SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2023
ORGANIZATION AND MANAGEMENT SERIES NO. 178

BACK TO BLACK? MACROECONOMIC ANALYSIS OF HARD COAL SECTOR IN EUROPEAN UNION 1990-2030

Paweł ANTONOWICZ[1*], Liwia DELIŃSKA[2], Jędrzej SICIŃSKI[3], Piotr SLIŻ[4]

[1] Faculty of Management, University of Gdańsk, Sopot; pawel.antonowicz@ug.edu.pl, ORCID: 0000-0002-8673-1044
[2] Faculty of Management, University of Gdańsk, Sopot; liwia.delinska@ug.edu.pl, ORCID: 0000-0002-1183-6247
[3] Faculty of Management, University of Gdańsk, Sopot; jedrzej.sicinski@ug.edu.pl, ORCID: 0000-0001-6810-3792
[4] Faculty of Management, University of Gdańsk, Sopot; piotr.sliz@ug.edu.pl, ORCID: 0000-0001-6776-3369
* Correspondence author

Purpose: The purpose of the article is to present the results of a PEST analysis of the legal, economic, social and technological determinants of hard coal market development in the European Union from 1990 to 2030.
Design/methodology/approach: The research process was carried out with the use of four methods: analysis and synthesis (1) critical review of the literature (2), statistical techniques (3) and an industry case study (4).
Findings: Detail regulatory (legal), economic, social (socio-cultural) and technology variables affecting the hard coal market have been identified. All the factors examined exhibited a destimulating effect on the development of the market, from the perspective of the entities operating on the hard coal extraction and utilization market in the European Union. The most pronounced negative effect stems from the social factors. The impact of the legal and economic determinants is of similar magnitude, whereas technological changes show the lowest potency in this regard.
Research limitations/implications: Dynamic geopolitical changes and high susceptibility to interventionism can significantly affect the deviations of point forecasts in the pest coal industry in the long run.
Practical implications: PEST analysis is used to assess the development of economic sectors regardless of the industry life cycle phase. It can also help determine a given industry's life cycle phase and its future migration trends in practice.
Originality/value: The originality of this article lies in the employment of the quantification of macroenvironmental areas significantly affecting the industry, using an authorially modified PEST-based analysis.

Keywords: coal market; hard coal trade; economy of fossil fuels; PEST analysis.

Category of the paper: Research paper.

1. Introduction

The hyper-turbulent economic environment is shaping the functioning of many sectors of the economy in the European Union. The geopolitical situation associated with the conflict in Europe has driven the COVID-19-pandemic-related problems of broken supply chains to persist. It has also generated a state of affairs in which actions are being taken in the legal, economic, social and technological dimensions to accelerate the regulatory efforts and policies aimed at the search for alternative energy sources. This is accompanied by a change in the way hard coal, which once constituted a key factor in Europe's energy security and today is still of no small importance to EU industry and heating, is perceived. What is more, the uncertainty with regard to the price and availability of an interim fuel, i.e., natural gas, has been intensifying discussions on the future of hard coal and strategies for the sector in coming years.

The research problem was formulated into a question of the following wording: What are the main legal, economic, social and technological determinants of hard coal market development in the European Union between 1990 and 2030? The structure of the research problem, in terms of the areas studied, refers to the assumptions of the PEST analysis, which predetermined the shape of the research questions (RQ) and the main objective. The implementation of the method of diagnosing the PEST environment for the assessment of this sector also determines the originality of this study.

- RQ1: What changes in the legal framework governing the mining, transportation and processing of hard coal have affected and may affect the functioning of the hard coal market in the European Union?
- RQ2: Which economic factors have determined the development of the hard coal market in the European Union most heavily?
- RQ3: Which social factors should be addressed, and what is the impact thereof on the development of the hard coal market in the European Union?
- RQ4: What is the relevance of technology in the context of hard coal mining and processing in the European Union?

The structure of the research questions has delineated the main objective of the article, which is to present the results of a PEST analysis of the legal, economic, social and technological conditions affecting the development of the hard coal market in the European Union from 1990 to 2030. The article aims to provide knowledge of the factors which have shaped the hard coal market, as well as the potential significance thereof in the future. In order to implement a research problem and objectives formulated as such, the methods of literature review and PEST analysis were used.

In summary, the main axis of this article is aimed at an attempt to assess the current state, forecast the future state and identify potential challenges to the development of the hard coal market in the European Union. The Authors also draw attention to the fact that the originality

of this article lies in the use of highly operationalized PEST analysis, incorporating an economic perspective on problem solving and challenge assessment within the hard coal market. The economic dimension of the assessment can facilitate identification of the coal market transition supporting potentials and limiting factors, taking the interdisciplinary nature of the issue under study into account.

The article is organized into 4 parts. The first outlines the theoretical background to the research problem formulated, to establish the current state of knowledge. The methods section presents the methodology adopted and the structure of the data used in the PEST analysis. Part 3 presents, and comments on, the partial results for the legal, economic, social and technological dimensions. The final section (discussion) elaborates on the results obtained, while the conclusion presents the factors likely to affect the sector examined in the longer term, i.e., after 2020. Study limitations and directions for further research have also been outlined.

2. Literature review

The COVID-19 pandemic (Gałaś et al., 2021; Wang et al., 2022) and the conflict in Ukraine have generated a set of exogenous factors sharply affecting the operation of the energy sector (Nerlinger, Utz, 2022a). This applies to both the global perspective (Guenette et al., 2022; Khudaykulova et al., 2022), as well as the functioning of companies within the energy sector itself (Nerlinger, Utz, 2022b). Following the COVID-19 pandemic (2020-2022), a global cost-of-living crisis, characterized by rising levels of energy poverty, has emerged (Benton et al., 2022). Currently, as of February 24, 2022, the war in Ukraine has been generating a scenario in which the risk of energy poverty appears to be increasing, as the Russia-Ukraine conflict affects both the conventional and renewable energy markets (Umar et al., 2022). Moreover, the high energy and food prices pose a direct threat to human security, in the context of post-pandemic inflation and limited fiscal capacity, particularly among low-income and vulnerable populations in all economies (Benton et al., 2022).

The rationale presented here renders it necessary to examine the determining factors of selected energy sectors in EU countries for years 2020-2030, using data from 1990 onwards. The hard coal sector is, in the Authors' opinion, a sector requiring such analysis. Coal extraction in the European Union countries, particularly in countries such as Poland and the Czech Republic, historically constituted a key branch of the economy. The literature review made it possible to determine that, according to the current state of knowledge, there is a shortage of research in this sector using retrospective analysis (past) and an attempt to assess the shaping of trends in the future. In addition, no one has previously assessed this sector using PEST analysis, so the approach proposed by the authors will be pioneering. The analysis of the European Community's coal sector determinants is of particular importance, as it fills, at least

in part, the cognitive gap regarding the paucity of publications outlining the directions of coal sector development through adoption of multiple evaluation criteria. To be more precise, the article focuses on presenting the legal, economic, social and technological conditions affecting the development of the hard coal market in the European Union in the period 1990-2030, using PEST analysis. The rationale behind the employment of PEST analysis stemmed from the studies of the literature on the subject, which revealed that the context of hard coal market operation is linked to the areas of: legal and political regulation (See: Hámor, 2004; Brauers, Oei, 2020), economics (See: Dorian, Humphreys, 1994; Anderson, 1995; Manowska et al., 2018), sociology (See: Ponomarenko et al., 2016; Mancini, Sala; 2018; Manowska et al., 2018; Yousefian et al., 2024) and technology (Shoko et al., 2006; Allen, 2012; Kaczmarek et al., 2022).

3. Materials and methods

The research process was carried out using four methods: analysis and synthesis (1) critical review of the literature (2), statistical techniques (3) and industry case study (4). Conventionally in science, the case-study method is most often implemented to assess unit enterprise cases (e.g., a single entity), but its potential in sectoral analyses should be likewise emphasized (Lindgreen et. al., 2021). The overarching goal of the study was achieved by means of a PEST-type macroeconomic environment analysis technique. The name (PEST) is an acronym referring to four preeminent sources of variability flowing from the downstream environment, namely the political, economic, social and technological spheres (Sammut-Bonnici, Galea, 2015). The result of the PEST analysis provides a diagnosis of the most important spheres of the environment which, in current as well as future terms, will require appropriate strategic adjustments to the object under study. This method is widely recognized in both the scientific as well as the practical domain, owing to its universality and timelessness. The solution was first proposed by F. J. Aguilar, who suggested that the approach provides an apt starting ground for scanning the business environment and the forces piling up within it (Aguilar, 1967). The PEST model also serves as a complementary reinforcement of other strategic analysis methods, such as SWOT analysis and M.E. Porter's five forces model. Its versatility is practically unlimited – the method shows high application value in terms of studying entire economies, sectors (emerging as well as declining), business entities, nonprofit and sports organizations (Antonowicz, Jedel, 2015), as well as individual organizational units, as exemplified by, for instance, its successful implementation in the study of the academic library environment (Cox, 2021). Inherent in the process of PEST-based diagnosis is the use of ‘brainstorming’, which is particularly suitable when determining and listing the factors within a given sphere of the environment, including the associated risks (Butryn et al., 2015).

The analysis of the coal sector, carried out by the Authors, followed a hybrid (i.e., facilitated by other research methods and techniques) implementation schedule for each phase of the PEST technique. The general course of this process is presented in Table 1.

Table 1.
The course of the implemented PEST-model-employing research on the hard coal sector - proposed hybrid method

PEST analysis phase	Phase description	Phase objective	Accompanying research methods and techniques in a given phase		
			Literature analysis	Brainstorming	Statistical techniques
1.	Identification of the most relevant factors within each area, i.e., the political, technological, social and economic spheres.	Compilation of a list of the most critical forces of influence in the coal sector, within each PEST area.	Yes	Yes	No
2.	Assessment of the strength and trend in the identified forces affecting the coal sector.	Each of the forces designated was assigned an appropriate intensity of impact (-5;+5), followed by establishment of long-term trends within the four PEST areas.	Yes	Yes	Yes
3.	Assessment of the weights of influence for individual forces.	Each of the forces designated was assigned an appropriate weight within the area plane, factoring in the fact that the weight ratings for a PEST i-area must meet the condition: Σ=100%	Yes	Yes	Yes
4.	Visualization of the results, estimation of the gap in the sector's potential, and proposed strategic diagnosis for the sector through 2030.	Demonstration of the long-term trends and regularities in the impact of environmental forces on the coal sector, including assessment of shortage in the industry's potential.	Yes	No	Yes

Source: own elaboration.

In the first phase, a literature review was carried out to identify the most relevant environmental forces affecting the sector within specific areas, i.e., the political, technological, social and economic spheres. The team of Authors, through brainstorming, reduced the initial list of forces to those of greatest relevance, taking the expert opinions presented in specialized industry reports on hard coal into account. Once the environmental forces were identified and reduced, each force was assigned an appropriate direction and intensity of impact on the sector under study (-5; +5). This process was carried out in two rounds and backed up by a re-analysis of the literature, including a review of the industry reports factoring in the industry opportunities and development risks, as well as a review of European statistical data from 1990 onward. The first round of designating the forces of influence was carried out by each of the Authors in the form of blind analysis, as an effect of the expert evaluation and literature review. In the second round, the final impact intensity rating assigned to a given force entailed the

arithmetic mean of all the Authors' indications developed via blind analysis, which was ultimately confirmed through renewed brainstorming. The third stage was characterized by a procedure similar to the second - here, however, the subject of estimation and averaging were the weights (relevance ratings) of a given force within each sphere of the PEST analysis. As per the methodology macroenvironment environment analysis techniques, the sum of the weights for a given area needed to be equal to 100%. In this phase, the formulation of weights was coupled with other research methods, due to the need to examine coal-sector-related industry reports and publications of a statistical nature. The final stage, which synthesized the results of the preceding phases, entailed graphical presentation of the long-term development trend for all identified forces, estimation of the gap in the industry's potential, and diagnosis of strategic implications for the sector through 2030.

4. Results

4.1. Regulatory (legal and political) determining factors

State interventionism is defined as the main state administrative function in the shaping of economic order taking social expectations into account (Kraśniewski, 2018). Based on the literature study, the following premises were factored into the summative assessment of Variable 1A: EU member states' implementation of national energy sector development programs (e.g., in Poland: Strategia na Rzecz Odpowiedzialnego Rozwoju [Strategy for Responsible Development], 2017), EU member states' internal policies regarding coal mining regulations and limits (See: Szczerbowski, 2018), the decreasing volume of coal mined in Europe and Poland (Eurostat, 2023d), the declining number of coal-mining countries within the EU (Eurostat, 2023d), the efforts to seek energy sources alternative to hard coal, the realization of European decarbonization goals by 2050 (See: Searle, Christensen, 2018) and The European Green Deal (Pleßmann, Blechinger, 2017a, 2017b). It should be noted here that Poland is the main hard coal miner in Europe (Eurostat, 2023d), but the volume of mining in million tons has decreased fourfold between 1980 and 2020 (Frużyński, 2009; Geoportal, 2023). The summative assessment of the area in question, presented in Table 2, is the resultant of the incorporation of the aforementioned criteria. Noteworthy is the change in perception, from the perspective of the coal sector of 2000-2010, caused by the limits on hard coal mining in the European Union, and the restrictions on hard coal im-ports into the EU, particularly considering year 2022 (embargo on coal from Russia) (Eurostat, 2023a). Summing up, the regulatory perspective of European Union (EU) countries exerts strong influence on the coal sector. In recent years, the EU has been laying emphasis on greenhouse gas emission reduction, pushing the member states to reduce emissions from fossil fuel-based, primarily coalfired, power generation.

Table 2.
Regulatory (legal) market development determinants in the coal mining and coal power generation sector – weighted assessment of 1990-2030 market changes in the European Union

No.	Regulatory (legal) determinants of coal mining and coal power generation market development	WEIGHT		a RATING (from -5 to + 5) b weighted RATING (product of weight and rating)				
				1990	2000	2010	2020	2030
1a	Level of state interventionism (mining restrictions, embargoes, regulated prices, subsidies and coal purchase aid)	17.50%	a	3.00	2.00	0.25	-1.00	-2.25
1b			b	0.53	0.35	0.04	-0.18	-0.39
2a	Energy mix - the role of hard coal substitutes	26.25%	a	2.00	0.75	-1.25	-2.50	-3.50
2b			b	0.53	0.20	-0.33	-0.66	-0.92
3a	Geopolitical determining factors of hard coal distribution (import/export disruptions, regulatory framework for the operation of coal depots)	18.75%	a	-0.25	0.00	2.25	0.25	-2.75
3b			b	-0.05	0.00	0.42	0.05	-0.52
4a	CO2 emission rights market (free movement of rights, level of restrictions, risk of speculation)	20.00%	a	0.00	-1.00	-2.00	-3.25	-4.25
4b			b	0.00	-0.20	-0.40	-0.65	-0.85
5a	Level of intra-Community law harmonization - the level of autonomy in the formation of Member States' energy policies	17.50%	a	4.00	2.50	0.75	-2.00	-3.25
5b			b	0.70	0.44	0.13	-0.35	-0.57
TOTAL		100.00%	-	1.70	0.78	-0.13	-1.78	-3.25

Source: own elaboration.

The expert assessment of Variable 2A incorporated such factors as the global growth of energy consumption (both European and worldwide), and the increase in the prominence of alternative energy sources in the mix (oil, nuclear energy, natural gas, renewable energy). To be more precise, it is worth noting the significant increasing the role of wind power production in the European Union since 2015 (See: Katić et al., 2012). The resultant assessment structure clearly indicates that a change in the assessments, from the coal sector's perspective, is discernable after 2000. The rationale behind the negative values in Table 2 primarily stemmed from the drop in the share of coal in the energy mix, both in Europe and globally (2000-2020). "The structure of primary energy carrier consumption is largely determined by its availability, understood both as the possession of own resources as well as the potential to obtain resources on world markets" (Czaplicka-Kolarz, Pyka, 2007). It is worth noting that each EU country is free to create its own energy mix. Hard coal resources in Poland – the main extractor of this resource in Europe – can provide energy security for several decades, hence hard coal and lignite are recognized as the country's security stabilizer and is disposed to play an important part in the national (Polish) energy mix (Kielerz, Porzerzyńska-Antonik, 2019). To sum up, the energy mix plays a key role in the issue under study. Increasing the share of renewable energy sources, such as wind and solar, can support greenhouse gas emission reduction as well as strengthen energy independence. It is worth emphasizing here that a more sustainable energy mix requires investment in new infrastructure, advanced technologies and smart energy systems.

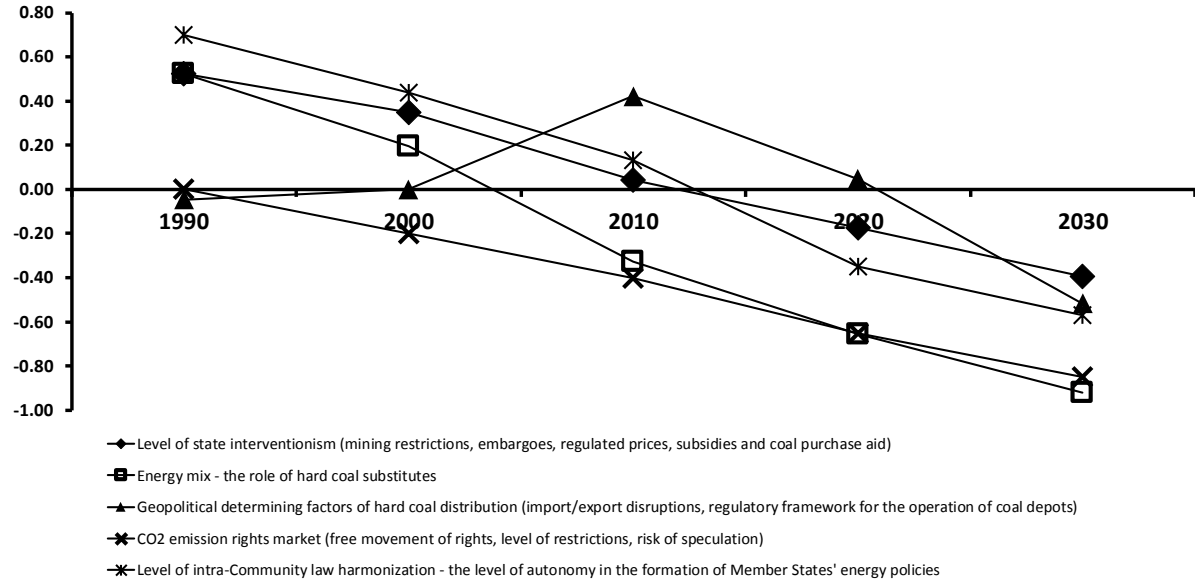

Figure 1. Weighted rating of the variables affecting the regulatory (legal) environment of the EU coal mining and coal power generation market in 1990-2030.

Source: own elaboration.

The geopolitical outlook in European Union countries exerts strong influence on the coal sector. Decisions on energy policy and energy supply within the EU, but also on the import and export of raw materials are largely determined by strategic factors. It should be noted here that, in terms of hard coal, European countries used to rely heavily on imports of this raw material from Russia. This has generated efforts to diversify the sources of energy, in order to reduce dependence on the imports from Russia. This section of the assessment focuses on the determining factors of coal distribution, from the perspective of the geopolitical premises determining the functioning of the coal sector in Europe. The experts' assessments were positive until 2020, which was related to the increase in coal imports to EU countries between 1990 and 2020, from 8.49 million tons (1990) to 43.7 million tons (Eurostat, 2023c). It is also worth noting that the positive assessments during the period in question were associated with the volume of hard coal exports by EU countries (Eurostat, 2023b). Conversely, the main post-2020 factors taken into account in the experts assessment included: the war in Ukraine and the embargo on the import of coal from Russia to EU countries, as well as the internal regulations of member states on restrictions on trade in raw materials from Russia. In sum, the factoring in of the geopolitical perspective into the analysis carried out was crucial considering the coal sector under study. This is sup-ported by such premises as the implementation of the EU and member countries' energy policies, the supply of energy, but most importantly the efforts to protect the climate and the search for alternative sources of energy located outside the countries covered by the embargo on imports.

This section of the assessment primarily covered two parameters, the first of which entailed the implementation degree of EU CO2 Emissions Trading System phases in years 2005-2021. According to Kaczyński et al., 2019, starting in 2021, phase 4 began, which has affected the

negative assessment for 2020 and 2030 (See: Table 2). Moreover, the assessment incorporated the current price of CO2 emission rights (up to 2020) (IBISWorld, 2022) and the projected increase in the EU ETS price of CO2 emission allowances. It is worth noting here that in 2023, the price per tCO2 emission exceeded 100 euros. From the coal sector perspective, the measures to reduce CO2 emissions, as well as the increase in the price of EU-ETS, have caused the industry to be associated with negative assessments (since 2000) in the period under review. From the perspective of the coal sector in Europe, the implementation of CO2 emission regulations and the EU-ETS has made coal-fired generation of electricity less profitable, whereas the cost of emissions has been included in the cost of energy production. This means that the implementation of formulated climate targets within the EU (see, e.g., climate neutrality by 2050, decarbonization) results in a need to reduce the coal sector's CO2 emissions and abandon the use of coal in the long term.

The sphere concerning the level of intra-EU harmonization of laws exerts significant influence on the coal sector, particularly within the con-text of hard coal mining and coal use as a raw material for generation of electricity. Intra-Community regulations cover a number of aspects, such as environmental protection (CO2 reduction) and the external/internal trade rules. The ongoing efforts to harmonize the EU law are causing the demand for hard coal in the community to decrease significantly. This has been expressed by the hard coal mining parameters, the number of coal-producing countries, but also the volumes of coal imports and exports. One of the effects of legislative harmonization are the directives and regulations on greenhouse gas emissions, resulting in lower profitability of hard coal in relation to other energy sources (such as gas). According to the Authors, the EU directives on environmental protection and CO2 emission reduction, but also the search for alternative (renewable) sources of energy, have contributed to the post-2010 decline in the demand for in-vestment in the coal sector.

4.2. Economic determining factors

The economic environment has a nonnegligible impact on the hard coal sector in Europe. Despite the fact that production of coal is already at a marginal level in most EU countries (Grudziński, 2019), and it is not uncommon for the actors in this sector to be offered various central-budget financial respiration mechanisms, the sector remains vulnerable to the forces flowing from selected economic spheres. This is due to the multi-dimensional relationship between hard coal and other goods (substitutes and complementary goods) as well as the direct impact thereof on the formation of energy derived demands. The hard coal sector remains an important employer, not only regionally but also nationally - which is particularly the case in countries such as Poland, Germany and the Czech Republic. Human resources, trained and experienced in working with hard coal, customarily comprise highly competent personnel, who often possess narrow yet very specialized technical skills. The aspect of the potential re-skilling of miners, particularly hard coal workers, has been debated for years by the community countries. Among others, a study on the restructuring of the coal sector, carried out in 2009

(Dubiński, Turek, 2009), draws attention to this thread. It is thus reasonable to include a factor quantifying the important role labor market plays within the coal sector in environmental analysis. A number of transformations are currently observed on this labor market and incentives to participate in the process of reskilling towards the renewable energy sector are being undertaken. The steadily declining enrollment in technical mining classes (a phenomenon observed in Poland and the Czech Republic), as a consequence of lower interest among young people in entering this profession is also noteworthy (Energetyka24.com, 2023). The prospects for the next few years do not seem to be bright – the negative impact of the labor market economics factor will intensify. This also follows from the administrative guidelines regarding carbon dioxide emission reduction, and the coal sector extinguishment policy supporting the realization of this goal through e.g., offers of financial incentives for miners to retire sooner, which exacerbates the negative impact of the labor market on the sector under study.

Table 3.
Economic (business-related) market development determinants in the coal mining and coal power generation sector - weighted assessment of 1990-2030 market changes in the European Union

No.	Economic (business-related) determinants of coal mining and coal power generation market development	WEIGHT		a RATING (from -5 to + 5) b weighted RATING (product of weight and rating)				
				1990	2000	2010	2020	2030
1a	Level of coal mining sector concentration - relevance to the labor market	21.25%	a	-1.50	-0.25	-1.25	-2.50	-3.75
1b			b	-0.32	-0.05	-0.27	-0.53	-0.80
2a	Share of coal mining sector in GDP of member states	20.00%	a	1.75	1.25	0.00	-2.00	-3.25
2b			b	0.35	0.25	0.00	-0.40	-0.65
3a	CSR relevance and costs - internalization of external costs (inter alia, environmental costs)	16.25%	a	0.00	-0.75	-1.75	-2.50	-3.75
3b			b	0.00	-0.12	-0.28	-0.41	-0.61
4a	Industry-sector profitability	25.00%	a	1.75	0.50	-2.75	-0.75	-3.75
4b			b	0.44	0.13	-0.69	-0.19	-0.94
5a	Level of investment in mining and logistics infrastructure	17.50%	a	2.50	1.75	-0.75	-2.00	-3.00
5b			b	0.44	0.31	-0.13	-0.35	-0.53
TOTAL		100.00%	-	0.91	0.51	-1.37	-1.88	-3.52

Source: own elaboration.

Until a decade or so ago, mining constituted an important, and for many European countries even a priority, economic area in terms of the contribution of generated added value to gross domestic product (Eurocoal, 2023). This state of affairs provided a natural stimulus for new investments and the development of mining as the flywheel of many economies. It should be emphasized, however, that European regions, which currently as well as in the past relied significantly on coal production, today in the vast majority show levels of GDP per capita lower than the average of their respective countries (Alves Dias et al., 2018). Accordingly, it is reasonable to consider the inclusion of a factor representing the coal sector's share in the GDP of European Union countries in the PEST environment analysis as legitimate. As highlighted above, the development trend of this factor should be assessed and forecast negatively – which corresponds to the average expert impact ratings ranging from +1.75 in 1990 to -3.25 in

the closing period of the analysis (2030). This can be explained by the increasing concentration of production structure in the EU countries and the pan-European downward trend of the so called coal rents, measured as a share of GDP (Data World Bank, 2023).

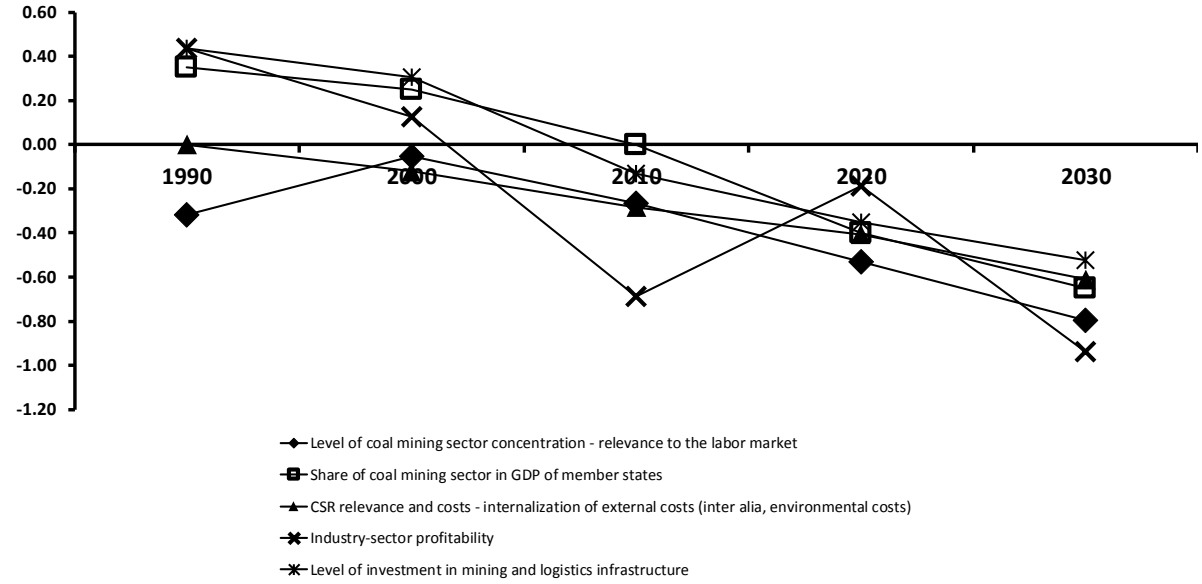

Figure 2. Weighted rating of the variables affecting the economic environment of the EU coal mining and coal power generation market in 1990-2030.

Source: own elaboration.

Another important economic factor, which conditions the health of the coal sector, pertains to the sphere of CSR and the costs of internalizing the externalities of coal production. Despite the fact that the sphere of mining externality reclamation and internalization can in itself create additional jobs and generate added value for the economy (creation of so-called 'green jobs') (Czyżak, Kukuła, 2020), the overall impact of this force on the coal sector is negative. The direction of the factor's impact on the coal production sector, as well as the trend in its intensity, should therefore be considered (as well as projected for the future) as eminently unfavorable. This can be substantiated by the increasing scale and cost of externality internalization (including subsequent reclamation) by hard coal mining sites, as well as the exclusion of the coal energy sector from financial support via the so-called EDM mechanism[1] (Czyżak, Kukuła, 2020).

The next aspect of the economic environment analyzed pertains to the general decline in the sector's profitability, which has been evident almost continuously over the years. This phenomenon has been apparent, for instance, in the previously mentioned historically low, in relation to GDP, level of coal rents in Europe (World Bank, 2023), the increasing burden of

[1] EDM - Early Decommissioning Mechanism: "The Early Decommissioning Mechanism (EDM) supports numerous coal-fired power units, which should be decommissioned sever-al years earlier EDM does not comply with a Paris Agreement-compliant coal budget avail-able for Poland", source: Czyżak, Kukuła (eds.) (2020). *Monopol węglowy z problemami. Analiza restrukturyzacji polskiego sektora energetycznego (Poland's planned coal monopoly – who pays the price? Analysis of the restructuring of the Polish power sector).* ClientEarth & Instrat.

CO2 emission rights prices, and the low number of newly com-missioned mining operations in the community, which generally entails extraction of deeper and less profitable coal seams. It should be emphasized, however, that the years 2022-2023 may bring about a temporary return to profitability for many coal mines (due to the strong volatility of coal quotations as a result of the war in Ukraine). In addition, a significant challenge for stable profitability is also the significant seasonality of sales in the sector (Rybak, Manowska, 2017). The higher value of the market surpluses captured by hard coal producers, in turn, is likely to worsen the financial condition of such industrial coal consumers as thermal power plants, power plants and steel mills. This induces the need to implement shielding mechanisms addressed to mass consumers of hard coal (including plants of strategic continuity), which are costly for the budget. As such, the direction and strength of the impact exerted by this factor (profitability) on the sector's overall health, proposed in the PEST analysis, has been based on a data-supported assumption that a general decline in hard coal production profitability is observed in the 21st century (Jonek-Kowalska, 2014). Moreover, according to the Authors of the study, the short-term increase in the sector's profitability, associated with the strong volatility of coal price quotations to the advantage of the mining sector in the midst of the war in Ukraine, will not have a lasting impact and is not going to reverse this long-term trend.

The last factor identified in the economic sphere of the PEST analysis is the level of investment in mining and logistics infrastructure. This factor, in the Authors' opinion, shall be characterized by a negative impact trend and an increasing (negative) effect on the coal production sector. Motivating arguments for this choice include the general trend of moving away from coal, the administrative targeting of EU funds on investments in the low-carbon economy (Dembicka-Niemiec et. al., 2023), as well as the increasing importance of ESG reporting and the consequent change in bank financing policies, e.g., limited crediting of new coal assets and the rise in the adoption of the so-called green banking (Zhang et al., 2022).

4.3. Social (socio-cultural) determining factors

Hard coal extraction and coalfired generation of power have driven human progress and fundamentally transformed societies. Nevertheless, the impact of the long-term use of fossil fuels on the environment and human health is substantial (Finkelman et al., 2021). Climate change has become a major environmental problem on a global level. The progressive degradation of the environment is forcing reduction of carbon dioxide emissions, which are the main cause of most of the adverse climate changes (Moreira, Pacca, 2020). Coal combustion accounts for 40% of global CO2 emissions from energy consumption (Jakob et al., 2020). In 2008, the European Union set a goal of reducing greenhouse gas emissions by 20% from the levels of 1990. This target has been met, with GHG emissions down by 24% in 2019 and 31% lower in 2020 (compared to 1990 levels). A new target was set in 2021 to reduce greenhouse gas emissions by at least 55% from the 1990 levels by 2030 (Europarlament, 2018).). To keep global warming below 1.5°C, most of the world's coal resources must remain unextracted

(Welsby et al., 2021). Pursuant to the Paris Agreement, this will be feasible if the world achieves zero emissions or climate neutrality by 2050 (Intergovernmental Panel on Climate Change, 2018). Summing up, the decade-to-decade increasing awareness of the climate ramifications resulting from the production and use of hard coal is affecting the sector under study adversely.

Table 4.
Social (socio-cultural) market development determinants in the coal mining and coal power generation sector - weighted assessment of 1990-2030 market changes in the European Union

No.	Social (socio-cultural) determinants of coal mining and coal power generation market development	WEIGHT		a RATING (from -5 to + 5) b weighted RAITING (product of weight and rating)				
				1990	2000	2010	2020	2030
1a	Awareness of the impact of coal production and use, in the context of environmental changes (including climate change)	17.50%	a	2.25	1.00	-1.25	-3.00	-4.75
1b			b	0.39	0.18	-0.22	-0.53	-0.83
2a	Awareness of the impact of coal production and use in, the context of health (health care, preventive care)	26.25%	a	0.00	-1.25	-2.50	-3.50	-4.50
2b			b	0.00	-0.33	-0.66	-0.92	-1.18
3a	The role of carbon footprint in consumer purchasing decisions (sustainable consumption - changes in consumer behavior)	11.25%	a	1.50	0.25	-1.25	-2.75	-4.00
3b			b	0.17	0.03	-0.14	-0.31	-0.45
4a	Consumers' absorption of alternative energy sources	28.75%	a	2.75	1.00	-1.00	-2.75	-4.75
4b			b	0.79	0.29	-0.29	-0.79	-1.37
5a	Labor market supply formation	16.25%	a	3.25	1.75	0.50	-1.00	-1.75
5b			b	0.53	0.28	0.08	-0.16	-0.28
TOTAL		100.00%	-	1.88	0.45	-1.22	-2.71	-4.11

Source: own elaboration.

Coal combustion releases a mixture of hazardous substances, which inhaled pose a serious threat to human health (Gasparotto, Martinello, 2021). The emission of harmful substances into the air, in particular, leads to the development of respiratory diseases. It is estimated that in Europe, carbon kills approximately 23,300 people each year, and the annual eco-nomic cost of the health implications caused by coal combustion is about $70 billion (EndCoal, 2020). Climatologists and epidemiologists have modeled scenarios demonstrating that faster reductions in carbon emissions (to stabilize heating at 1.5-2°C) would prevent 150 million premature deaths globally between 2020 and 2100 (Shindell et al., 2018). Even though, coal mining in most countries is much safer than it was just a few decades ago, hundreds or thousands of miners lose their lives every year (Cunningham, 2014). Moreover, this occupational group is particularly vulnerable to coal workers' pneumoconiosis, the so-called black lung dis-ease (Markandya, Wilkinson, 2007). Awareness of the impact of coal pro-duction and use, in a health context, has followed a similar trend as awareness of climate consequences. The Authors nevertheless assigned a higher weight to this factor, on account of the psychological aspects of the determinants affecting the direct and perceived determinants of change, at the level of individuals, rather than the world as a whole.

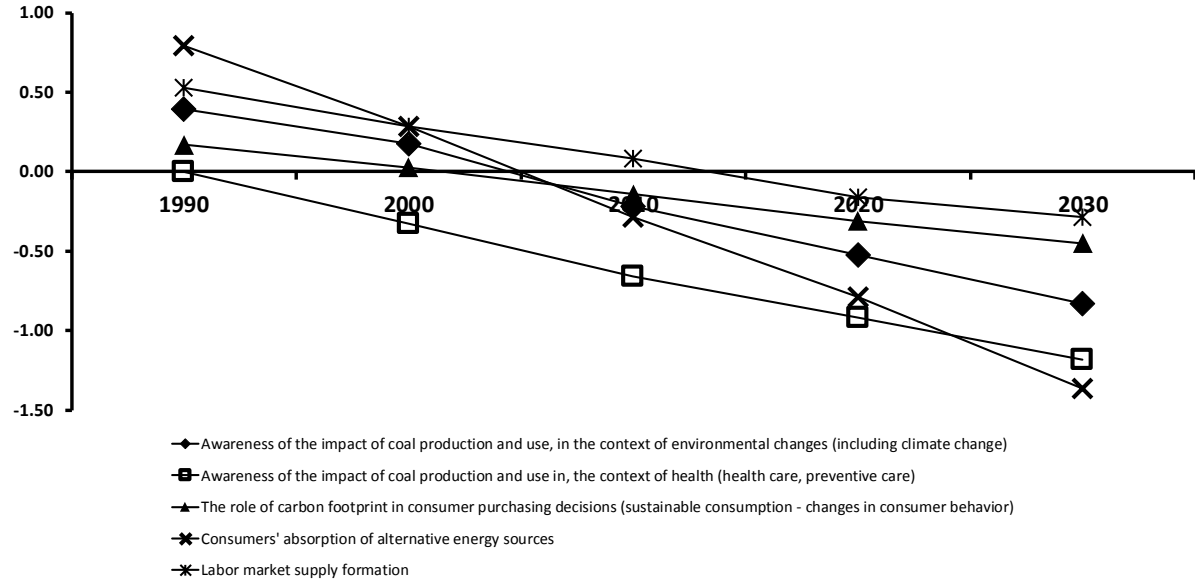

Figure 3. Weighted rating of the variables affecting the social environment of the EU coal mining and coal power generation market in 1990-2030.

Source: own elaboration.

Carbon footprint has been defined as the total sum of CO2-equivalent emissions directly and indirectly caused by a given activity, person, organization, event or product (Wiedmann, Minx, 2008). The concept of carbon footprint was first proposed by British researchers as part of the ecological footprint, but its rise began in the early 21st century. The carbon footprint has become increasing relevant in decisions, as many consumers wish to make sustainable purchases. Consumers who are aware of the climate impact of their lifestyles have become increasingly likely to choose products and services with smaller carbon footprints, or to forgo those that contribute to greenhouse gas emissions altogether. It is worth mentioning that in 2007 the world's first carbon footprint label – Carbon Trust – was created. The certification allows companies to measure and communicate the carbon footprint of the products they offer (Carbon.com, 2023). Carbon footprint information can guide consumers to make choices of lower im-pact on the environment, and climate change especially. In 2022, the Corporate Sustainability Reporting Directive (CSRD) was published in the EU Official Journal. The requirement to report on an organization's climate and environmental impact along the entire value chain is expected to apply to 50,000 companies in the European Union (Deloitte, 2022), further raising the weight of carbon footprint in future purchasing decisions.

Consumers' uptake of alternative energy sources is the social determinant to which the Authors assigned the highest weight. It is the level of renewable energy source utilization that determines the reduction of greenhouse gas emissions from the combustion of fossil fuels. Worth mentioning is the fact that in in 2022, 37% of energy in the EU came from renewable sources (Eurostat, 2022d). Interest in alternative energy sources is growing among consumers. One example is the photovoltaic market, where increasing numbers of households opt to install

solar panels, solar collectors or heat pumps. A surge in the uptake of alternative energy sources is also likely to occur as a result of Russia's invasion of Ukraine in 2022. In response to the difficulties and disruptions in the global energy market, the European Commission has put forward the REPowerEU plan, which calls for an increase in the share of renewable sources, including the uptake of photovoltaic energy (among other things, it is planned to phase in a mandatory installation of solar panels on new buildings) (European Commission, 2022).

The section assessing the formation of labor market supply incorporates such factors as employment in the coal mining sector, the training of new cadres for the mining industry, the demand for labor in mining, the retirement age in mining, or the number of workers in need of labor market support as a result of decarbonization. In recent years, Poland's coal mining sector has seen multiple restructuring and downsizing, due to financial difficulties, environmental challenges and increased competition from other energy sources. In 1990, the Polish coal mining sector employed 388,000 workers, compared to 83,000 in 2020 (Cire.pl, 2020), which indicates a systematic employment reduction in the sector. On the one hand, a decline in employment can be observed, yet on the other, the demand for employees with advanced qualifications and skills, particularly in mining process automation and digitization, has been growing. What is more, the number of mining graduates in Poland has also dropped over the years. The demand for labor in Poland (in Silesia) is forecast to outstrip supply starting in 2026, due to a projected shortage of at least 20,000 workers per year in the region (Sokołowski et al., 2022). In sum, from a social-spere perspective, the impact assessment coincides with the conclusions drawn with regard to the economic sphere - the general supply situation in the coal labor market has a destimulating effect on the area under study.

4.4. Technological determining factors

Sector decline does not take place in isolation from capital flows. The PEST-analyzed aspects were assessed from an economic perspective, among other things. Materialization thereof, however, takes place in technology precisely. After all, it seems impossible to think of a sector, and heavy industry in particular (including manufacturing, mining or processing activities, which require significant capital outlays), ending its life cycle without previously withdrawing or gradually reducing investment/replacement expenditures. All the more so as this sector can be deemed traditional, meaning, it is ingrained in our mentality - both socially and economically. Through this multi-decade experience, we are well aware of the technology investment and depreciation cycles. We can also assess the prospectiveness of further R&D development in this sector. Two of the five variables analyzed are stimulants of the market's further development, namely (2) the impact of clean-coal technologies (CO2 emissions, gasification) as well as (5) the technical devices and machinery (safety, productivity, technological support). In the intervals adopted, these were assessed differently from the other

factors, since they potentially provide support to the sector by prolonging its declining (as diagnosed in the conclusions) phase. At one end of the spectrum, clean-coal technology can play a role in reducing negative environmental impacts, but on the other, the directional legislative changes, as known from the observation thereof (see analysis of the 'P' determinants, in the PEST model), are moving towards an energy model different from the current one. The Special Report on Carbon Capture Utilization and Storage (International Energy Agency, 2020) refers to a scenario of zero-carbon production in term of the world's energy potential by 2070, with precisely the year 2030 set to mark an interim stage, involving the modernization of fossil-fuel-based energy, i.e., the modernization of current assets and the facilitation of low-carbon hydrogen production.

Table 5.
Technological market development determinants in the coal mining and coal power generation sector - weighted assessment of 1990-2030 market changes in the European Union

No.	Technological determinants of coal mining and coal power generation market development	WEIGHT		a RATING (from -5 to + 5) b weighted RATING (product of weight and rating)				
				1990	2000	2010	2020	2030
1a	R&D expenditures on technologies supporting the coal mining process	18.75%	a	2.50	1.25	0,00	-1.25	-2.00
1b			b	0.47	0.23	0,00	-0.23	-0.38
2a	Impact of clean-coal technologies (CO2 emissions, gasification)	17.50%	a	-1.00	0.00	1,00	1.75	2.50
2b			b	-0.18	0.00	0,18	0.31	0.44
3a	Impact of energy sources alternative (substitute) to hard coal	28.75%	a	2.00	0.50	-0,75	-2.25	-3.50
3b			b	0.58	0.14	-0,22	-0.65	-1.01
4a	Technology depreciation versus asset replacement expenditures	25.00%	a	4.00	1.00	-1,00	-2.75	-4.75
4b			b	1.00	0.25	-0,25	-0.69	-1.19
5a	Technical devices and machinery used at work (safety, efficiency, technological support)	10.00%	a	-0.50	0.50	1,50	2.50	3.25
5b			b	-0.05	0.05	0,15	0.25	0.33
TOTAL		100.00%	-	1.82	0.68	-0,14	-1.01	-1.81

Source: own elaboration.

The last of the variables analyzed – technical devices and machinery, which affects the safety, but also the efficiency (optimization), of labor, also acts as a stimulant in the period under examination. This, however, does not stem from the uniqueness of the sector, but rather from the general (cross sector) premises relating to the growing improvement of labor management methods, the optimization of labor and, most importantly, the changes translating into increased safety.

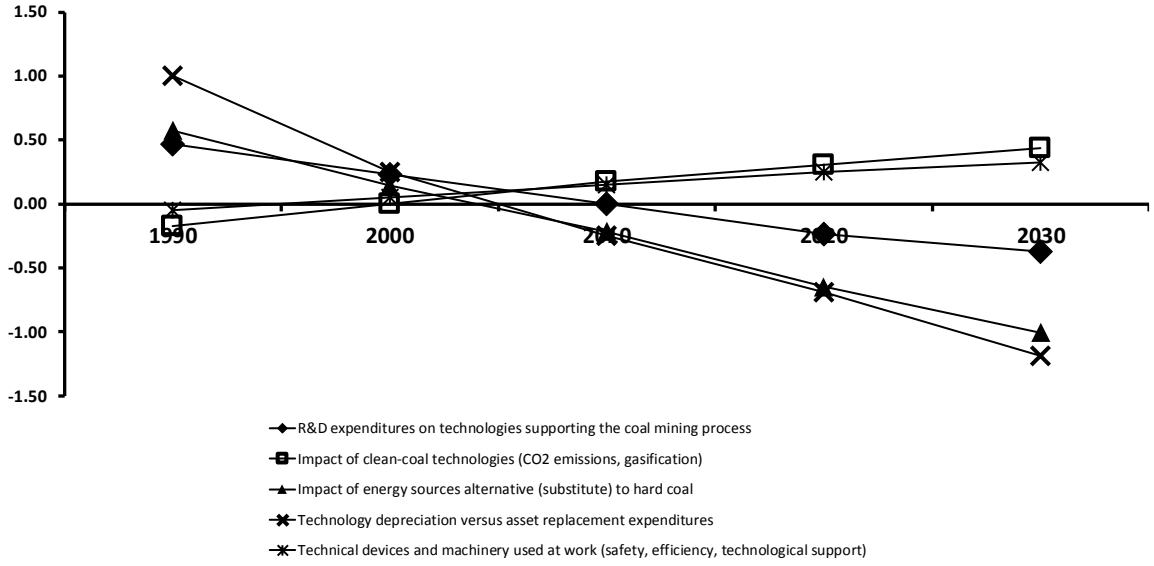

Figure 4. Weighted rating of the variables affecting the technological environment of the EU coal mining and coal power generation market in 1990-2030.

Source: own elaboration.

The remaining variables of a technological nature analyzed show a tendency to exert increasing pressure on the sector, which translates (Figure 4) into these variables de facto taking on negative values since 2010. The variable with the strongest negative impact is the technological depreciation and asset replacement expenditures. Here, however, a significant disruption, resulting from Russia's war on Ukraine, is worth noting, though it should be born in mind that "increased demand for the raw material does not imply a return to coal, but a prolongation of the very process of coal mine shutdowns" (Sawicki, Parkiet, 2022). Investment outlays in Polish coal mines (Agencja Rozwoju Przemysłu, 2022) rose to PLN 1.78 billion by September 2022 (against PLN 1.49 billion in the previous year), while the industry's CAPEX increased from PLN 2.9 billion to PLN 3.9 billion. The year 2023 is expected to be a year of not only large investments, but also a strongly accentuated mining recovery. The analysis carried out breaks down the assessment not by year, but by decade, hence the industry's periodic prosperity is expected to be ultimately offset by the strategic plans of coal mine activity extinguishment. If, however, the mine investment data were to be regarded objective, and their contribution to a postponement of coal mine shutdowns beyond 2030 was assumed, the variable's assessment (in the current perspective, if not in the 2030 assessment as well) would have to be raised.

The last variable exerting a negative impact on the industry, is the growing relevance and development of energy sources alternative to hard coal. EUROSTAT data unequivocally shows a declining share of hard coal (production), with 1990 as the base period (Forsal.pl, 2021). "Coal pollution and its health impacts travel far beyond borders, and a full coal phase-out in the EU would bring enormous benefits for all citizens across the continent" (CAN, 2016). This, however, calls for alternative investments – differing at the level of member states, naturally, but accounting for, inter alia, such scenarios of energy demand hedging as:

(1. RES) wind technologies (including offshore), gas "Although natural gas is the cleanest of the fossil fuels, it is still a major source of the global increase in CO2 emissions" (Jackson et al., 2018); (2. Nuclear scenario) involving retention of the youngest coal-fired power plants in the system, to perform a backup function (Stryjecki, 2019).

5. Discussion

The analysis presented in the study was carried out in a retrospective view (1990-2020) and as a forecast for 2030. While in respect to the analysis of historical data, the Authors have full confidence in the validity of quantifying the phenomenon of the gradual transition from energy pro-duction that is based on hard coal mining and processing towards its declining phase, the future perspective may empirically provide development scenarios different than those described in the article. All the more so as in most industry studies, two other (conventional) dates, in addition to the forecast horizon adopted in the paper, are also considered relevant, i.e., 2050 and 2070, when the power industry is to be entirely based on zero-carbon generation sources. This, however, could be considerably disrupted by various events affecting the further energy transition of the European Union and the World, which are qualitative in nature and involve significant - but at the same time extremely difficult to predict - leapfrogging changes. The past experiences of pandemics (2020, SARS COV-2) as well as Russia's war on Ukraine certainly qualify as such events. Given the decreasingly short business cycles, the intensified turbulence of the markets (both within the real sphere of the economy as well as on strictly financial markets), even today a hypothesis can be posed that the next crisis – on not only on a European, but also an intercontinental scale will occur before the end of the next decade. This calls into question the timing of the withdrawal of individual economies from traditional energy sources. More so, such radical changes should not be made in times of crisis, lest, both economically and socially, the problems associated with implementing the change in a socially and economically unstable environment escalate even further.

Equally important are the changes expected to take place in sub-sectors, or complementary and/or substitute sectors. The announced reduction in the sale of internal combustion vehicles in the EU as of 2030, for instance, will surely catalyze an increase in the demand for energy, which so far is mainly obtained precisely from the traditional, fossil fuel sources. Moreover, it is difficult to expect investors to suddenly withdraw from a given sector when capital expenditures (CAPEX) have not been fully amortized. In such large industries as power generation, the changes will be rather evolutionary, accommodating stakeholders gradually to the transformation which, according to the Authors, will unfold precisely within the four areas analyzed, i.e., regulatory, economic, social and technological. Any deviation from the plans, due to non-acceptance, technological misalignment, demand-supply imbalance or, as known from experience at the EU level, the years needed to achieve full legal harmonization – could

prolong these processes. This eventuality calls for preparation, while the fact that the environment is constantly changing is by no means a reason against analyzing and estimating the changes taking place precisely because of the successive variables affecting the future model of the energy market in the EU and worldwide. The results of the study bring new knowledge to the issues of this sector. This is, among others, the forecasted trend of the impact of individual dimensions of the environment, taking into account the extinguishing effect of the pandemic and the impact of the war in Ukraine on the flow of fossil resources in Europe. It should be emphasized that compared to previously conducted analyzes and past studies conducted by other researchers, we notice some similarities as well as differences. The completed PEST analysis confirms the decline of the hard coal sector in Europe and its consistent displacement from the energy mixes of European countries. On the other hand, research suggests that it will not happen as soon as it was thought before the pandemic. Due to the current economic and political situation, a quick, complete phasing out of the use of hard coal in Europe seems unrealistic. Taking into account the conditions of the macroeconomic environment, the departure from coal will be consistent, but not radical, as in some cases it will take over the function of a transitional fuel - i.e. the one previously attributed to natural gas. The next phase of research planned by the authors of this study will be an update of the PEST analysis after the fossil fuel market has fully stabilized after the end of the war in Ukraine and perhaps the return of Russian fossil fuels to the European market.

6. Conclusions

Using PEST analysis to assess life cycle prospectivity (or decline) for various sectors, a methodological attempt to weigh each of the four perspectives contained in this method can be made. However, there is always a certain research insufficiency consisting in the question of whether we have taken into account enough perspectives - PEST was, after all, significantly developed in the course of evolution to include other areas of analysis (such as environmental, or related to digitization, virtualization of the economy). However, we are convinced that in times of so much information (often of poor quality), quantification and multidimensional analysis is extremely useful in making decisions. In particular, when it comes to long-term decisions, as well as investment decisions. Therefore, we are sure that further extension of the analysis based on the proposed methodology can successfully bring new values - to the theory of management and quality science, economics and finance, but also (and perhaps above all) to economic practice. As the authors of the study, however, we are well aware that so many factors can disrupt our prediction. However, this does not mean that it is not worth making such predictions. They are a decision-making guidepost, and due to the multidimensionality of the analysis, we hope that it becomes particularly applicable to economic practice.

When it comes to the hard coal mining and coal power generation market, two clashing forces are de facto involved. On one side, there is the moral depreciation of coal as an energy carrier – as evidenced in the analysis of social determining factors, and the politicians' declarations (supporting these processes) regarding the advent of the Green Energy era. On the other, however, the sector needs to deal with the strong impact of the growing use of alternative energy sources, as well as the technological development of substitute markets placing heavy pressure Europe's existing model of energy market. The extent of the moving away from coal-fired generation of power is evident from the PEST synthesis (shown in Table 6). The sector's so-called 'missing potential', i.e., is the distance of the weighted assessment of all 20 analyzed variables from the maximum value the sector could hypothetically achieve, is relevant here. The increase in this gap to the projected level of 163.42% in 2030 indicates the potential phaseout of the sector.

Table 6.
PEST analysis summary of coal mining and coal power generation market development – years 1990-2030

Symbol	COAL MARKET DETERMINANTS ANALYSED	1990	2000	2010	2020	2030
P	Regulatory (legal) determining factors	1.70	0.78	-0.13	-1.78	-3.25
E	Economic determining factors	0.91	0.51	-1.37	-1.88	-3.52
S	Social (socio-cultural) determining factors	1.88	0.45	-1.22	-2.71	-4.11
T	Technological determining factors	1.82	0.68	-0.14	-1.01	-1.81
TOTAL	Total weighted rating [p.]	6.31	2.42	-2.86	-7.38	-12.68
MAX	Maximum sum of weighted ratings [p.]	20.00	20.00	20.00	20.00	20.00
N/A p.	Difference between rating and max value [p.]	13.69	17.58	22.86	27.38	32.68
N/A %	Sector's missing potential [%]	68.45%	87.92%	114.31%	136.89%	163.42%

Source: own elaboration.

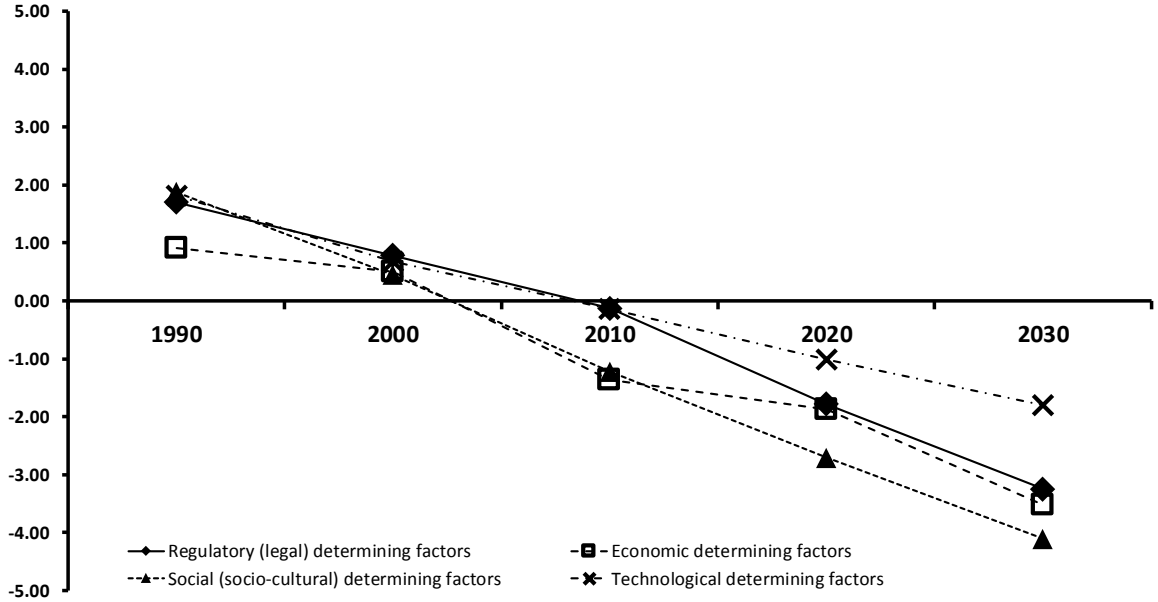

Figure 5. Weighted PEST assessment of coal mining and coal power generation market development – years 1990-2030.

Source: own elaboration.

In summary, the PEST analysis entailed an observation of the current state of Europe's hard coal market over more than thirty years, incorporating a forward-looking vision of changes over the coming decade. The regulatory (legal), economic, social (socio-cultural) and technical (technological) determining factors all have exhibited a destimulating effect on the development of the hard coal mining and coal power generation market. The strongest impact is exerted by social factors. The impact of legal as well as economic determinants is similar. Technical factors show the weakest yet still negative impact. In 1990 and 2000, the strength of the impact of all factors analyzed under the PEST analysis carried out yielded a positive result, which means that the variables' impact was of a market-stimulating nature. In 2010, 2020 and 2030, in turn, negative impact of individual determinants on the development of the European hard coal market was observed. Generalizing from decade to decade, the intensity of the adverse impact strength increases. It should be emphasized that all activities carried out as part of the PEST analysis have been presented from the perspective of the players on the European Union hard coal mining and coal power generation market. In conclusion, the process of the empirical study resulted in an answer to the research questions posed earlier. The following were singled out (RQ1) as significant regulatory developments in the mining, transportation and processing of hard coal in Europe (RQ1): the energy mix – the role of hard coal substitutes, the CO2 emission rights market, the geopolitical determinants of hard coal distribution, as well as the level of state interventionism and the level of intra-community law harmonization the level of autonomy in shaping the energy policy of member states. The economic factors most strongly driving the development of the hard coal market in Europe were identified as (RQ2): the sector's profitability, the level of hard coal mining concentration significance for the labor market, the share of the hard coal mining sector in the GDP of member states, the level of investment in mining and logistics infrastructure, CSR relevance and cost - internalization of external costs. The social factors to be taken into account in terms of the hard coal market development in Europe (RQ3) are (RQ3): absorption alternative energy sources by consumers, awareness of the health implications of hard coal use, awareness of the impact of hard coal use on environmental changes, the formation of labor market supply, and the role of the carbon footprint in consumer purchasing decisions. The relevance of technology, in the context of hard coal mining and processing in Europe is dependent on (RQ4): the impact of energy sources alternative to hard coal, technological depreciation versus asset replacement expenditures, R&D expenditures on technologies supporting the coal mining process, the impact of clean-coal technologies, as well as the technical devices and machinery.

References

1. Agencja Rozwoju Przemysłu (2022). https://arp.pl/pl/, 23.02.2023.
2. Aguilar, F.J. (1967). *Scanning the Business Environment*. New York: Macmillan.
3. Allen, R.C. (2012). Backward into the future: The shift to coal and implications for the next energy transition. *Energy Policy, 50*, 17-23.
4. Alves Dias, P., Kanellopoulos, K., Medarac, H., Kapetaki, Z., Miranda-Barbosa, E., Shortall, R., .Tzimas, E. (2018). *EU coal regions: opportunities and challenges ahead. European* Commission (pp. 20-32). Petten, The Netherlands: Joint Research Centre.
5. Anderson, K. (1995). The political economy of coal subsidies in Europe. *Energy Policy, 23(6)*, 485-496.
6. Antonowicz, P., Jedel, J. (2018). Evaluation and development prospects of the sports and recreation market in Poland in 2000-2030. PEST analysis from a legal, economic, socio-cultural and technological perspective. *Baltic Journal of Health and Physical Activity, 10(4)*, 202-212.
7. Benton, T.G., Froggatt, A., Wellesley, L., Grafham, O., King, R., Morisetti, N., Schröder, P. (2022). *The Ukraine war and threats to food and energy security*. Chatham House—International Affairs Think Tank.
8. Brauers, H., Oei, P.Y. (2020). The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels. *Energy Policy, 144*, 111621.
9. Butryn, B., Gryncewicz, W., Kutera, R., Leszczyńska, M. (2015). *The Application of PEST Analysis to the Creation of the Profile of an IT Product Designed to Activate and Support Senior Citizens in Poland.* Proceedings of 9th International Symposium on e-Health Services and Technologies (EHST 2015), pp. 109-115.
10. Carbon.com (2023). www.carbontrust.com/what-we-do/assurance-and-labelling/product-carbon-footprint-label, 20.02.2023.
11. Cire.pl (2022). www.cire.pl/artykuly/serwis-informacyjny-cire-24/158880-w-kopalniach-wegla-kamiennego-zatrudnienie-stoi-w-miejscu, 24.02.2023.
12. Cox, J. (2021). The higher education environment driving academic library strategy: A political, economic, social and technological (PEST) analysis. *The Journal of Academic Librarianship, 47(1),* 102219.
13. Cunningham, C. (2014). *Coal: the World's Deadliest Source of Energy*. Available at: https://oilprice.com/Energy/Coal/Coal-The-Worlds-Deadliest-Source-Of-Energy.html, 22.02.2023.
14. Czaplicka-Kolarz, K., Pyka, I. (2007). Miks energetyczny w Unii Europejskiej do 2030 r.-rola paliw rodzimych. *Górnictwo i Geoinżynieria, 31(2),* 171-178.

15. Czyżak, P., Kukuła, W. (2020). *Monopol węglowy z problemami. Analiza restrukturyzacji polskiego sektora energetycznego*. ClientEarth & Instrat, Retrieved from: https://instrat.pl/restrukturyzacja/, 20.02.2023.
16. Deloitte (2022). https://www2.deloitte.com/pl/pl/pages/risk/articles/rewolucja-w-sprawozdawczosci-srodowiskowej-w-UE.html, 20.02.2023.
17. Dembicka-Niemiec, A., Szafranek-Stefaniuk, E., Kalinichenko, A. (2023). Structural and Investment Funds of the European Union as an Instrument for Creating a Low-Carbon Economy by Selected Companies of the Energy Sector in Poland. *Energies, 16(4)*, 2031.
18. Dorian, J.P., Humphreys, H.B. (1994, February). Economic impacts of mining: a changing role in the transitional economies. *Natural Resources Forum, Vol. 18, No. 1,* pp. 17-29. Oxford, UK: Blackwell Publishing Ltd.
19. Dubiński, J., Turek, M. (2009). Wybrane aspekty zmian restrukturyzacyjnych w polskim górnictwie węgla kamiennego (w latach 1990-2008). *Prace Naukowe GIG. Górnictwo i Środowisko/Główny Instytut Górnictwa*, 5-19.
20. EndCoal Health (2020). EndCoal.org, https://endcoal.org/health/.
21. Energetyka24.com (2023). https://energetyka24.com/gornictwo/slask-nie-bylo-chetnych-do-klas-gorniczych, 22.02.2023.
22. Europarlament (2018). Retrieved from: www.europarl.europa.eu/news/pl/.
23. European Commission (2022). *RepowerEU: Affordable, secure and sustainable energy for Europe*. Retrieved from: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_pl, 25.02.2023.
24. Eurostat (2023a). *Renewable energy statistics*. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/NRG_TI_SFF__custom_4396646/default/table?lang=enon, 6.01.2023.
25. Eurostat (2023b). *Exports of solid fossil fuels by partner country*. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/NRG_TE_SFF/default/table?lang=en&category=nrg.nrg_quant.nrg_quanta.nrg_t.nrg_te, 6.01.2023.
26. Eurostat (2023c). *Imports of solid fossil fuels by partner country*. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/NRG_TI_SFF__custom_4396646/default/table?lang=en, 6.01.2023.
27. Eurostat (2023d). *Energy production and imports.* Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_production_and_imports/pl&oldid=195319, 6.01.2023.
28. Finkelman, R.B., Wolfe, A., Hendryx, M.S. (2021). The future environmental and health impacts of coal. *Energy Geoscience, 2(2),* 99-112.
29. Forsal.pl (2021). https://forsal.pl/biznes/energetyka/artykuly/8412230,produkcja-i-konsumpcja-wegla-wzrosla-w-2021-r-eurostat.html, 20.02.2023.

30. Frużyński, A. (2009). *Reforma, której nie było–polskie górnictwo w latach 80. XX wieku*, https://depot.ceon.pl/bitstream/handle/123456789/17259/reforma_ktorej_nie_bylo_polskie_gornictwo_w_latach_80_XX_wieku.pdf?sequence=1, 2.01.2023.
31. Gałaś, A., Kot-Niewiadomska, A., Czerw, H., Simić, V., Tost, M., Wårell, L., Gałaś, S. (2021). Impact of Covid-19 on the mining sector and raw materials security in selected European countries. *Resources, 10(5),* 39.
32. Gasparotto, J., Martinello, K.D.B. (2021). Coal as an energy source and its impacts on human health. *Energy Geoscience, 2(2),* 113-120.
33. Geoportal (2023). http://geoportal.pgi.gov.pl/surowce/energetyczne/wegiel_kamienny, 2.01.2023.
34. Grudziński, Z. (2019). International steam coal markets–supply, demand, prices. *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi Polskiej Akademii Nauk,* 5-20.
35. Guenette, J.D., Kenworthy, P.G., Wheeler, C.M. (2022). *Implications of the War in Ukraine for the Global Economy.*
36. Hámor, T. (2004). Sustainable mining in the European Union: the legislative aspect. *Environmental Management, 33,* 252-261.
37. headlines/society/20180703STO07123/zmiana-klimatu-w-europie-fakty-i-liczby, 15.02.2023
38. IBISWorld (2022). *Average closing spot prices of European Emission Allowances (EUA) from 2010 to 2021 (in euros per metric ton of carbon dioxide) [Graph]*. Statista. Retrieved from: https://www-1statista-1com-1isvchty303f6.hansolo.bg.ug.edu.pl/statistics/1329581/spot-prices-european-union-emission-trading-system-allowances/, 19.01.2023.
39. Intergovernmental Panel of Climate Change (2018). *Global Warming of 1.5°C.* Retrieved from: https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf, 2.03.2020.
40. International Energy Agency (2020). Special Report on Carbon Capture, Utilisation and Storage: CCUS in Clean Energy Transitions. *Energy Technology Perspectives*.
41. Jackson, R.B., Le Quéré, C., Andrew, R.M., Canadell, J.G., Korsbakken, J.I., Liu, Z., Zheng, B. (2018). Global energy growth is outpacing decarbonization. *Environmental Research Letters, 13(12),* 120401.
42. Jakob, M., Steckel, J.C., Jotzo, F. (2020). The future of coal in a carbon-constrained climate. *Nat. Clim. Chang., 10,* 704-707. https://doi.org/10.1038/s41558-020-0866-1.
43. Jonek-Kowalska, I. (2015). State aid and competitiveness of the hard coal mining industry in the European Union. Equilibrium. *Quarterly Journal of Economics and Economic Policy, 10(1),* 69-87.
44. Kaczmarek, J., Kolegowicz, K., Szymla, W. (2022). Restructuring of the coal mining industry and the challenges of energy transition in Poland (1990-2020). *Energies, 15(10),* 3518.
45. Katić, V.A., Dumnić, B.P., Katić, N.A., Milićević, D.M., Grabić, S.U. (2012). Potentials and market prospects of wind energy in Vojvodina. *Thermal science, 16(suppl. 1),* 141-157.

46. Khudaykulova, M., Yuanqiong, H., Khudaykulov, A. (2022). Economic consequences and implications of the Ukraine-russia war. *International Journal of Management Science and Business Administration, 8(4),* 44-52.
47. Kielerz, A., Porzerzyńska-Antonik, M. (2019). Węgiel w energetyce zawodowej i ciepłownictwie – stan obecny i perspektywy. *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi i Energią PAN, 108,* 39-50.
48. Kraśniewski, M. (2018). Prawna realizacja Strategii na Rzecz Odpowiedzialnego Rozwoju w sektorze energetycznym. *Współczesne Problemy Bezpieczeństwa Energetycznego,* 91.
49. Lindgreen, A., Di Benedetto, C.A., Beverland, M.B. (2021). How to write up case-study methodology sections. *Industrial Marketing Management, 96,* A7-A10.
50. Mancini, L., Sala, S. (2018). Social impact assessment in the mining sector: Review and comparison of indicators frameworks. *Resources Policy, 57,* 98-111.
51. Manowska, A., Osadnik, K.T., Wyganowska, M. (2017). Economic and social aspects of restructuring Polish coal mining: Focusing on Poland and the EU. *Resources Policy, 52,* 192-200.
52. Markandya, A., Wilkinson, P. (2007). Electricity generation and health. *The Lancet, 370(9591),* 979-990.
53. Moreira, J.R., Pacca, S.A. (2020). The climate change mitigation potential of sugarcane based technologies for automobiles; CO2 negative emissions in sight. *Transportation Research Part D: Transport and Environment, 86,* 102454.
54. Nerlinger, M., Utz, S. (2022a). The impact of the Russia-Ukraine conflict on the green energy transition–A capital market perspective. *Swiss Finance Institute Research Paper*, 22-49.
55. Nerlinger, M., Utz, S. (2022b). The impact of the Russia-Ukraine conflict on energy firms: A capital market perspective. *Finance Research Letters, 50,* 1032-1043.
56. Plessmann, G., Blechinger, P. (2017). How to meet EU GHG emission reduction targets? A model based decarbonization pathway for Europe's electricity supply system until 2050. *Energy Strategy Reviews, 15,* 19-32.
57. Pleßmann, G., Blechinger, P. (2017). Outlook on South-East European power system until 2050: Least-cost decarbonization pathway meeting EU mitigation targets. *Energy, 137,* 1041-1053
58. Ponomarenko, T.V., Vol'nik, R., Marinina, O.A. (2016). Corporate Social responsibility in coal industry (Practices of russian and european companies). *Journal of Mining Institute, 222,* 882-882.
59. Rybak, A., Manowska, A. (2017). Seasonality of the coal demand in Poland and the strategies of hard coal production. *Zeszyty Naukowe Organizacja i Zarządzanie, 108.* Politechnika Śląska, pp. 373-382. https://doi.org/10.29119/1641-3466.2017.108.33.
60. Sammut-Bonnici, T., Galea, D. (2015). *PEST Analysis*. Wiley Encyclopedia of Management. Hoboken, NJ, USA: John Wiley & Sons.

61. Sawicki, B. (2012), Ożywienie górnicze nie oznacza powrotu do węgla. *Parkiet, 12.12.2022*.
62. Searle, S., Christensen, A. (2018). *Decarbonization potential of electrofuels in the European Union.* Washington, DC, USA: The International Council on Clean Transportation.
63. Shindell, D., Faluvegi, G., Seltzer, K., Shindell, C. (2018). Quantified, localized health benefits of accelerated carbon dioxide emissions reductions. *Nature Climate Change, 8(4),* 291-295.
64. Shoko, E., McLellan, B., Dicks, A.L., Da Costa, J.D. (2006). Hydrogen from coal: Production and utilisation technologies. *International Journal of Coal Geology, 65(3-4),* 213-222.
65. Sokołowski, J., Frankowski, J., Mazurkiewicz, J., Lewandowski, P. (2022). Hard coal phase-out and the labour market transition pathways: The case of Poland. *Environmental Innovation and Societal Transitions, 43,* 80-98.
66. *Strategia na rzecz odpowiedzialnego rozwoju do roku 2020 (z perspektywą do 2030 r.), no. 8* (2017). Retrieved from: https://isap.sejm.gov.pl/isap.nsf/download.xsp/WMP20170000260/O/M20170260.pdf, 4.01.2023.
67. Stryjecki, M. (2019). Dekarbonizacja 2040 - czy to jest możliwe? *Nowa Energia, 5/6,* 33-37.
68. Szczerbowski, R. (2018). Wyzwania polskiego sektora wytwórczego do 2030 roku. *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi Polskiej Akademii Nauk*.
69. Umar, M., Riaz, Y., Yousaf, I. (2022). Impact of Russian-Ukraine war on clean energy, conventional energy, and metal markets: Evidence from event study approach. *Resources Policy, 79,* 102966.
70. Wang, Q., Yang, X., Li, R. (2022). The impact of the COVID-19 pandemic on the energy market–A comparative relationship between oil and coal. *Energy Strategy Reviews, 39,* 100761.
71. Welsby, D., Price, J., Pye, S., Ekins, P. (2021). Unextractable fossil fuels in a 1.5° C world. *Nature, 597(7875),* 230-234.
72. Wiedmann, T., Minx, J. (2008). A definition of 'carbon footprint'. *Ecological economics research trends, 1,* 1-11.
73. Worldbank, (2023). https://data.worldbank.org/indicator/NY.GDP.COAL.RT.ZS?locations=EU, 25.02.2023.
74. Yousefian, M., Bascompta, M., Sanmiquel, L., Vintró, C. (2023). Corporate social responsibility and economic growth in the mining industry. *The Extractive Industries and Society, 13,* 101226.
75. Zhang, X., Wang, Z., Zhong, X., Yang, S., Siddik, A.B. (2022). Do green banking activities improve the banks' environmental performance? The mediating effect of green financing. *Sustainability, 14(2),* 989.