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Environmental, Social, and Governance Impact on Energy Sector Default Risk—Long-Term Issuer Credit Ratings Perspective

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The aim this study is to analyze the impact of environmental, social, and governance (ESG) measures on energy sector credit ratings. The main hypothesis is as follows: The ESG measures have had a significant impact on energy sector credit ratings during the COVID-19 crisis. The analysis has been conducted by using long-term issuer credit ratings presented by the main credit rating agencies. To verify the hypothesis, quarterly data from financial statements, macroeconomic data, and ESG measures for all companies listed on the stock exchanges from all over the world for the 2000–2021 period were collected. The sector was divided into sub-samples according to the type of sector and the moment of the COVID-19 crisis. It was noticed that a stronger reaction of credit ratings during the COVID-19 crisis on ESG factors, than that before it, was also observed, and confirms the increasing role of ESG measures in the financial market. On the other hand, credit rating agencies take into consideration ESG factors during the first estimation. Later, the mentioned variables lose their importance. This is based on a few reasons. It is still a small sample of entities that publish non-financial statements connected with ESG. Some countries have yet to implement regulations associated with climate risk. The significance of electricity power consumption and CO2 emissions confirms the significance of the mentioned direct or indirect impact of ESG factors. Credit rating agencies are not willing to change credit ratings because usually companies from the energy sector, especially from coal and oil and gas subsectors, are large entities. They sometimes receive financial support from governments. Governments are also stakeholders that create a lower risk of default. In less developed countries, coal is one of the main energy sources, and costs connected with alternative, renewable energy are more expensive. The prepared research also suggests that particular ESG measures have varying significance on credit ratings. Therefore, it can help to analyze and build models by investors. It will not be without significance for estimating the default risk and the cost of the capital. In most cases, the most significant measure is the E factor.

Keywords: energy sector, default risk, COVID-19, credit ratings, crisis

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1 INTRODUCTION

In recent years, one of the basic problems that the world has experienced is the condition of the environment. The mentioned situation has started to become one of the most dangerous during the last 2 years due to climate change. Frequently, information about new tornados, hurricanes, sweltering heat at nearly 50°C, food shortage, or huge fires over a very large area is reported. In the last years, we have noticed new diseases, which are difficult to combat. The most significant were SARS, MERS, and now COVID-19 with all its variants. The mentioned situation creates a need to measure and verify factors associated with environmental risk. These measures belong to ESG (environmental, social, and governance) factors. The mentioned risk is noticed by regulators and national governments. As a result, regulations are introduced connected with reducing CO2 emissions, water saving, pollution reduction, renewable energy introduction, etc. In April 2021, a draft of the directive on non-financial reporting by the European Commission was published. This will replace the current non-financial reporting directive. The CSRD (Corporate Sustainable Reporting Directive) imposes more reporting obligations and expands the list of entities obligated to report. All large companies—not only those listed on the stock exchanges—will have to report their ESG statements. The CSRD will need to be implemented into national regulations by the Member States by the end of 2023. First reporting will start in 2024 and will take data for 2023.

The OECD Strategy, known as ESG Investing, Environmental Pillar Scoring, and Reporting was published in 2020 to focus attention on the strategic reorientation investment on renewable energy. The main idea is to reduce the carbon footprint and reduce carbon transition. As a result, its use is recommended to climate-risk managers by financial institutions during investment decision making. The mentioned strategy also describes the significance of adapting climate-related risk management, as well as operational processes, to improve water use, waste management, and impact on biodiversity. E scores reflect outputs such as carbon emissions and score metrics that capture the negative effects of business activities on the environment and to understand the impact of climate change on businesses. Many central banks in OECD countries are now in the process of integrating ESG assessment into their investment approaches as one of the tools to better align portfolios with a transition to low-carbon, climate-resilient economies. It is the effect of initiatives such as the Network for Greening the Financial System (NGFS) proposal. It was also noticed that the risk of higher volatility is lower in the case of higher ESG indices. ESG investing is growing rapidly, it was worth 18 trillion USD globally in 2019 (GSIA, 2019). The growth of ESG-related traded investment products exceeded 1 trillion USD.

The COVID-19 pandemic and all problems connected with environmental pollution, especially coal pollution and using green energy instead, bring a new risk connected with the regulation changes. Many institutions have changed their model of financing creditors and placed more attention on the regulation changes connected with climate risk. The mentioned situation is important for the energy sector, especially energy based on coal and petroleum subsectors. It also generates new changes for renewable energy. The presented risk is estimated by credit rating agencies during the risk assessment process. In the analysis of the S&P Global Rating (2021) methodology, the energy sector was sensitive to a few problems during the last years. The oil and gas subsector has risks associated with lockdowns, mild winter, OPEC+ compliance breaks, and rapid energy transition problems. Coal energy risk relates to the ESG regulations. The presented factors that can influence the default risk of companies from the mentioned sector suggested changes in the main methodology used by credit rating agencies to assess the default risk. It confirms the increasing role of the ESG measures during the preparation and modification of credit ratings. It is especially significant because credit ratings determine the cost of capital, especially CDS spreads, interest on bonds, or decisions about investing capital taken by banks, investment funds, insurers, or others. The analysis of the methodologies presented by main credit rating agencies, i.e., S&P, Moody's, and Fitch, suggested that the ESG measures were not taken to analyze default risk before. In some cases, the CSR polices were used to correct the final credit rating, but the mentioned variable was not the main variable, but the additional feature. The presented analysis gives new insight into the factors that can influence the final credit ratings given by credit ratings agencies.

The presented relationship created the need to analyze the impact of ESG measures on energy sector credit ratings. They are a few reasons why the presented paper has been prepared. At first, in most studies, ESG ratings were analyzed in terms of different sources of information that influence credit ratings. In this paper, the significance of the list of financial, macroeconomic and ESG variables has been tested to determine their influence on long-term issuer credit ratings. In previous analyses, ESG measures have not been taken into consideration. The second reason is that the energy sector is one of the most sensitive in terms of the ESG measures and regulations connected with them. It relates to the obligation to analyze the E factor by financial intermediaries during the analysis of the probability of default and taking investment decisions. Also, the changes in regulations and CO2 emissions have a direct impact on the financial condition of the mentioned sector. Companies that belong to the coal subsector or oil and gas are usually large companies that are listed on the stock exchange. The significance of the ESG impact on lending policies and credit scoring has been verified by Attig et al. (2013) and Birindelli et al. (2015), but the literature suggests that ESG objectives are not clearly defined and used in credit lending policies (Zeidan et al., 2015). On the other hand, Friede et al. (2015) suggest that ESG criteria are not taken into consideration during investment decisions, even if they are important. The mentioned differences can be connected with the type of sector that caused it to be analyzed. And finally, in previous studies about factors that can determine credit ratings, more attention has been put on the whole sample without division in sectors and subsectors. As was suggested before, the energy subsector is not homogenic. In particular, subsectors, i.e., coal, oil and gas, uranium, and renewable

energy, have different types of risk, especially when connected with ESG measures. The increasing differences are noticed in recent years, especially during the COVID-19 crisis. Therefore, studies prepared on data before the mentioned period can give different results than those that are in practice. As a result, the following hypothesis has been put forward: ESG measures have had a significant impact on energy sector credit ratings during the COVID-19 crisis. Thus, this paper will empirically examine the impact of ESG factors and the financial condition of companies belonging to the energy sector on a sample of all public and private entities from all over the world—data are available for the years 2000–2021.

The remainder of the paper proceeds as follows. **Section 2** presents a literature review of previous studies that investigate the relationship between ESG criteria and the default risk and the practical analysis of the significance of the mentioned factors on investment decisions. **Section 3** reports the methodology by describing the features of the data sample and model specification on which this study is based. **Section 4** provides a discussion of findings, and then **Section 5** concludes by stating the limitations of the current study and consequently suggesting future development.

2 LITERATURE REVIEW

2.1 Impact of Environmental, Social, and Governance Measures on Companies' Financial Conditions

The analysis of previous studies on the relationship between ESG measures and their impact on companies' financial condition shows varied results. On the one hand, they present opinions about the lack of influence of the ESG measures on companies' value and additional profits from introducing ESG policies (Orlitzky et al., 2003; Friede et al., 2015). Some researchers believe that social and environmental factors are not taken into account by financial institutions to verify the potential value of the company, even if they have potentially positive impacts (Cellier and Chollet, 2016; Fatemi et al., 2017; Gutsche et al., 2017; Lins and Servaes, 2017). Others suggest that the mentioned factors are insignificant during investment decision making by investors (Revelli and Viviani, 2015; Revelli, 2017). The described opinions are different in recent research. This can be connected with changes to regulations and more attention being placed on the verification of climate risk. The significance of ESG measures in the credit policy has been described by Zeidan et al. (2015) and Miralles-Quirós and Miralles-Quirós (2017). The law changes associated with climate risk have a direct impact on the macroeconomic condition of companies, in practice, especially from the energy sector. Next, large pollution and high-carbon activity increases the credit margin and credit risk and has a direct impact on loan loss provisions and non-performing loans during the assessment stage by banks.

The significance of the particular ESG factors is also varied in analyses. The S factor is a factor that has been analyzed more often than others. One of the first studies about the impact of CSR on credit rating estimation was prepared by Grunert et al. (2005). Weber et al. (2014) and Weber et al. (2010) verified the impact of social announcements on the abnormal rates of return on stock prices.

There is still a lack of research about the relationship between ESG measures and the probability of default. ESG factors have a direct impact on the cost of capital. The increase in the ESG score decreases yield spreads according to Ge and Lui (2015). As a result, a better, more responsible CSR policy can reduce the cost of debt according to Cooper and Uzur (2015). Because credit ratings are taken during the analysis of the credit risk by banks and assessed as a value of credit margin, we can establish that ESG measures—as a part of the estimation credit rating—have an indirect impact on the cost of debt. As a result, they influence the probability of default, loan loss provisions, and the possibility to receive credit. Hoepner et al. (2016) found S and E factors to have a statistically significant impact on receiving loans. According to the methodology presented by main agencies, indirect or direct impacts of ESG measures can exist. Moreover, the impact of regulations regarding ESG obligations can be noticed, especially climate risk, on the macroeconomic level of the estimation of credit ratings, considering each type of subsector.

Menz (2010) has an opposing opinion. He found that ESG-CSR factors increase corporate spreads and decrease their credit ratings. This can be an effect of introducing ESG-CSR policies by entities with higher risk premiums to reduce the cost of the capital and improve credit ratings. The presented opinion has been suggested to be unreliable, because of the use of a big data sample (498 European corporate bond spreads) for a 3-year period. Goss and Roberts (2011) have a similar opinion. They suggest that companies with CSR policies pay more for borrowing cash than those that do not have them.

In some research, stronger attention has been placed on the E factor. Stellner et al. (2015) found that the environment saving policy has a more significant impact than social and governance factors. This measure reduces the default risk and increases credit ratings. Social policies have an impact on credit ratings and zero-volatility spreads. The mentioned opinion about the significance of the E factor is also held by Ga-Young et al. (2020). The higher value of the E scores decreases the cost of debt in a small company subsample. They also found that credit ratings cannot explain the impact of ESG measures to analyze bonds by investors that are assessing risk by themselves. ESG factors are not fully reflected in credit ratings. Large investors create pressure to develop ESG criteria.

The negative impact of ESG factors on credit ratings can be an effect of conflict between large investors specialized in climate risk investments who would have to bear the associated costs as shareholders, and managers who receive profits from overinvestments (Goss and Roberts, 2011). It is an effect of the information asymmetry between these two groups. Perez-Batres et al. (2012) found that the high level of ESG increases fixed companies' costs. ESG factors are also used to devaluate inappropriate company behavior and accounting inaccuracies (Kim et al., 2014). It is assumed that overinvesting in ESG binds meager (financial) resources, and therefore, too poor of an ESG

performance should be associated with lower credit risk, and vice versa (Goss and Roberts, 2011).

Boffo et al. (2020) presented some findings connected with the ESG providers. At first, the low correlation between E scores and the ESG scores is observed. Investing in high-scoring ESG portfolios does not necessarily mean that such tilting includes companies that have received high ratings for managing their carbon emissions or risk management. E scores other than environmental metrics have greater weights in the methodologies—it can help investors to understand the long-term transition. As a result, investing in a high E score may, in some cases, inadvertently result in a greater carbon footprint in portfolios. Next, an opinion that portfolio exposures to the energy sector and other industries with high emissions did not decrease, and in some cases materially increased is presented. Quantitative analysis indicates that the number of emissions in these high-ESG portfolios is higher on a gross and average basis for some of the very large ESG funds. This draws attention to the sustainability of such funds for investors that wish to achieve risk-adjusted returns and reduce the carbon footprint of their portfolios. Other types of investment products, such as those tailored to climate transitions, may provide more targeted tools for investors to rebalance portfolios away from companies with carbon extensive outputs or supply chains. Highly tailored low-carbon or carbon-transition portfolios may have asset composition and risk characteristics that stray widely from standard market benchmarks that are most used by institutional investors.

Using different metrics by the different rating agencies may also reflect their preferences for certain approaches by ESG corporate reporting framework providers. As these providers have different ranges of financial materiality, alignment with stakeholder values, climate risk assessment, and mitigation, the weight of the low-carbon impact is varied.

The analysis of the structure of the STOXX600 index and the STOXX600 ESG-X index shows that the ESG index does little to improve the environmental impact relative to the benchmark index. A similar situation is observed for the S&P500 and its ESG counterpart. Moreover, the weight of the energy industry has increased. Rebalancing portfolios away from such companies may inadvertently shift investments toward high E-rated forms that happen to be above-average polluters. The largest companies for STOXX600 indices are Total, BP, and Royal Dutch Shell (with a Refinitiv environmental pillar score at or above 90/100), and for S&P500 indices are Exxon Mobil Co., Chevron Co., CoconoPhilips. Funds, such as the PIMCO Climate Bond fund, the Blackrock iShares Global Green Bond ETF, and the Invesco WilderHill Clean Energy ETF make investment decisions by using ESG measures. They are focused on investing in green bonds, that are certified to be green by third parties or by the institutional investor and are based on the low-carbon issuers, i.e., PIMCO invests in bonds issued to receive financial sources on green projects, while Invesco invests in projects based on clean renewable energy.

Green banks are public and nonprofit financing entities that have been established by national and local governments to leverage public dollars for the purpose of driving private capital into clean power technology and accelerating the entrance of such technologies into the market. Examples of these institutions are California CLEEN Centre, Connecticut Green Bank, Green Energy Market Securitization, GEMS, New Jersey Energy Resilience Bank, New York Green Bank, and Rhode Island Infrastructure Bank. Maryland's Montgomery Country has established its Montgomery Country Green Bank. The mentioned institutions invest in low-carbon technologies. Many green banks have been established with the further motivations of carbon emission reduction, lowering the cost of capital and energy costs, creating jobs, promoting energy security, and furthering local development of green technology markets. Green banks can use limited public cash to attract private funding into the sector.

Credit ratings are one of the measures used to analyze the default risk by banks and investment institutions. As a result, a decision to assess the impact of ESG factors on credit rating changes has been initiated. The direct or indirect impact of the notes' changes on the cost of the capital has been observed. Downgrades or upgrades of credit ratings are changed if financial or nonfinancial information is published, so this paper tests if ESG measures lead to favorable credit ratings. If the ESG factor positively impacts a higher credit rating, this means that companies can receive benefits at a lower cost of debt. The energy sector will be included in the analysis as one of the most sensitive to changes to the ESG policies. The mentioned sector is highly sensitive to CO2 emissions' regulations. The important impact on its financial conditions also has restrictions connected with coal extractions and distribution. In addition, some regulations connected with refinancing renewable energy and atomic energy are also not without significance.

In this study, it is assumed that all ESG criteria have a significant impact on the credit rating changes of the energy sector. In some research, the significance of E factors is highlighted. English (1999) suggested that E factors such as pollution and water saving have a long-term perspective and uncial characters, and that S and G indicators are mostly limited internally (Han et al., 2016; Ga-Young et al., 2020). As a result, the significant impact on the financial statement measures and E factors means that S measures are unimportant.

2.2 Impact of Financial Condition Measures on Corporate Credit Ratings

The analysis of the methodologies presented by credit ratings agencies, according to which the mentioned institutions verify and test the default risk and prepare credit ratings, suggests that the most significant variables are financial and macroeconomic factors. The impact of the mentioned factors is varied in particular sectors and changes especially during crises. A different list of factors is noticed in the case of banks, insurers' countries, and non-financial entities. In the case of the last group of variables it is noticed, in the stable group of factors, that significance is varied in particular sectors. Each of the analyzed credit rating agencies publish their own methodology and the information about the financial situation for each sector. Taking into account the whole sample without distinguishing the subsamples is a mistake, because each sector has its own

TABLE 1 | Studies about financial factors influencing corporate credit ratings.

Authors	Significant Variables
Kaplan and Urwitz (1979)	Interest coverage, the long term debt to total assets ratio, the long term debt to net worth ratio, the net income to total assets ratio, the coefficient of variation of total assets, the coefficient of variation of net income, and total assets
Ederington (1985)	Interest coverage, the long term debt to capital ratio, and total assets
Blume et al. (1998)	Pre-tax interest coverage, operating income to sales, long term debt to assets, total debt to assets, and total assets
Bouzouita and Young (1998)	Profitability, growth in surplus, leverage, line mix, liquidity, size, and organizational form
Kamstra et al. (2001)	Net income plus interest expenses divided by interest expenses to represent interest coverage, a debt ratio measured by total debt divided by total assets, profitability captured by the net income total assets ratio, and firm size measured as the book value of firm assets
Bhojraj and Sengupta (2003)	Institutional ownership, proportion of the board consisting of outsiders, concentrated ownership, debt/equity, profit margin, total assets, and market value of common equity/book of common equity
Kim and Gu (2004)	Debt service coverage, profitability, and size
Roje (2005)	ROA, ROE, profit, market value of equity, tangible book value/assets, leverage, long-term debt/total assets, projected benefit obligation-pension plan assets/total assets, and volatility of earnings
Ashbaugh-Skaife et al. (2006)	Number of outside blockholders, quality accruals, timeliness of firms' earnings, independence of the board, CEO power, percentage of shares held by officers or directors, board expertise, leverage, ROA, net income before extraordinary items, size, subordinated debt, and interest coverage
Gray et al. (2006)	Interest coverage, leverage, profitability, and industry concentration
Sih (2006)	Industry, cash, and market value
Bone (2010)	Interest coverage and short-term debt/total debt
Chodnicka-Jaworska (2021)	Gross margin, effective tax rate, asset turnover, pretax ROA, earnings retention, reinvestment rate, current ratio, time interest earned ratio, debt to equity ratio, long-term debt to capital ratio, difference between total debt and cash divided by EBITDA, A/R turnover ratio, inventory turnover ratio, fixed assets turnover ratio, working-capital to sales growth ratio, ESG combined score, ESG score, environmental pillar score, social pillar score, corporate governance pillar score, ESG controversies score

Source: own elaboration.

specific type of risk. As a result, analysis should be prepared for each sector, and sometimes subsectors separately. This is the main reason why this analysis is prepared for the energy sector with subsectors.

This subsection contains the analysis of the significance of the previous studies about the impact of financial indicators on corporate credit ratings. The main idea is to categorize and introduce them to estimate the final model.

The background of the literature about the analysis of corporate default risk is the model prepared by Altman (1968). The mentioned bankruptcy model was the basis of the next group of models prepared by Kaplan and Urwitz (1979) and Ederington (1985). Each of the presented models has its own group of variables. For example, Kaplan and Urwitz (1979) assessed the size of the company measured by the total assets; they also tested the impact of the leverage, earnings, and profitability ratios. Ederington (1985) underlined the significance of the size of the company but also put attention on the quality of debt ratios. Kamstra et al. (2001) broadened the mentioned list of variables on the net income to total assets ratio, which is a measure of the profitability indicators. The mentioned list of factors has been used in later research. From all of the mentioned studies, the following conclusions are apparent: profitability and earnings factors have a positive impact, leverage ratios have a negative influence, higher credit ratings are given for bigger entities, and the interest coverage on corporate notes is insignificant. Blume et al. (1998) developed a list of variables on the operating income to sales ratio. They also put attention on the ambiguous relationship between leverage ratios and credit ratings, that can be an effect of using correlated debt indicators. The same problem was reviewed by Amato and Furfine (2004).

The most significant studies with their list of variables are presented in **Table 1**.

In practice, apart from financial and macroeconomic variables, there are other additional factors that influence the credit ratings given by agencies. One of them is the period of cooperation with a particular credit rating agency. If the mentioned period is longer, entities receive higher notes (Mahlmann, 2011). The mentioned problem was noticed by the European Commission, which then brought in changes in regulations connected with credit ratings.

The knowledge of factors influencing corporate credit ratings is very important because of a few reasons. Credit ratings are the basic measure of estimating default risk (Kang and Liu, 2007). The higher the ratings are, the lower the probability of default, and vice versa (Choy et al., 2006). They are also used to establish the cost of capital. The cost of debt influences the possibility to find investors or even staying on the market (Gray et al., 2006). The external methods of estimation of credit risk are based on credit ratings. The mentioned methods are used by banks and insurers. As a result, they are significant if companies want to receive credit. The standardized methods used by banks, especially in developing countries, is useful to assess the capital adequacy indicators required by regulators. The mentioned method is based on credit ratings. Regulators and investors treat credit ratings as a benchmark during assessment of capital requirements for solvency purposes. Credit ratings also reduce the asymmetry of information between issuers, stakeholders, and supervisors. They are useful during investment decisions, effectively reallocate capital (Papaikonomou, 2010), and classify financial instruments according to their quality and possibility to sell (Pinches and Singleton, 1978). Most professional investors, like money market

funds, can only invest in instruments that have got an investment grade. Credit ratings also perform the function of corporate governance (Kang and Liu, 2007).

The presented study is different from others because of various reasons. A homogenic sample was taken, where the energy sector was divided into subsectors. As a result, the findings were more appropriate and better represented the research problem. The only study about the impact of ESG measures on corporate credit rating changes in sectors, that was prepared by Chodnicka-Jaworska (2021), underlined the need to verify the mentioned phenomenon for the energy sector as a specific sector. Most studies were also prepared for local economies. This research helps to analyze the whole market. In this study, credit ratings presented by the biggest credit rating agencies were assessed. Previous studies were based on internal credit ratings presented by banks. In most cases, the mentioned notes were higher than those proposed by credit rating agencies, so they were overestimated. External notes that are given by credit rating agencies are a part of the estimation made by banks to verify the credit and default risk and assess the loan loss provisions and the expected loss. They are also used to make decisions on whether money should be borrowed. They are an important part of investing money in the capital market. In previous studies, the impact of financial determinants or ESG-CSR measures, never both, was analyzed. And finally changes of regulations, the financial situation of the mentioned sector, and new types of risk causes were used by credit rating agencies to develop their methodologies (Camargo, 2009) to not lose their creditability in public opinion.

3 MATERIALS AND METHODS

The aim of the paper is to analyze the impact of ESG measures on energy sector credit ratings. The main hypothesis is as follows: ESG measures have a significant impact on energy sector credit ratings during the COVID-19 crisis. To analyze the determinants of the energy sector's credit ratings, all long-term issuer credit ratings given to companies listed on the stock exchange from all over the world were used. Until the end of July 2021, only a few different credit ratings were proposed by credit rating agencies for the mentioned companies. The mentioned credit ratings were collected from the Refinitiv database. From 2021, S&P's credit ratings could not be collected from the Refinitiv database. For a better understanding of the problem, energy sector companies' credit ratings from the period between 1990 and 2021 were collected. A separate analysis for a particular credit rating agency and a period of crisis was prepared. In the analysis, more than 2,800 companies from all countries were analyzed. To analyze the impact of determinants on companies' credit ratings, the linear decomposition proposed by Ferri et al. (1999) was used. The same methodology was used in other research presented in the literature review. There is also an inherent limitation of using the non-linear method for the decomposition of credit ratings connected with the lack of data about the CDS spreads. Also using 10-years bond to verify the mentioned phenomenon reduces the strength of the sample. The linear method of decomposition is presented in **Table 2**.

Refinitiv (Thomson Reuters) presents the following ESG measures: the ESG combined score, the environmental pillar score, the social pillar score, and the corporate governance pillar score. The mentioned variables are described in **Table 3**. Previous literature suggests a varied impact of ESG factors on companies' financial condition. In the mentioned sector, the significance of these variables can also be different in particular subsectors. Not without significance is the size of the companies, because bigger entities sometimes receive higher ESG indexes and higher credit ratings. This is an effect of buying CO2 certificates. A strong correlation is evident between ESG measures. Separate models have been prepared for each factor.

The next group of factors belongs to financial and macroeconomic determinants. The financial indicators have been divided by profitability, earnings power, liquidity, leverage, and operating measures, according to the Chodnicka-Jaworska (2021) research. The description of the particular factors and their impact on the credit ratings changes is presented in **Table 4**.

Ordered logit panel data models in which energy sector companies' long-term issuer credit ratings are the dependent variable were used for the analysis. Logit models rely on the verification of the probability unit, which is then transformed into its cumulative probability value from a normal distribution. The final version of the ordered logit model is

$$y_{it}^{*} = \beta x_{it-1}^{'} + \gamma Z_{it} + \varepsilon_{it},$$

Where Y_{it}^{*} is an unobservable latent variable that measures the credit-worthiness of a company i in period t; X'_{it-1} is a vector of time varying explanatory variables; β is a vector of unknown parameters; Z_{it} represents time-invariant regressors that are generally dummy variables; and ε_{it} is a random disturbance term that has a normal distribution.

y_{it}^{*} is related to the observed variable y_i, which is a credit rating in this case, as follows:

$$\begin{gathered} y_i = -5\, if\ y_i^{*} < \tau_0 \\ 0\, if\ \varepsilon_0 < y_i^{*} < \tau_1 \\ 5\, if\ \varepsilon_1 < y_i^{*} < \tau_2 \\ 10\, if\ \varepsilon_2 < y_i^{*} < \tau_3 \\ 15\, if\ \varepsilon_3 < y_i^{*} < \tau_4 \\ 20\, if\ \varepsilon_4 < y_i^{*} < \tau_5 \\ 100\, if\ \varepsilon_{21} < y_i^{*} < 0 \end{gathered}$$

where τ_s $(\tau_0 < \tau_1 < \tau_2 < \cdots < \tau_{22})$ are the known threshold parameters to be estimated. The following model can be referred to as a factor ordered probit model:

$$y_{it}^{*} = \beta F_{it-1}^{'} + \gamma Z_{it} + \delta (F * Z)_{it} + \varepsilon_{it} \tag{1}$$

where y_{it} is an unobservable latent variable that measures the credit-worthiness of a company from energy sector i in period t.

F_{it} is a vector of explanatory variables, i.e.,:

TABLE 2 | Decomposition of Moody's, Dominion Bond Rating Service, and Fitch long-term issuer credit ratings.

Moody's Long-Term Issuer Rating		DBRS Long-Term Issuer Rating		Fitch Long-Term Issuer Rating	
Rating	Code	Rating	Code	Rating	Code
Aaa	100	AAA	100	AAA	100
Aa1	95	AA (high)	96	AA+	94.74
Aa2	90	AA	92	AA	89.47
Aa3	85	AA (low)	88	AA-	84.21
A1	80	A (high)	84	A+	78.95
A2	75	A	80	A	73.68
A3	70	A (low)	76	A-	68.42
Baa1	65	BBB (high)	72	BBB+	63.16
Baa2	60	BBB	68	BBB	57.89
Baa3	55	BBB (low)	64	BBB-	52.63
Ba1	50	BB (high)	60	BB+	47.37
Ba2	45	BB	56	BB	42.11
Ba3	40	BB (low)	52	BB-	36.84
B1	35	B (high)	48	B+	31.58
B2	30	B	44	B	26.32
B3	25	B (low)	40	B-	21.05
Caa1	20	CCC (high)	36	CCC	15.79
Caa2	15	CCC	32	CC	10.53
Caa3	10	CCC (low)	28	C	5.26
Caa	5	CC (high)	24	RD	-5
C	0	CC	20	D	-5
WR	-5	CC (low)	16	WD	-5
NULL	0	C (high)	12		
		C	8		
		C (low)	4		
		SD/D	–5		

Source: own elaboration.

TABLE 3 | Description of ESG measures.

Variable Name	Description	Abbreviation
ESG combined score	Refinitiv ESG combined score is an overall company score based on the reported information in the environmental, social, and corporate governance pillars (ESG score) with an ESG controversies overlay	**ESG**
Environmental pillar score	The environmental pillar measures a company's impact on living and non-living natural systems, including air, land, and water, as well as complete ecosystems. It reflects how well a company uses best management practices to avoid environmental risks and capitalize on environmental opportunities in order to generate long-term shareholder value	**ESGE**
Social pillar score	The social pillar measures a company's capacity to generate trust and loyalty with its workforce, customers, and society through its use of best management practices. It is a reflection of the company's reputation and the health of its license to operate, which are key factors in determining its ability to generate long-term shareholder value	**ESGS**
Corporate governance pillar score	The corporate governance pillar measures how well a company's systems and processes ensure that its board members and executives act in the best interests of its long-term shareholders. It reflects a company's capacity, through its use of best management practices, to direct and control its rights and responsibilities through the creation of incentives, as well as checks and balances, in order to generate long-term shareholder value	**ESGG**

Source: own elaboration based on the Refinitiv system description.

$$F_{it} = [A_{it-1},\ B_{it-1}, C_{it-1}\ ] \tag{2}$$

where F_{it} is a vector of micro financial variables, i.e.,:

$$A_{it} = [EBIT_{it},\ TAX_{it},\ TUR_{it}\ ,\ ROA_{it},\ EQ_{it}, COM_{it}, EAR_{it},\ RINV_{it},\ CUR_{it}\ ,\ COV_{it},\ CYC_{it},\ DEBT_{it}, HIS_{it},\ ART_{it},\ VEN_{it},\ FIX_{it},\ WC_{it},\ RET_{it}] \tag{3}$$

where $EBIT_{it}$ is the EBITDA margin; TAX_{it} is the income tax rate; TUR_{it} is the assets turnover ratio; ROA_{it} is the return on assets ratio; EQ_{it} is the total assets to common equity ratio; COM_{it} is the tax complement rate; EAR_{it} is the earnings retention rate; $RINV_{it}$ is the reinvestment rate; CUR_{it} is the current ratio; COV_{it} is the interest coverage ratio; CYC_{it} is the average net trade cycle days; $DEBT_{it}$ is the long-term debt to equity ratio; HIS_{it} is the history net debt to EBITDA ratio; ART_{it} is the net income to liabilities ratio; VEN_{it} is the inventory turnover ratio; FIX_{it} is the fixed assets turnover ratio; WC_{it} is the value of working capital to sale ratio; and RET_{it} is the return on long-term capital ratio.

B_{it} is a vector of explanatory variables connected with the ESG measures, i.e.,:

$$B_{it} = [ESG_{it},\ ESGE_{it},\ ESGS_{it}\ ,\ ESGG_{it}] \tag{4}$$

TABLE 4 | Description of the impact of the financial factors on credit ratings.

Variable Name	Description	Opinion and Previous Studies	Direction
Profitability			
EBITDA margin	This is the annual earrings before interest, taxes, and depreciation expressed as a percentage of the annual total revenue	The higher the EBITDA margin, the higher the credit rating (Altman, 1968; Logue and Merville, 1972; Adams et al., 2003; Galil, 2003; Gray et al., 2006; Fink et al., 2006; Poon and Chan, 2008; Daniels et al., 2009; Murcial et al., 2014; Jiang and Packer, 2017)	+
Effective tax rate	This value is total income tax for the fiscal year divided by the same period's income before taxes and is expressed as a percentage	On the one hand, the higher value of the tax rate decreases profits and increases business costs, on the other hand, higher taxes are connected with higher profits (Fink et al., 2006; Murcial et al., 2014; Jiang and Packer, 2017)	+/-
Earning power			
Asset turnover	The amount of revenue generated for each unit of assets. Also known as TAT. It is calculated as primary revenue for the fiscal year divided by the average total assets for the same period	The higher the asset turnover, the higher the credit rating (Kim and Gu, 2004; Kumar and Bhattacharya, 2006; Matousek and Stewart, 2009)	+
ROA	This item represents the return on assets before taxes. It is calculated as income before tax for the fiscal year divided by the average total assets for the same period and is expressed as a percentage	The higher the pretax ROA, the higher the credit rating (Kim and Gu, 2004; Matousek and Stewart, 2009; Frey, 2013)	+
Earnings retention	This is a ratio of retained earnings to income available to common excluding extraordinary items for the fiscal year and expressed as a percentage	The retention ratio is the portion of earnings kept back in a firm to grow the business. It helps investors determine how much money a company is keeping to reinvest in the company's operations. Growing companies typically have high retention ratios as they are investing earnings back into the company to grow rapidly. The higher the earnings retention rate, the higher the credit rating (Kim and Sohn, 2008)	+
Reinvestment rate	This ratio is calculated by dividing retained earnings for the fiscal year by the average common shareholders equity for the same period and is expressed as a percentage. Retained earnings refer to the income available to common excluding extraordinary items minus gross dividends (common stock)	The reinvestment rate is the return an investor expects to make after reinvesting cash flows earned from a previous investment. It can be negatively affected by interest rate risk, which is the potential for investment losses resulting from changes in interest rates and the reinvestment risk, which is the potential the investor will be unable to reinvest cash flows at a rate comparable to their current rate of return (Kim and Sohn, 2008; Alp, 2013)	+/–
Tax complement rate	This is net income including extraordinary items for the fiscal year divided by income before tax for the same period	The tax complement rate has a positive impact on credit ratings (Fink et al., 2006; Murcial et al., 2014; Jiang and Packer, 2017)	+
Liquidity			
Current ratio	This is the ratio of total current assets for the fiscal year divided by total current liabilities for the same period. This item does not distinguish between current and long-term assets and liabilities	Current ratio from the one side measures a company's ability to pay short-term obligations. On the other hand, the high value of this factor can suggest that management may not be using its assets efficiently (Opler et al., 1999; Baum et al., 2008; Shyam-Sunder and Myers, 1999; Nevitt and Fabozzi, 2000; Matousek and Stewart, 2009)	+/–
Interest coverage	Measures the number of times within a fiscal year the company generates enough operating income to meet its interest payments. It is calculated as earnings before interest and taxes for the fiscal year divided by interest expense for the same period	The higher the value of time interest earned, the higher the credit rating (Kim and Gu, 2004; Tanthanongsakkun and Treepongkaruna, 2008; Matousek and Stewart, 2009; Alp, 2013; Frey, 2013)	+
Average net trade cycle days	This value represents the sum of average inventory (days) and average receivables collection period (days) minus average payables payment period (days) for the most recent trailing 12 months	The higher the average net trade cycle days, the lower the credit rating (Kim and Gu, 2004; Tanthanongsakkun and Treepongkaruna, 2008; Matousek and Stewart, 2009; Alp, 2013; Frey, 2013)	–
Leverage			
Assets/equity	This is the ratio of total assets for the fiscal year to common shareholders equity for the same period and is expressed as a percentage	The higher the value of the assets to equity ratio, the lower the credit rating (Cantor and Packer, 1997; Pottier and Sommer, 1999; Adams et al., 2003; Elayan et al., 2003; Poon, 2003; Kim and Gu, 2004; Gray et al., 2006; Kumar and Bhattacharya, 2006; Alp, 2013; Anand et al., 2016)	–
Debt/equity	This is the ratio of total debt as of the end of the fiscal year to common shareholders equity for the same period and is expressed as a percentage	The higher the value of the debt to equity ratio, the lower the credit rating (Cantor and Packer, 1997; Pottier and Sommer, 1999; Adams et al., 2003; Elayan et al., 2003; Poon, 2003; Kim and Gu, 2004; Gray et al., 2006; Kumar and Bhattacharya, 2006; Alp, 2013; Anand et al., 2016)	–
LT debt/capital	This is the ratio of long-term debt divided by total capital at the end of the fiscal year and is expressed as a percentage. Total capital is the sum of total equity, total debt, and minority interest	The higher the value of the long-term debt to capital ratio, the lower the credit rating (Cantor and Packer, 1997; Pottier and Sommer, 1999; Elayan et al., 2003; Gray et al., 2006; Kumar and	–

(Continued on following page)

TABLE 4 | (*Continued*) Description of the impact of the financial factors on credit ratings.

Variable Name	Description	Opinion and Previous Studies	Direction
		Bhattacharya, 2006; Tanthanongsakkun and Treepongkaruna, 2008; Alp, 2013)	
(Total debt-cash)/ EBITDA	This is the average net debt divided by the EBITDA for the fiscal year. EBITDA is EBIT for the fiscal year plus the same period's depreciation and amortization expenses	The higher the value of the total debt reduced by cash to EBITDA ratio, the lower the credit rating (Gray et al., 2006; Kumar and Bhattacharya, 2006; Elayan et al., 2003; Frey, 2013; Alp, 2013)	–
Operating			
A/R turnover	This item measures the number of times receivables are cycled through in a given period. It is calculated as primary revenue for the fiscal year divided by the average total net receivables for the same period	The higher the value of the A/R turnover ratio, the higher the credit rating (Kumar and Bhattacharya, 2006; Elayan et al., 2003)	+
Inv turnover	This is the ratio of total cost of revenue for the fiscal year to the average total inventory for the same period	The higher the value of the inventory turnover ratio, the lower the credit rating (Kumar and Bhattacharya, 2006)	–
Fixed assets turnover	The amount of revenue generated for each unit of fixed assets. It is calculated as primary revenue for the fiscal year divided by the sum of total net property, plant and equipment, and total net utility plant for the same period	The higher the value of the fixed assets turnover ratio, the higher the credit rating (Kumar and Bhattacharya, 2006)	+
WC/sales growth	This is the change in working capital to sales for the fiscal year	The higher the value of the working capital to sales growth ratio, the higher the credit rating (Frey, 2013)	+
Macroeconomic			
GDP growth	GDP growth	The higher the GDP growth, the higher the credit rating (Altman, 1968; Cantor and Packer, 1997; Chodnicka-Jaworska, 2019)	+
Inflation rate	The inflation rate	The higher the inflation rates the lower the credit rating (Altman, 1968; Cantor and Packer, 1997; Chodnicka-Jaworska, 2019)	–
CO2 emission	This is the CO2 emission metrics tons per capita	The impact of CO2 emission is varied in particular subsectors	+/–
Electric power consumption	This is the electric power consumption in kWh per capita	The impact of renewable energy consumption is varied in particular subsectors and regions	+/–
Renewable energy consumption	This is the renewable energy consumption as a percentage of total final energy consumption	The impact of renewable energy consumption is varied in particular subsectors	+/–

Source: own elaboration based on the Chodnicka-Jaworska (2021).

where ESG_{it} is the ESG combined score; $ESGE_{it}$ is the environmental pillar score; $ESGS_{it}$ is the social pillar score; and $ESGG_{it}$ is the governance pillar score;

C_{it} is a vector of explanatory variables connected with the macroeconomic variables, i.e.,:

$$C_{it} = [GDP_{it}, INF_{it}, CO2_{it}, EL_{it}; REV_{it}] \quad (5)$$

where GDP_{it} is the GDP growth; INF_{it} is the inflation rate; $CO2_{it}$ is the CO^2 emission metrics tons per capita; EL_{it} is the electric power consumption in kWh per capita; and REV_{it} is the renewable energy consumption as a percentage of total final energy consumption.

Z_{it} contains time invariant regressors that are generally dummy variables.

ε_{it} is a random disturbance term.

The strong correlation between ESG measures creates the need to prepare the analysis for factors separately. In the presented analysis, models were prepared in a subsample for each type of sector. Sectors were divided into four groups, i.e., renewable energy, uranium, coal, oil, and gas.

The presented analysis will be presented in two ways. First, which factors are significant for estimation of the energy sector's credit ratings will be assessed. Second, changes of the mentioned independent variables influencing statistically significant credit rating changes will be calculated. As a result, the analysis was also prepared on the first differences. A robustness check was undertaken to prepare the final models.

4 RESULTS

4.1 Environmental, Social, and Governance Factors' Impact on Energy Sector Credit Ratings

The aim of the paper was to analyze the impact of ESG factors on credit rating changes. The analysis was prepared in two parts. First, the impact of only ESG factors on credit rating and the impact of changes of the ESG measures on the credit rating changes were analyzed. The idea was to assess if the mentioned variables were significant during the credit rating assessment by particular agencies, then it was checked if these measure changes were important in later credit rating changes, and if the changes were significant for estimating the default risk changes.

Results of the first estimation of the impact of ESG measures were prepared for long-term issuer credit ratings given by Fitch, Moody's (**Table 5**), and DRBS (**Table 6**) in subsectors. The received findings suggest that the impact of the ESG measures varied for particular credit ratings agencies. For example, notes given by Fitch, DRBS, and Moody's had negative scores on the higher ESG index in the coal subsample. The mentioned situation

TABLE 5 | Impact of ESG factors on credit rating changes according to sector division and type of credit rating agency.

Rating	Fitch				Moody's					
	Oil and Gas		Coal		Oil and Gas		Coal		Renewable Energy	
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
esg	−0.15123	0	−0.09554	0.011	0.03863	0	−0.07411	0.003	0.081384	0.095
/cut1	−5.10695	0	−3.58036	0.089	1.125,193		−3.37053	0.114	3.388,548	0.182
/cut2	−4.60777	0	−3.39394	0.108	1.272,666		−2.87255	0.177	8.19511	0.018
/cut3	−4.59131	0	−1.44071	0.528	1.278,668		−1.36176	0.524		
/cut4	−4.58316	0			1.290,713		0.084292	0.969		
/cut5	−4.55082	0			1.296,753		1.808,512	0.405		
/cut6	−4.47792	0			1.31084					
/cut7	−4.38633	0			1.314,864					
/cut8	−4.15965	0			1.328,919					
/cut9	−4.08636	0			1.803,221					
/cut10	−3.85804	0			2.374,806					
/cut11	−3.56841	0			3.134,004					
/cut12	−3.19328	0			3.521,393					
/cut13	−2.90406	0			3.866,266					
/cut14	−2.86957	0			4.531,447					
/cut15	−2.57122	0			4.85762					
/cut16	−1.77339	0.016			5.271,547					
/cut17	0.070904	0.929			5.980,201					
no obs	1904		64		2,696		203		22	
no group	32		1				5		3	
Wald	0		0		0		0.0034		0.0946	
R2					0.0417					

esg - the ESG, index; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

TABLE 6 | Impact of ESG factors on DRBS long-term issuer credit rating changes according to sector division.

Rating	DRBS					
	Coal		Oil and Gas		Uranium	
	Coef	P > z	Coef	P > z	Coef	P > z
esg	−0.032	0.001	−0.0062	0.399	0.627,096	0.045
/cut1	−3.03758	0	−1.52313	0.011	48.35463	0.043
/cut2	0.616,258	0.229	−1.32461	0.027		
/cut3	1.427,433	0.02	−1.03879	0.081		
/cut4			−0.91997	0.122		
/cut5			−0.55748	0.349		
/cut6			−0.31216	0.6		
/cut7			0.313,372	0.599		
/cut8			1.579,626	0.009		
/cut9			2.310,427	0		
/cut10			3.277,027	0		
/cut11			3.591,681	0		
/cut12			4.157,186	0		
/cut13			5.182,721	0		
no obs	91		773		34	
no group	2		18		1	
Wald	0.0012		0.3992		0.0447	

esg - the ESG, index; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

is an effect of the current regulation about reducing CO2 emissions. The strongest impact was noticed for the Fitch ratings. As mentioned in the introduction, the ESG directive COP26 drew attention to the reduction of using coal as the source of energy production. Some countries decided to withdraw fully from using coal. The mentioned differences between the strength of the impact of the ESG measures on credit ratings were due to varied subsamples and the size of the companies.

A stronger reaction of credit ratings on the ESG index was noticed for Fitch notes for the oil and gas subsector. In the case of DRBS ratings, for the oil and gas subsample, notes were insensitive to ESG factors. The positive impact of the ESG index on credit ratings was noticed for Moody's ratings. The mentioned reaction was connected with using oil and gas as a transition source of energy and the size of companies. As mentioned before, bigger entities, especially from the oil and gas subsector receive higher ESG indexes. The renewable energy subsector in Moody's notes positively reacted to ESG measures. The strongest positive reaction was noticed for the DRBS ratings for the uranium subsector. It is connected with using the energy from uranium and renewable sources as an alternative to the coal and oil and gas subsectors.

The described situation confirms previous findings. A significant impact of the ESG factors on the credit ratings according to Zeidan et al. (2015) and Miralles-Quirós and Miralles-Quirós (2017) was observed. The mentioned reaction was related to various reasons. At first, a positive reaction for the renewable energy subsector was observed. In the mentioned sector, new climate risk ideas were threatened positively by investors. The worldwide policy tends toward pollution reduction and renewable energy is boosted by additional financial sources from governments by receiving subsidies, non-returnable loans, etc. Moreover, some specialized investors, as mentioned earlier, are interested in investing in this type of energy.

On the other hand, the coal subsector reacted negatively, such as in Menz (2010) and Goss and Roberts (2011). They suggested

TABLE 7 | Impact of ESG factors on Moody's long-term issuer credit rating changes according to sector division.

Rating	Coal										Oil and Gas							
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
dESG	−0.02824	0.650							−0.015724	0.355								
dSCORE			−0.050744	0.509							−0.015185	0.544						
dESGE					−0.017664	0.791							−0.002526	0.893				
dESGS							−0.051697	0.231							−0.016735	0.367		
dESGG									−0.001302	0.983							−0.003444	0.815
/cut1	−5.19615	0.000	−5.63711	0.000	−5.19217	0.000	−5.725,407	0.000	−5.176,619	0.000	−7.940,221	0.000	−7.940,193	0.000	−7.93382	0.000	−7.943,194	0.000	−7.93320	0.000
/cut2	−4.48685	0.000	−4.93346	0.000	−4.493,204	0.000	−5.015813	0.000	−4.477,806	0.000	−6.14668	0.000	−6.146,652	0.000	−6.140,267	0.000	−6.149,658	0.000	−6.13964	0.000
/cut3	−4.08560	0.000	−4.52107	0.000	−4.082046	0.000	−4.601,602	0.000	−4.066651	0.000	−5.538,758	0.000	−5.53873	0.000	−5.532,334	0.000	−5.541,742	0.000	−5.53171	0.000
/cut4	−3.79219	0.000	−4.22590	0.000	−3.788,681	0.000	−4.305,523	0.000	−3.773,254	0.000	−5.45139	0.000	−5.451,361	0.000	−5.444,963	0.000	−5.454,374	0.000	−5.44434	0.000
/cut5	4.48673	0.000	4.601,661	0.000	4.471,502	0.000	4.648,048	0.000	4.476,861	0.000	−5.296,524	0.000	−5.296,495	0.000	−5.290,092	0.000	−5.29951	0.000	−5.289,471	0.000
/cut6											−5.227,173	0.000	−5.227,145	0.000	−5.220,739	0.000	−5.230,161	0.000	−5.220,118	0.000
/cut7											−4.999,344	0.000	−4.999,316	0.000	−4.992,909	0.000	−4.992,333	0.000	−4.992,284	0.000
/cut8											−4.796,847	0.000	−4.79682	0.000	−4.790,409	0.000	−4.799,835	0.000	−4.789,782	0.000
/cut9											−4.673,166	0.000	−4.673,139	0.000	−4.666,722	0.000	−4.676,155	0.000	−4.666,095	0.000
/cut10											−3.52938	0.000	−3.529,526	0.000	−3.52306	0.000	−3.53246	0.000	−3.522,427	0.000
/cut11											4.021684	0.000	4.017994	0.000	4.021825	0.000	4.017826	0.000	4.022769	0.000
/cut12											5.529,521	0.000	5.525,844	0.000	5.529,555	0.000	5.525,744	0.000	5.530,486	0.000
/cut13											5.98294	0.000	5.979,257	0.000	5.982,979	0.000	5.979,177	0.000	5.983,897	0.000
/cut14											6.137,451	0.000	6.133,769	0.000	6.13749	0.000	6.133,689	0.000	6.138,408	0.000
/cut15																				
/cut16																				
no obs	178		178		178		178		178		2,787		2,787		2,787		2,787		2,787	
no group	5		5		5		5		5		68		68		68		68		68	
Wald	0.6497		0.5088		0.7905		0.2311		0.9827		0.3551		0.5444		0.8929		0.3669		0.8146	

esg - the ESG, index; score - the ESG, combined score; esge - environmental pillar score; esgs - social pillar score; esgs - governance pillar score; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

that companies that want to increase credit ratings try to use ESG policies. They did not analyze the energy sector, but in this case, this opinion might be correct. ESG policies can be used to improve notes. They thought that it is typical for companies with higher default risk, but in this case, it can be connected with building an opinion in society about reducing emissions and introducing new lower carbon emission ideas. Companies from the coal sector are usually big entities with high capital and their default risk can relate to the lower carbon policy introduced by regulators and governments.

The next step relies on the analysis of changes to the ESG factors on the credit rating changes. The prepared models (**Tables 7–9**) suggest that in most cases the ESG measures changes were unimportant during decisions based on the verification of credit rating changes. The significance was noticed only in the case of the DRBS analysis made for the oil and gas subsector for the ESG index. The mentioned relationship was related to various reasons. At first, it was connected with the subsample. Mostly big companies were included in the analysis, where the ESG factor changes were insignificant. More important was the analysis of the financial condition changes and the other non-financial factors. In some cases, the owner, or one of the stakeholders of the company was the government—especially in the case of the oil and gas and coal subsector entities. The impact of the type of ownership plays a significant role in the decisions about the credit rating changes. The mentioned relationship was observed by Chodnicka-Jaworska (2019) for banks, where companies with the government as a stakeholder received higher notes. The second reason relates to using ESG factors to create an opinion about being socially and environmentally responsible, as was suggested by Perez-Batres et al. (2012). The third cause relates to the low flexibility of the energy sector credit ratings. In most cases, the mentioned notes were not corrected, as a result, in some subsectors, it was impossible to generate an analysis. The subsample was also smaller. It relates to a lower tendency to change credit ratings given for bigger institutions by credit rating agencies and asymmetry of information.

An attempt was made to execute an analysis for the COVID-19 crisis impact on the ESG measures and its changes on the credit ratings. Results of the analysis are presented in **Tables 10–12**, but the sample was small. It was connected with small changes in credit ratings in the mentioned period of time. It can be related to little sensitivity of the energy sector's credit ratings on the COVID-19 crisis and the anticyclical character of these groups of credit rating changes. Prepared analysis for the COVID-19 crisis period suggested that, similar to the entire analysis period, the statistically significant impact of ESG measure changes on credit rating changes was not noticed.

In the case of the impact of ESG measures on credit ratings, there was a stronger reaction of credit ratings on the mentioned variables during the COVID-19 crisis. For notes given by Moody's, the strongest reaction in the case of the oil and gas subsample was observed in the E factor. On the other hand, notes given for the coal subsector by Moody's were more sensitive to the S factor. The analysis made for DRBS suggested that the mentioned ratings in the oil and gas subsample were the equally sensitive to these three groups of factors. It was impossible to prepare this analysis for Fitch ratings due to the sample being too small. The received findings confirmed

TABLE 8 | Impact of ESG factors on DRBS long-term issuer credit rating changes according to sector division.

Rating	DRBS																			
	Total													Oil and Gas						
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
dESG	0.086									0.055158	0.045									
dSCORE			0.043469	0.542									0.0409,915	0.574						
dESGE					−0.006146	0.887									−0.0086665	0.844				
dESGS							0.064886	0.150									0.0633,125	0.161		
dESGG									−0.0102,426	0.800									−0.011504	0.785
/cut1	−6.32302	0.000	−6.29258	0.000	−6.29962	0.000	−6.29815	0.000	−6.298,484	0.000	−6.225,064	0.000	−6.186,046	0.000	−6.1945	0.000	−6.19214	0.000	−6.191,736	0.000
/cut2	−5.62812	0.000	−5.59763	0.000	−5.60461	0.000	−5.60352	0.000	−5.603,598	0.000	−5.529,998	0.000	−5.490,888	0.000	−5.49928	0.000	−5.497,333	0.000	−5.496,667	0.000
/cut3	−4.70676	0.000	−4.6761	0.000	−4.68267	0.000	−4.68211	0.000	−4.681,779	0.000	−4.83325	0.000	−4.793,905	0.000	−4.801,888	0.000	−4.800,466	0.000	−4.799,423	0.000
/cut4	−4.52276	0.000	−4.49205	0.000	−4.49847	0.000	−4.49801	0.000	−4.497,552	0.000	−4.608,329	0.000	−4.568,861	0.000	−4.576,628	0.000	−4.575,371	0.000	−4.574,142	0.000
/cut5	−3.34253	0.000	−3.31451	0.000	−3.32134	0.000	−3.31784	0.000	−3.320,098	0.000	−3.4837	0.000	−3.448,984	0.000	−3.457,132	0.000	−3.452,726	0.000	−3.454,266	0.000
/cut6	4.138,218	0.000	4.10245	0.000	4.08322	0.000	4.14466	0.000	4.086793	0.000	4.048237	0.000	3.99388	0.000	3.973,904	0.000	4.037902	0.000	3.979,267	0.000
/cut7	6.351,615	0.000	6.31452	0.000	6.29534	0.000	6.35613	0.000	6.298,839	0.000	6.264,049	0.000	6.207,642	0.000	6.187,743	0.000	6.250,999	0.000	6.193	0.000
no obs	544		544		544		544		544		489		489		489		489		489	
no group	23		23		23		23		23		21		21		21		21		21	
Wald	0.0858		0.5424		0.8863		0.1501		0.8001		0.0447		0.5732		0.8440		0.1611		0.7854	

esg - the ESG, index; score - the ESG, combined score; esge - environmental pillar score; esgs - social pillar score; esgs - governance pillar score; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

TABLE 9 | Impact of ESG factors on Fitch long-term issuer credit rating changes according to sector division.

Rating	Fitch									
	Total									
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
dESG	0.0097391	0.904								
dSCORE			0.0247,638	0.835						
dESGE					0.0646,185	0.343				
dESGS							0.0813,426	0.119		
dESGG									−0.0793,938	0.027
/cut1	−6.229,878	0.000	−6.223,259	0.000	−6.226,156	0.000	−6.226,504	0.000	−6.418,527	0.000
/cut2	−5.534,759	0.000	−5.528,127	0.000	−5.53103	0.000	−5.531,379	0.000	−5.723,747	0.000
/cut3	−5.127,319	0.000	−5.120,676	0.000	−5.123,582	0.000	−5.123,948	0.000	−5.316,647	0.000
/cut4	−4.837,657	0.000	−4.831,038	0.000	−4.833,913	0.000	−4.834,482	0.000	−5.027327	0.000
/cut5	5.542,303	0.000	5.553,651	0.000	5.63748	0.000	5.735,587	0.000	5.670,722	0.000
/cut6	6.237,414	0.000	6.248,647	0.000	6.332,979	0.000	6.431,531	0.000	6.376,672	0.000
no obs	510		510		510		510		510	
no group	11		11		11		11		11	
Wald	0.9405		0.8321		0.3426		0.1188		0.0267	

esg - the ESG, index; score - the ESG, combined score; esge - environmental pillar score; esgs - social pillar score; esgs - governance pillar score; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

work by Han et al. (2016), English (1999) and Ga-Young et al. (2020) about the varying impact of ESG measure types, even in the same sector.

4.2 Financial and Macroeconomic Situation Impact on Energy Sector Credit Ratings

The next step of the analysis relied on researching the impact of financial and macroeconomic variables on credit ratings and their first differences (**Supplementary Appendixes 1–8**). This research was prepared according to the type of credit rating agency and the type of energy sector. The first group of models was prepared for Moody's long-term issuer credit ratings for coal and gas and oil subsectors. In the case of the coal subsector, a significant impact was observed especially for the E and G factors; the S factor was insignificant. In the case of their changes, their impact was insignificant. Only for Moody's notes was it possible to make this type of estimation. Other agencies published too few ratings numbers or did not change them to verify the mentioned impact. A significant relationship for the coal subsector was observed for CO2 emissions. If the mentioned emissions in a particular country were higher, notes given for entities increased. It was connected with the source of energy and low-carbon policy. The described relationship could also be due to the level of wealthiness of a society. In poor and developing countries, more energy is produced from traditional energy sources. If the CO2 emission is higher, it is usually connected with more sensitive energy production from coal. Usually, the mentioned countries do not have an alternative energy source, or they are more expensive.

In the case of the coal subsector's credit ratings, the statistically significant impact occurred in the inventory turnover ratio, the value of working capital to sale ratio, and the current ratio. The high value of working capital as a percentage of sales decreased credit ratings. It was connected with the reduction in investment and having plenty of cash in the current capital. The mentioned situation in the low-carbon policy—where the investment decisions were connected with finding new, more ecological coal sources and using the newest technologies was important—caused a negative impact on credit ratings. The current ratio had a positive impact on the mentioned situation. Having a higher value of current assets than current liabilities reduced the default risk and problems with short-term insolvency. The inventory ratio—calculated as the cost of goods to average inventory—had a negative impact on the mentioned credit ratings. A high ratio implied strong sales or insufficient inventory to support sales. It also suggested selling coal with a low margin. The mentioned situation also stimulated investments and financing new coal deposits, sometimes with a high cost of extraction. If Moody's changed long-term issuer credit ratings, attention was placed on the average net trade cycle days. The mentioned variable increased notes. It shows how long cash is frozen in the trading cycle before it can be used as cash again. It also shows how much cash is frozen in unsold coal.

The next step relied on the analysis of the oil and gas subsector. The prepared models suggested some important results. At first, similar to the coal subsector, a significant impact of the ESG measures on credit ratings was observed. For Moody's notes, only the G factor was insignificant. For Fitch, the S factor was

TABLE 10 | Impact of ESG factors on Moody's long-term issuer credit ratings according to sector division during the COVID-19 crisis.

Rating	Moody's																	
	Oil and Gas										Coal							
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
ESG	0,0477,516	0,000							–0,1,021,736	0,051								
SCORE			0,063943	0,000							0,1,044,581	0,044						
ESGE					0,062271	0,000							–0,0087195	0,768				
ESGS							0,042159	0,000							0,5,246,135	0,040		
ESGG									0,0221,828	0,000							0,0767,109	0,033
/cut1	1,952,455		3,078277		2,737,041		1,894,245		0,8,340,841		-6,001329		7,744,668		–0,1,601,472		40,03412	5,409,991
/cut2	2,000719		3,131,779		2,794,099		1,944,133		0,8,731,734		-4,617,089		9,232,267		1,022423		44,23393	6,943,803
/cut3	2,024533		3,159,231		2,822,597		1,968,895		0,8,924,743									
/cut4	2,45088		3,633,192		3,337,478		2,407,152		1,250,483									
/cut5	3,603,086		4,904,563		4,699,895		3,579,373		2,283,569									
/cut6	4,137,706		5,485,156		5,300,868		4,122,593		2,803,278									
/cut7	4,702,486		6,098687		5,92879		4,699,517		3,375,059									
/cut8	4,966,461		6,389,925		6,221,153		4,975,242		3,646,185									
/cut9	5,666,149		7,164,154		7,001967		5,714,444		4,368,403									
/cut10	7,085606		8,656,043		8,536,619		7,176,601		5,804,554									
/cut11	8,18811		9,767,161		9,670,525		8,236,644		6,908,897									
no obs	228		228		228		228		228		18		18		18		18	
R2	0,05		0,1070		0,1378		0,0748		0,0202		0,13		0,1464		0,0026		0,8472	0,1985
Wald	0		0		0		0		0		0,0366		0,0265		0,7672		0	0,0098

esg - the ESG, index; score - the ESG, combined score; esge - environmental pillar score; esgs - social pillar score; esgs - governance pillar score; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

TABLE 11 | Impact of ESG factors on DRBS long-term issuer credit ratings according to sector division during the COVID-19 crisis.

Rating	DRBS									
	Oil and Gas									
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
ESG	0.0630,291	0.000								
SCORE			0.0753,644	0.000						
ESGE					0.0567,825	0.000				
ESGS							0.050078	0.000		
ESGG									0.0516,301	0.000
/cut1	1.265,203		1.883,007		0.6,957,609		0.4,808,363		1.574,708	
/cut2	1.650,039		2.289,608		1.123,727		0.8,312,288		1.951,202	
/cut3	2.004363		2.676,946		1.531,133		1.159,339		2.268,156	
/cut4	2.54311		3.277,207		2.146,632		1.695,532		2.713,637	
/cut5	3.928,901		4.868,664		3.720,511		3.146,858		3.903,467	
/cut6	4.596,907		5.667,201		4.452,776		3.904,413		4.58325	
/cut7	4.861,634		6.008605		4.744,499		4.239,094		4.877,285	
/cut8	5.798,501		7.103,017		5.716,919		5.327,981		5.852,529	
/cut9	6.271,277		7.594,678		6.187,187		5.825,098		6.313,501	
no obs	84		84		84		84		84	
R2	0.0595		0.1079		0.1017		0.0784		0.04	
Wald	0		0		0		0		0	

esg - the ESG, index; score - the ESG, combined score; esge - environmental pillar score; esgs - social pillar score; esgs - governance pillar score; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

insignificant, but on the other hand, for DRBS, the only statistically important impact was the G factor. The mentioned situation confirmed the previous opinion about the varied significance of the ESG measures on the cost of capital, here as one of the measures of the higher probability of the default risk. In the case of Moody's subsample, the strongest impact was noticed for S indicators, for Fitch, E indicators, and for DRBS, G indicators. The significance of the S factor was underlined by Weber et al. (2010), Weber et al. (2014), Menz (2010), and Goss and Roberts (2011). They suggested that companies that have a CSR policy pay more for borrowing capital than those that do not have one. Moody's ratings confirmed that opinion. The significance of the E score, according to Stellner et al. (2015), suggested that smaller companies only received positive effects from an E policy. The opinion of English (1999) regarding global interaction between the E factor and limited internal effect of S and G indicators, on the cost of capital, confirmed the presented results; on the other hand, the ESG factor changes, accept DRBS notes, were unimportant for credit rating changes. As a result, companies can try to receive higher credit ratings and introduce ESG policies (Goss and Roberts, 2011). The improvement of the ESG policies was insignificant for change notes.

Next, the impact of macroeconomic variables on credit rating changes was assessed. The significance of the particular factors varied. GDP growth is one of the measures that is used to analyze the wealthiness of a society. In the opinion presented by Fitch, the mentioned variables had a positive impact on credit ratings. In more developed countries, the probability of default of companies from the oil and gas subsector is lower. The analysis prepared in other research suggested that the developed oil and gas sector also had a positive impact on GDP growth. As a result, the mentioned relationship had a spiral effect. The statistically significant impact of the inflation rate was noticed in the case of Moody's notes, but the strength of influence was very low. Low inflation had a positive effect on the economy. If, in the inflation of the basket of goods and services, the costs of oil and gas have a high weight, it can positively influence the financial condition of the mentioned companies. Electric power consumption also has a very weak negative impact on credit ratings. It should be analyzed with the value of coal used to produce energy indicators. Here, the CO2 emission ratio was used to verify the mentioned relationship. This variable had a significant impact on Moody's and DRBS notes and a positive impact on Fitch ratings. The value of CO2 emissions was strictly connected to the coal subsector as an alternative source of energy. In addition, not without significance were regulations taken by governments to reduce CO2 emissions and introduce new technologies to improve the environment condition, new ideas such as electric cars, new engine norms in cars, etc. The described relationship was strictly connected with the mentioned reasons and the analyzed sample.

In the case of the impact of macroeconomic variable changes on credit rating changes, a negative significant impact of CO2 emissions and positive inflation rate changes only for Moody's notes was observed. As a result, the macroeconomic situation, the level of pollution, and the level of economic growth had a significant impact on companies involved in oil and gas subsector financial conditions.

Next, the impact of microeconomic variables on credit ratings of companies from the oil and gas subsector was verified. The mentioned variables were divided into a few groups. The first one was the group of profitability ratios in which factors such as EBITDA margin and the tax income rate are included. From this group of indicators, only the EBITDA margin had a statistically significant impact on credit ratings given by Fitch and Moody's. The mentioned factor measures a company's operating profit as a percentage of its revenue. It is focused on business essentials, its

TABLE 12 | Impact of ESG factor changes on credit rating changes according to sector division during the COVID-19 crisis.

dRating	Moody's										DRBS									
			Oil and Gas										Oil and Gas							
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
dESG	−0.0186,246	0,783									−0.007601	0,943								
dSCORE			0.008639	0,972									−0.0045008	0,994						
dESGE					0.0643,658	0,700									−0.007455	0,995				
dESGS							0.0319,159	0,849									−0.144,467	0,970		
dESGG									−0.0299,705	0,710									−0.000551	0,996
/cut1	−6.033016	0,000	−6.026386	0,000	−6.017021	0,000	−6.023831	0,000	−6.052087	0,000	−4.38971	0,000	−4.394,389	0,000	−4.39441	0,000	−4.39309	0,000	−4.39443	0,000
/cut2	−5.331,014	0,000	−5.324,324	0,000	−5.314,833	0,000	−5.321,556	0,000	−5.34977	0,000	−3.26597	0,000	−3.270,774	0,000	−3.27080	0,000	−3.26947	0,000	−3.27081	0,000
/cut3	−3.415,858	0,000	−3.411,123	0,000	−3.400,919	0,000	−3.408,217	0,000	−3.431,442	0,000	3.694,794	0,000	3.688,954	0,000	3.688,921	0,000	3.690,506	0,000	3.688,903	0,000
/cut4	6.043921	0,000	6.029826	0,000	6.055331	0,000	6.033127	0,000	6.071154	0,000										
no obs					227										82					
no group					66										21					
Wald	0,7827		0,9715		0,7003		0,8486		0,7102		0,9427		0,9935		0,9952		0,9697		0,9964	

d–first differences; esg - the ESG, index; score - the ESG, combined score; esge - environmental pillar score; esgs - social pillar score; esgs - governance pillar score; Wald–Wald test probability; R2—R-squared ratio; no obs–number of observations; no - number of groups. Source: own elaboration.

operating profitability, and cash flows. A stronger relationship was noticed for Fitch ratings, than Moody's. If it rises, higher credit ratings are received by companies from the oil and gas subsector.

The next group of indicators were those connected with the companies' earnings power. In this mentioned group of indicators, factors such as the asset turnover ratio, return on asset ratio, tax complement ratio, reinvestment rate, earnings retention rate, and total assets to common equity ratio were used. The strongest impact of the mentioned variable on credit ratings was on the asset turnover ratio, which measures the efficiency of a company's assets in generating revenue or sales. If it is higher, higher notes are given by the credit rating agency, especially by Moody's. Return on assets had a statistically significant impact on Moody's credit rating. The increase in the total assets to common equity ratio had a negative impact on the credit ratings given by Moody's. The low weight of the common equity in the total assets suggested the high default risk because companies do not have the possibility to finance from the capital if they have issues with solvency. The complement ratio did not have a statistically significant impact on the credit ratings given by analyzed institutions. The reinvestment rate refers to the rate at which cash flows from an investment can be reinvested into another. It is also the amount of interest that an investor can earn when the cash flow from one investment is taken out and placed in another. It creates interest risk when an investor buys a new bond and retains the bond on demand. As a result, the mentioned variable did not have a direct impact.

The next group of factors that was analyzed included liquidity ratios, such as the current ratio, interest coverage ratio, and average net trade cycle days ratio. The high value of the current ratio had a strong positive impact on the Fitch credit ratings. The mentioned relationship between current assets and current liabilities helped to assess the ability to pay off short-term debts. The weak positive (Moody's rates) or negative (Fitch notes) impact was noticed for the average net trade cycle days ratio. It represents the sum of the average inventory and receivable collection period minus the average payables payment period. It presents how long the cash is tied up in the trade cycle before coming back out as cash again. This net number of days can either be positive (usually) or negative. When the net trade days are positive, the company needs to fund those days with net income or a line of credit. When the net trade cycle is negative, the firm is being paid for the service or product before the firm pays its vendor.

The models also verified the impact of the leverage ratios on credit ratings, including the long-term debt to equity ratio and history net debt to EBITDA. The long-term debt to equity ratio suggests that if a company borrows capital for a long time, and if the mentioned indicator is high, it decreases the weight of the equity ratio in total assets. It increases the default risk, so if the mentioned variable is higher, and credit ratings should be lower. The described situation was observed in the case of Moody's and DRBS ratings, where the latter was more sensitive to this factor. Fitch ratings reacted positively to the mentioned variable. It was connected with the type of sample and borrowing capital from banks and capital market as a way to collect money for investment, then finding new stakeholders. Only during the ratings estimation by Fitch was the history of net debt to EBITDA ratio analyzed. If the

mentioned indicator was higher, credit ratings were lower, which was due to the increasing default risk and high value of debt and low incomes to repay it.

The last group of financial indicators that were verified were operating ratios, including the net income to liabilities ratio, inventory turnover ratio, fixed assets turnover ratio, value of working capital to sale ratio, and return on long-term capital ratio. From the mentioned variables, only a few had a statistically significant impact on the credit ratings. The inventory turnover ratio is the rate at which inventory stock is sold or used or replaced. It is calculated by dividing the cost of goods by average inventory for the same period. A higher ratio tends to point to strong sales and a lower one to weak sales. The mentioned variable had a negative impact on notes proposed by Moody's and Fitch. It related to high costs connected with extraction and maintaining oil and gas. The fixed assets turnover ratio had a strong negative impact on credit ratings given by Moody's and especially by Fitch. It measures how well a company uses its fixed assets to generate sales. It is calculated by dividing net sales by net of its property, plant, and/or equipment. It should be compared with competitors. A low ratio shows that a firm does not efficiently use its fixed assets to generate sales. It is worth creditors and investors checking how well a company can repay loans used to purchase equipment. The return on long-term capital ratio quantifies how much return a company has generated using its long capital. On the mentioned variable, sensitive credit ratings were given by DRBS and Fitch. The mentioned relationship varied as it was connected with the sample that had been taken for analysis. The last factor that was only significant for Fitch was the working capital to sale ratio.

The analysis prepared for financial indicator changes on the credit rating changes suggested that when DRBS changed notes, the return on assets ratio was particularly important, however, the relationship was negative. It can be connected with the sample, and it should be analyzed by comparing investment and inventory. In the case of rating changes by Moody's, there was a statistically significant negative impact on the total assets to common equity ratio. The interest coverage ratio determines how easily a company can pay interest on its outstanding debt. It is calculated by dividing a company's earnings before interest and taxes by its interest expense during a given period. The changes of the mentioned variable had a positive impact on the credit rating changes presented by Moody's. A positive reaction of credit ratings on changes of the long-term debt to equity ratio was observed, which was related to borrowing capital from banks and capital market as a way of collecting money for investment, then finding new stakeholders.

5 CONCLUSION

The prepared analysis suggested the existence of the impact of ESG measures on energy sector credit ratings. The hypothesis that ESG measures have had a significant impact on energy sector credit ratings during the COVID-19 crisis has also been confirmed. A stronger reaction of credit ratings during the COVID-19 crisis on ESG factors, than that before it, has also been observed. This confirms the increasing role of ESG measures in the financial market. On the other hand, credit rating agencies take into consideration ESG factors during the first estimation. Later, the mentioned variables lose their importance. This is based on a few reasons. It is still a small sample of entities that publish non-financial statements connected with ESG. Some countries have yet to implement regulations associated with climate risk. The significance of electricity power consumption and CO2 emissions confirm the significance of the mentioned direct or indirect impact of ESG factors. In the near future, it will be worth recalculating the presented models for longer periods, because in some cases, limitations connected with the size of the sample have been observed. Credit rating agencies are not willing to change credit ratings, because usually, companies from the energy sector, especially from coal and oil and gas subsectors, are large entities. They sometimes receive financial support from governments. Governments are also stakeholders that create a lower risk of default. In less developed countries, coal is one of the main energy sources, and costs connected with alternative, renewable energy are more expensive. In future research on a larger sample, it would be worth analyzing the mentioned relationship according to a country's development and a company's size.

The presented study also confirms the need to analyze the impact of the mentioned ESG factors on the long-term credit ratings in subsamples, i.e., coal, oil and gas, uranium, and renewable energy. Credit rating agencies put a lot of attention on the current regulations. The effect of this is the varied impact of the mentioned measures on the credit rating changes. The notes given for the entities from the coal subsector react negatively to these factors. The oil and gas subsector nearly do not react to them. A positive impact has been noticed for the uranium and renewable energy subsectors. It shows that these sectors can be divided into three groups, in which credit ratings react in an opposite manner to the ESG measures. Not without significance is the type of companies' portfolio, especially the size of them. The mentioned analysis will be developed in the future because of the war in Ukraine. Europe's dependence on oil and gas supplies as a source of energy, problems connected with the situation in Ukraine, and presented sanctions can reduce the significance of ESG policies, especially in the case of poorer countries. It is possible that coal will be threatened as a transitional source of energy, but it strictly depends on political decisions and the mentioned war. The mentioned opinion can be observed on the stock prices of the entities from the coal subsector, especially during the first days of war. Next, countries who do not have an alternative method to coal and oil and gas should invest more in the renewable energies.

Credit ratings are sensitive to ESG measures during the first moment of being given notes. It is because the energy sector, especially coal and oil and gas subsectors, belongs to big companies, sometimes with the government as one of the investors. Credit ratings of the mentioned companies are quite stable and do not present fluctuations. ESG measures are also threatened as a marketing tool and a way to promote an environmentally and socially responsible policy. The presented findings suggest that investors should pay more attention to the type of ownership. Also, more attention should be paid to the construction of ESG indexes. The low volatility of credit ratings of companies from the energy sector has been noticed during the COVID-19 crisis. It confirms the

previous opinions about the anticyclical character of these groups of ratings. Prepared analysis for the COVID-19 crisis period suggests that, similar to the entire analysis period, the statistically significant impact of ESG measure changes on credit rating changes is not noticed.

The prepared research also suggests that particular ESG measures have varying significance on credit ratings. Therefore, it can help to analyze and build models by investors. It will not be without significance to estimate the default risk and the cost of the capital. In most cases, the most significant measure is the E factor. In the case of the impact of ESG measures on credit ratings, the stronger reaction of credit ratings on the mentioned variables during the COVID-19 crisis is noticed. For notes given by Moody's, the strongest reaction in the case of the oil and gas subsample comes from the E factor. On the other hand, notes given for the coal subsector by Moody's are more sensitive to the S factor. The analysis made for DRBS suggests that the mentioned ratings in the oil and gas subsample are equally sensitive to these three groups of factors.

The received findings can be useful for lending companies, investors, and regulators. They can also be helpful for companies that would like to receive credit ratings for them to decide which factors they should focus on. They also confirm the opinion that ESG measures are significant for the costs of capital. The presented research also suggests that ESG measures are not the main group of variables that determine credit rating changes.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenrg.2022.817679/full#supplementary-material

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