets	OROA	Operating result	Total assets
Return on sales	ROS	Net financial result	Sales revenues
Cumulated gross return on assets	AROA	Cumulated gross financial result for 3 years	Total assets
Return on equity (self-financing ratio)	EC/A	Equity	Total assets
Adjusted ROE ratio	(EC-IC)/A	Equity less share capital	Total assets
Debt service coverage	B.P.	Net financial result plus depreciation	Total liabilities
Coverage of financial expenses	OR/C	Operating result	Financial expenses
Current liquidity	CR	Current assets	Short-term liabilities
Working capital to fixed assets	WC/NCA	Working capital	Fixed assets
Asset productivity	SI/A	Sales revenues	Total assets
Relative value of assets	Log A	Decimal logarithm of the value of assets	

Source: *Mączyńska and Zawadzki, 2006, p. 21.*

The methods of analysis and processing of results also include descriptive and comparative analysis, synthesis, and case study. The results are presented using deductive inference methods in a descriptive, tabular, and graphic form.

4. Results of the Research and Discussion, Limitations and Future Research

4.1 Energy Market in Poland in the COVID-19 Pandemic Period

State governments and financial institutions dominate the global energy sector. In Poland, a significant part of the energy sector is in the hands of large companies with state-owned participation. The great need for finance explains the state of affairs outlays in the sector. It should be noted that the energy sector is concentrated in the energy oligopoly of the PGE, Tauron, Enea, and Energa Groups, which dominate domestic production and distribution of energy (compared to Europe, this is the rule rather than the exception).

The concentration of capital among the major players in the sector is expected to continue in the coming years. It is believed that the liberalization of the energy sector while increasing the number of producers and suppliers in the E.U. market will transfer consolidation to the level of investors and capital providers who will finance most newly established entities. The most important regulations concerning the energy sector transformation are created at the E.U. and national levels. Funds for investment projects are allocated to E.U. member states.

"Many components of the energy sector infrastructure, such as transmission lines, transformer stations, or even power plants, have not been modernized since the 1980s, 1970s, or even earlier. Consequently, the reliability of the transmission grid and, thus, the security of the energy supply is questionable. Compared to the countries of Western Europe (Switzerland, Germany, France, the Netherlands), as well as Slovakia and the Czech Republic, Poland is characterized by a lower grid density. Moreover, it has a much smaller number of transformer stations than more developed countries. As electricity demand grows and renewables develop (which are low power and widely dispersed), increasing the density and modernizing the grid will be necessary. Investments in smart power grids will be particularly needed"
(*https://ir.enea.pl/en/file-download-centre/26111; https://ir.enea.pl/en/about-us)*.

In February 2021, the Council of Ministers approved "Poland's Energy Policy until 2040 (PEP2040). "It assumes that over half of the installed capacity will be in zero-emission sources until 2040. Adding offshore wind power generation to the Polish power system and commissioning a nuclear power plant will be particularly important. These will be the two new strategic areas and branches of industry to be created in Poland. It presents the geographic coverage and presents the sources of financing for PEP2040. The following are essential elements of PEP2040:

- Energy transition, including energy self-sufficiency;
- Increase the share of renewable energy sources (RES) in all sectors and technologies. In 2030, RES should cover at least 23% of final gross energy consumption, with the RES share being at least 32% in power generation (mainly wind and P.V. power), 28% in district heating (increasing by 1 p.p. y/y), 14% in transport (with an immense contribution of electromobility);
- Offshore wind power generation – installed capacity will reach from approx. 5.9 GW in 2030 to approx. 11 G.W. in 2040;
- Installed photovoltaic capacity will increase considerably: approx. 5-7 G.W. in 2030 and approx. 10-16 G.W. in 2040;
- In 2030, the share of coal in electricity generation will not exceed 56%, and given the increased prices of CO_2 emission allowances, it may drop even lower to 37.5%" (see *https://ir.enea.pl/en/about-us*).

"Energy is used in production processes and households. Its efficient use in the economy constitutes an essential factor influencing production costs and product competitiveness in an international market. Careless use of energy leads to problems with the pollution of the natural environment (through greenhouse gas emissions) and energy resource depletion. Energy demand is constantly growing. Therefore, objectives of a green economy include, among others, the need to improve energy efficiency and the efficient use of existing energy resources" (*Green economy…*, 2022, p. 29).

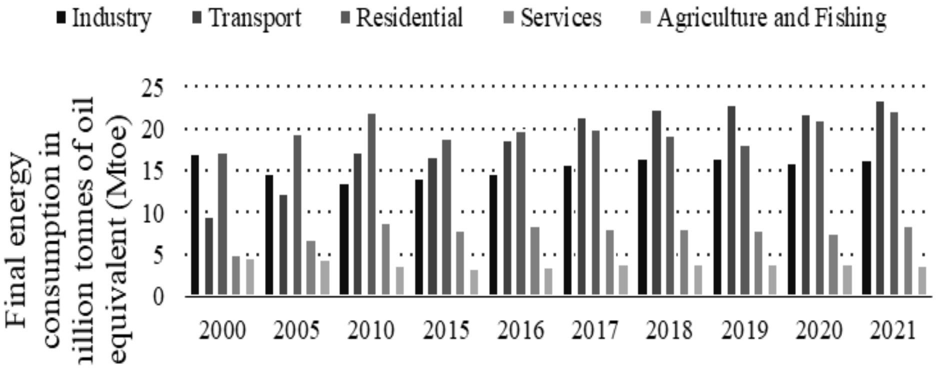
According to Statistics Poland (Green economy…, 2022, p. 29), *"primary energy is energy embodied in the primary energy carriers that are acquired directly from renewable and non-renewable natural resources necessary to cover the demand for final energy, having regard to the efficiency of the entire chain of processes related to production, conversion, and transport to the final customer".*

Total primary energy consumption (gross inland consumption of energy) expressed in tonnes of oil equivalent (toe) is the sum of five energy types: coal, electricity, oil, natural gas, and renewable energy sources. Toe–tonne of oil equivalent (conventional) is the energy measurement unit from different energy carriers, using conversion rates, and used in international balances. It means the amount of energy that can be produced by burning one tonne of crude petroleum.

One tonne of conventional oil equals 41.868 GJ (11.63 MWh). In 2021, total primary energy consumption was 109.0 Mtoe, higher than the previous year and compared to 2000 by 6.4% and 20.7%, respectively. Among primary energy carriers in 2021, hard coal and lignite dominated (46.7% of total consumption).

Their share in the total consumption between 2020 and 2000 was reduced by 2.7 pp and 18.0 pp, respectively (Green economy…, 2022, p. 30).

Figure 1. *Volume of final energy consumption in Poland from 2000 to 2021 by sector (in million tons of oil equivalent)*



Source: *Own elaboration based on Energy sector in Poland, STATISTA, 2023 and retrieved from: https://www-1statista-1com-1ayulzzq60199.han.bg.sggw.pl/study/70079/energy-sector-in-poland/.*

The data show that European Union countries' primary energy productivity indicator (EU=27) in 2020 was 9.7 PPS/kgoe. According to (Green economy..., 2022, p. 29) the highest primary energy productivity in E.U. countries was in Ireland (22.4 PPS/kgoe), Denmark (14.3 PPS/kgoe) and Romania (12.8 PPS/kgoe). The lowest indicator was noted in Malta (5.1 PPS/kgoe), Finland (5.8 PPS/kgoe) and Bulgaria (6.4 PPS/kgoe). Poland, having reached 8.4 PPS/kgoe was in the 17th place among 27 E.U. Member States.

In Poland in 2021, the primary energy productivity indicator was 22.91 PLN/kgoe and grew by about 2020 and 2000 by 4.7% and 193.4%, respectively, which is a positive fact (Green economy..., 2022, p. 30). From 2000–2021, changes in the structure of final energy consumption took place in Poland. In 2021, the biggest consumer was the transport sector, with a 31.7% share, followed by households – 29.8%, industry – 22.1%, services – 11.4%, and agriculture – 5.1%. Concerning 2000, the most significant decrease in the share of final energy consumption was recorded in industry, namely by 9.6 pp (Figure 1).

The interconnection of economic growth (GDP) and energy consumption (E.C.) has been under review for a long time (Jiang *et al.*, 2021). During the COVID-19 crisis, curtailment in many activities, e.g., mobility, economic activity, construction, and manufacturing, dropped the global energy demand. The decline in energy demand and consumption brings damage to the energy industry.

For example, the COVID-19 pandemic caused the bankruptcy of at least 19 energy companies in the United States industry (Crider, 2020). Government interventions have been implemented promptly for energy industry responses (Akrofi and Antwi, 2020). The data in July 2020 shows that, compared to the same period in 2019, the peak reduction rates of electricity consumption (weather-corrected) in France, Germany, Italy, Spain, the U.K., China, and India during the lockdown period were more than 10% (IEA, 2020, p. 2).

The growth rate of energy demand (%) shows a higher decrease in the E.U. in 2020 than in 2019. The growth rate of energy demand (%) simultaneously indicates the lowest reduction in Africa. It is worth emphasizing that the demand for energy consumption declines during the lockdown periods, but this increases after lifting the lockdown.

Commercial and industrial demands decline, but residential demand increases (Senthilkumar *et al.*, 2020). Several beneficial strategies under the *"COVID-19 situation carefully consider disease mitigation without significant compromise on urban and energy sustainability. New lifestyles in cities with lower energy usage include, for example, the "15-minute city" and the self-sufficient buildings. These strategies can significantly reduce energy demand and CO2 emissions for travel, ease traffic jams, provide cleaner air, and considerably reduce pollution"*. These also have adverse effects.

Based on the overview of the impacts and challenges of the COVID-19 pandemic on energy demand and consumption, it is worth emphasizing that structural changes in energy demand and consumption have been observed in short-term versus long-term expectations, different sectors of the energy industry, residential versus non-residential consumptions, peak demand patterns, consumption philosophy during and after lockdowns, consumed products, and energy intensities in different regions.

Compared to 2019, the energy intensity in 2020 has presented apparent spatial-temporal differences, although both energy demand and GDP decreased. Considering the projected energy intensities in different regions, the USA presents the highest change rate (+29.3%), followed by Japan (+7.8%), while China (+2.8%) and the E.U. (+1.03%) present no apparent variations. The energy consumption recovered to the regular level about three months after relaxing lockdown measures in China when the pandemic was well controlled (Senthilkumar *et al.*, 2020, pp. 11-12).

4.2 Economic Outlook of Major Players in the Energy Markets in Poland During the COVID-19 Pandemic Period

PGE Polska Grupa Energetyczna SA held Poland's largest electricity generation market share (41%), followed by other generators (21%) and ENEA SA (16%) in 2022 (Figure 2).

In 2022, PGE Polska Grupa Energetyczna led electricity net generation in the Polish energy market. Enea company also plays a significant role in the energy sector (Table 3).

Figure. 2. *Market share of electricity generation in Poland in 2022 by company*

Source: *Own elaboration based on Energy sector in Poland, STATISTA, 2023. Retrieved from: https://www-1statista-1com-1ayulzzq60199.han.bg.sggw.pl/study/70079/energy-sector-in-poland/.*

Table 3. *Electricity net generation of major energy companies in Poland from 2019 to 2022 (in terawatt hours)*

Specification	**PGE Polska Grupa Energetyczna**	**Enea S.A.**	**Energa (Orlen Group)**	**Tauron**
2019	65,90	26,5	3,9	13,88
2020	58,31	22,5	3,2	12,50
2021	68,80	26,4	4,1	15,60
2022	66,13	26,2	4,5	15,55

Source: *Energy sector in Poland, STATISTA, 2023. Retrieved from: https://www-1statista-1com-1ayulzzq60199.han.bg.sggw.pl/study/70079/energy-sector-in-poland/.*

In 2022, PGE Polska Grupa Energetyczna led retail electricity sales in the Polish energy market, followed by Tauron Polska Energia S.A. (Table 4).

Table 4. *Retail sales of electricity of major energy companies in Poland from 2018 to 2022 (in terawatt hours)*

Specification	**PGE Polska Grupa Energetyczna**	**Enea S.A.**	**Energa (Orlen Group)**	**Tauron Polska Energia S.A.**
2018	42,6	20,5	19,8	34,5
2019	44,0	20,3	19,7	33,7
2020	37,48	21,1	18,8	32,4
2021	34,28	24,5	18,6	33,4
2022	34,3	23,7	18,0	31,13

Source: *Financial statements of researched companies.*

Regarding revenues, PGE Polska Grupa Energetyczna was the largest energy company in Poland in 2022, followed by Tauron Polska Energia S.A. (Table 5).

Table 5. *Revenues of major energy companies in Poland from 2018 to 2022 (in million zloty)*

Specification	PGE Polska Grupa Energetyczna	Enea S.A.	Energa (Orlen Group)	Tauron Polska Energia S.A.
2018	25 946	12 673	10 337	18 122
2019	37 627	16 401	11 479	19 558
2020	45 766	18 195	12 496	20 850
2021	52 772	21 289	13 692	25 614
2022	73 435	30 128	20 444	36 311

Source: *Financial statements of researched companies.*

5. Discussion of Empirical Result, Limitation, and Future Research

Table 6 presents findings of financial ratios used for the calculation of models of corporate bankruptcy prediction, namely models F and G by INE PAN. The financial ratios results confirm that during the COVID-19 pandemic, their level decreased slightly but obtained a negative value in some cases. The companies survived the pandemic time. The general evaluation of the data is positive. The financial standing of the research companies was stable during the period analyzed.

Table 6. *Empirical results of financial ratios used for calculation of models F and G by INE PAN*

Financial ratios	Energy sector companies	Years						
		2017	2018	2019	2020	2021	2022	2023
II	Company A	-0.18	0.12	0.45	0.22	0.15	0.31	0.30
	Company B	0.01	0.11	0.29	0.11	0.17	0.41	0.60
	Company C	0.03	-0.02	0.11	0.09	0.10	0.49	0.28
	Company D	-0.01	0.04	0.13	0.07	0.23	0.44	0.17
OROA	Company A	0.05	0.03	-0.05	0.01	0.06	0.04	-0.03
	Company B	0.05	0.03	0.05	-0.06	0.06	0.02	0.02
	Company C	0.06	0.05	0.002	0.03	0.06	0.05	0.05
	Company D	0.05	0.02	0.01	-0.04	0.02	0.02	0.07
EC/A	Company A	0.64	0.63	0.56	0.53	0.54	0.51	0.42
	Company B	0.49	0.50	0.47	0.44	0.44	0.43	0.40
	Company C	0.58	0.56	0.54	0.50	0.49	0.46	0.58
	Company D	0.50	0.51	0.46	0.42	0.41	0.37	0.36
BP	Company A	0.26	0.19	0.21	0.12	0.20	0.15	0.13
	Company B	0.16	0.15	0.12	-0.04	0.17	0.08	0.05
	Company C	0.04	1.14	1.08	0.91	0.88	0.50	0.90
	Company D	0.08	0.01	-0.01	0.01	0.01	-0.01	0.05
CR	Company A	1.06	0.73	1.06	1.00	1.04	0.96	0.83
	Company B	1.40	1.40	1.40	1.20	1.10	1.20	1.20
	Company C	2.30	1.70	0.90	0.70	0.60	0.60	0.60

	Company D	0.95	0.63	0.87	0.86	0.63	1.01	0.87
SI/A	Company A	0.32	0.34	0.48	0.56	0.59	0.69	0.85
	Company B	0.24	0.30	0.36	0.46	0.45	0.64	0.94
	Company C	1.57	1.72	1.56	1.03	1.23	0.90	1.41
	Company D	0.49	0.49	0.05	0.53	0.64	0.82	0.86

Source: *Own calculation based on financial statements of researched energy sector companies.*

Table 7 presents the findings of selected corporate bankruptcy prediction models F and G by INE PAN. Empirical results indicate that both F and G models show the highest threat of corporate bankruptcy. This is evident in the cases of the company D and B. Furthermore, these models estimate negative values in 2020, and model F shows a negative value in 2019. Namely, the F model presented a negative value in the case of company B in 2020 and the case of company D in the 2019 -2020 period, and the G model indicates the risk of corporate bankruptcy in the case of company B in 2020.

Table 7. *Empirical results of models F and G created by E. Mączyńska, M. Zawadzki at INE PAN*

Models	**Energy sector companies**	**Years**						
		2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Model F	Company A	1.89	1.30	0.62	0.83	1.64	1.22	0.24
	Company B	1.12	0.98	1.01	-0.67	1.09	0.58	0.62
	Company C	2.62	5.87	4.66	3.71	3.98	2.28	4.42
	Company D	0.89	0.27	-0.58	-0.49	0.03	0.13	0.73
Model G	Company A	2.49	1.92	2.61	3.39	2.05	1.57	0.4
	Company B	1.82	1.64	1.63	-1.04	1.63	1.00	0.81
	Company C	2.30	5.05	3.99	3.53	3.65	2.34	3.93
	Compay D	1.42	0.82	0.60	0.04	0.47	0.44	0.99

Source: *Own calculation based on financial statements of researched energy sector companies.*

The analysis reveals the following limitations and future research direction:

- the evaluation of long-term financial and economic consequences of the impact of COVID-19 on the energy market and companies,
- the Polish energy sector structure changes and adjustments to the E.U. requirements,
- improvements in infrastructure in the energy market, especially in the area of renewable energy resources, and energy sector and cross-sectional comparisons between different E.U. member countries,
- implement other methods and domestic and international models of financial standing and corporate bankruptcy evaluation.

6. Conclusions

The energy market is one of the most important pillars of each economy. The achievement of the climate and energy policy goals by 2030 is associated with the need to modernize European energy transmission and storage facilities. The condition of the Polish energy sector is improving.

However, the technical condition of the production and distribution infrastructure is poor and requires tremendous investments. The energy sector is strategic, which means that the state plays a significant role in monitoring and supporting its modernization and diversification of energy resources.

The research shows the role of corporate bankruptcy prediction models in monitoring and evaluating the financial standing of the energy sector companies through the lens of the RBV approach. These models have the predictive power to assess the potential risk of corporate bankruptcy in advance.

According to the empirical results, the financial standing of the research companies was relatively stable during the COVID-19 pandemic and has improved lately. The F and G models did not note the risk of energy sector companies' bankruptcy in 2023. The study shows that the corporate bankruptcy models are a proper tool for the financial standing and risk of the bankruptcy evaluation from the perspective of the owners, managers, and stakeholders acting on the energy market, including the state and governmental bodies.

These results also confirm that state-owned participation, the most significant, most competitive, and most successful companies that operate on the Warsaw Stock Exchange, has not been affected by the risk of bankruptcy and has survived in the market during the COVID-19 pandemic. The study positively verified both 1st and 2nd hypotheses.

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