energies

MDPI

Article

Restructuring of the Coal Mining Industry and the Challenges of Energy Transition in Poland (1990–2020)

Jarosław Kaczmarek *, Konrad Kolegowicz and Wojciech Szymla

Department of Economics and Organization of Enterprises, Cracow University of Economics, Rakowicka St. 27, 31-510 Cracow, Poland; kolegowk@uek.krakow.pl (K.K.); szymlaw@uek.krakow.pl (W.S.)
* Correspondence: kaczmarj@uek.krakow.pl

Abstract: The European Union's climate policy and the energy transition associated with it force individual countries, their economies and their industrial sectors to carry out thorough changes, often of a deep, high-cost and restructuring nature. The aim of the article is to provide a multidimensional assessment of the forms and effects of the restructuring of coal mining companies in Poland in light of the current energy transition process. The research problem is encapsulated within the following two interdependent questions: Has the restructuring process allowed the coal mining industry to achieve sufficient efficiency to sustainably compete in the open market, and to what extent, if at all, have the objectives of restructuring been achieved from the perspective of changes in the energy mix? The research covers all coal mining companies included in the official statistics. It adopts a long-term perspective (1990–2020), dating from the beginning of the systemic transformation in Poland. The research involved the use of multivariate financial analysis methods, including the logit model for predicting the degree of financial threat, as well as taxonomic methods for assessing the dissimilarity of structures and their concentration. The general conclusion of the research is that there has been a lack of consistency (follow-up) between the forms and effects of restructuring in coal mining companies in Poland on the one hand and changes in the composition of the country's energy mix as a result of the energy transition on the other. In particular, this means that such restructuring, being neither effective nor efficient, has failed to accelerate change in the energy mix.

Keywords: restructuring; energy policy; hard coal mining; energy transition

Citation: Kaczmarek, J.; Kolegowicz, K.; Szymla, W. Restructuring of the Coal Mining Industry and the Challenges of Energy Transition in Poland (1990–2020). *Energies* **2022**, *15*, 3518. https://doi.org/10.3390/en15103518

Academic Editor: Ben McLellan

Received: 10 April 2022
Accepted: 9 May 2022
Published: 11 May 2022

1. Introduction

The countries of the European Union are characterised by different structures of electricity production, differing availability of fossil fuels and different states of advancement in the use of renewable energy sources [1,2]. Poland is an example of a country with significant coal resources and a still high degree of dependence in terms of electricity production on hard coal and lignite. Therefore, one of the biggest challenges in the ongoing energy transition in Poland is the restructuring of the hard coal mining sector. Dealing with this challenge requires an extensive, long-term analysis of the directions and effects of the changes already made in this sector. Objective diagnosis of former achievements may become the basis for building policies and programs for simultaneous restructuring of the coal mining and energy sectors.

In the article, the research problem focuses on identifying consistency (follow-up) between the forms and effects of restructuring of coal mining companies in Poland on the one hand and changes in the composition of the country's energy mix on the other. This problem, in turn, provided the main platform for the research goals, namely a multidimensional assessment of the forms and effects of such restructuring in the context of the ongoing energy transition. This main goal is made more specific by the five sub-goals.

Therefore, the key questions posed in the research are as follows: has restructuring enabled the hard coal mining industry to reach a sufficient level of efficiency to compete

on a sustainable basis on the open market, and to what extent, if at all, were the assumed restructuring objectives achieved in the context of changes in the energy mix? These questions, in turn, determine whether the content of the main research hypothesis is verified. The main hypothesis was supported by three partial hypotheses (see Section 1.5).

The research conducted in the present article led to the general conclusion that there was a lack of coherence (follow-up) between the forms and effects of the restructuring of coal mining companies in Poland on the one hand and changes in the energy mix as a result of energy transition on the other. More specifically, this means that such restructuring, being inefficient did not accelerate change in the energy mix. Coal mining companies have not achieved sustainable profitability and competitiveness on the open coal market. Restructuring did not bring about any significant changes in the structure of employment, assets, capital expenditure or sales, nor did it trigger major technical and technological progress. The effects of restructuring revealed a number of important temporal caesura in this process, thanks to which it can be divided into different periods. The changes observed in the energy mix occurred as a result of having to cover higher energy demand with the increased use of non-carbon energy sources.

The methodology and results of the research as well as a discussion of its findings provide the structure of the article. In the first step, the results of the literature and a previously known research review are presented. The authors also define the relationships between the following triad of terms: transformation, structural changes and restructuring, and the research problem is embedded in an international context (restructuring of coal mining in EU countries), after which the research goals, hypothesis and methods forming the research framework are presented. The research results themselves have been arranged in order, beginning with an analysis of the degree of implementation of the restructuring objectives, followed by a cause-and-effect analysis of the results, concluding with an analysis of changes in the structures and analysed relationships. In the next step, the results were discussed in depth, which provided further confirmation of the research hypotheses. The final conclusions are presented in the summary.

The article is part of a series of publications on the restructuring and development of enterprises and industries with particular emphasis on the fuel and energy sector. The current research is a diagnosis of the state of dependence (follow-up/consistency) of the effects of coal mining restructuring and changes in the energy sector. The next stage will include a comparative analysis of the effectiveness limits (relation of effects and inputs) of all energy generation sources. Combining the current diagnosis with such an efficiency analysis (non-parametric approach) will allow for the formulation of the main elements of the new energy transition policy.

1.1. Restructuring and Structural Changes

In the present article, restructuring is treated as a different phenomenon from structural change. The year 1990 marked the beginning of the implementation in Poland of a set of reforms aimed at systemic transformation, including economic transformation [3] (pp. 102–103). It is commonly believed that the transformation positively contributed to economic development [4–6]. It was supported by structural changes, the factors and growth-related dependencies of which created a paradigm in economics [7] (pp. 10–18). These changes, induced by the transformation, gradually turned into autonomous processes [8] (pp. 45–54), [9,10].

In the above context, transformation involves the reconstruction of the structure of the economy, and restructuring, as an integral element the former, has become one of the levels of transformation in Poland [11] (p. 153). Generally speaking, restructuring concerns changes taking place in economic structures such as enterprises (a micro approach). As regards internal development opportunities, these fundamental, external factors have destabilised enterprises [12] (p. 114). To regain their equilibrium, enterprises have had to adjust [13] by adopting restructuring strategies [14] (pp. 260–269), [15] (pp. 391–397). Their goal is to eliminate discrepancies between changes in the environment and the path of an

enterprise's development. However, not only must they adapt to such changes, but they must also anticipate them [16] (pp. 50–62), [17] (pp. 81–92), [18] (pp. 301–308).

In its essence, restructuring is a multi-faceted and complex process [19–21]. The effects of restructuring are not immediately felt, but rather are spread out over time [22] (pp. 10–23), [23]. A distinction should be made between inputs that are primary and effects that are secondary [24]. The effects of restructuring are not always positive either [25].

As was noted above, the aim of a company's restructuring is to adapt to a changing environment. The future state or states of this environment are undefined and cannot be predicted with any certainty. As a consequence, an enterprise operates with an element of risk, and the sublimation of such a critical state constitutes a crisis for an enterprise [26,27] (pp. 42–48). Enterprises are exposed and vulnerable to a diverse range of risks, and this is especially true of Polish enterprises [28] (pp. 10–31). An open crisis usually results from a long-lasting "smouldering" crisis, i.e., from the accumulation of causes that are not neutralised and which assume a structural, systemic form. The symptoms of a company in crisis, which themselves constitute an interplay of various factors, are reflected in its performance, and ultimately in its results and financial condition [29]. At the present time, these are detected using early warning systems [30], which make use of discriminant analysis methods [31], in particular logit models [32] (pp. 60–74). Such a model was estimated for the present research.

The purpose of assessing structural changes in this article was to quantify not only the scale of changes that take place within particular structural components, but also to determine the degree of structural transformation over time [33]. Economic structures comprise sets of elements in the economic process together with the specific relationships that exist between them [34]. These can be mapped out based on the convergence between the numbers corresponding to these elements [35]. The main goal of measuring structural changes is to determine the absolute and relative differences between the shares of individual structure components in the whole [36] and the total impact of such changes at moments in time on the same or many different objects [37]. The task of analysing structural changes is to show the course and size of structural transformations as well as the dynamics of these changes, and also to identify the structural components that influence these changes [38]. The intensity of structural change was further assessed by determining its course, i.e., by measuring the factor of concentration (absolute concentration).

1.2. Restructuring of Coal Mining in Europe

Alongside the intensive mining of hard coal, in the years after World War II, mining countries such as Poland also embarked on a period of industrialisation and intensive development. In 1990, England, France, Germany, Belgium and Poland accounted for 90% of all coal extracted in Europe, with Poland producing 56% of the total. However, by 2020, its share had reached 96%. The turning point in the mining industry came in the second half of the 20th century, when oil rapidly overtook coal in economic importance. From that time, restructuring of the coal mining industry in Europe began in haste. Each country has adopted its own different approach based on different tools, the use of which was, and still is, conditioned by many internal and external factors [39].

In France, from 1960 onwards, the government began to pursue a policy aimed at increasing the share of nuclear energy in electricity output, thereby reducing the demand for domestic thermal coal. This change had the direct effect of reducing employment. Despite the fact that the mining industry in France had been owned by the state since 1946, social and regional factors prevented the French government from completely shutting down the mining industry, which only occurred in 2004 (finally two years later in Decision 3632/93/ECSC of the European Coal and Steel Community).

In Belgium, coal mining had been privately owned, but in 1967 the government nationalised the coal industry and embarked on its restructuring. The closure of the mines caused serious social tensions, but production costs were very high, and Belgian coal was unable to compete with imported coal. In addition, there was a high dependence on foreign

labour. The restructuring plan provided mainly for the reduction of employment, and eventually over 10,000 employees decided to leave and rely on redundancy schemes. By 1989, employment had dropped to 6000 people, and the second stage of restructuring came to an end with the closure of the country's last mine in 1992.

In the case of England, coal was replaced by oil as the main source of energy back in the 1960s, while nuclear energy and natural gas began to develop rapidly [40]. The end of the oil crisis (1979) and Margaret Thatcher's ascension to office ushered in the era of what came to be known as "state business" [41]. The country's least profitable mines began to be closed. The aim of restructuring was to make mining more competitive through its mechanisation, cut employment and introduce a business model specifically suited to private enterprises [42]. The end result was the complete privatisation of the mining industry, which had been concluded by 1994. In 2019, the decision was taken to close the country's last colliery, although this did not signal a definitive end to mining in England [43]. In 2020, the government approved the construction of the first new deep-sea coal mine in 30 years [44].

The German coal industry entered a period of crisis in the early 1960s [45]. The federal and regional authorities (the Ruhr region) pursued a consistent policy aimed at increasing productivity. In 1968, a comprehensive restructuring program was launched to adjust the volume of output to shrinking needs and introduce extensive social protection programmes [46]. In the early 1990s, pressure from the European Commission to cut enormous public aid allocated to mining together with forecasts of a decline in demand forced more radical restructuring. The last mines were closed by 2018 [47]. The restructuring path adopted by Germany, which was almost painless, was extended over time and guaranteed social peace, and as a consequence differed from the more drastic steps taken to liquidate the mining industry in Great Britain, which suffered widespread social protests as a result.

In Spain, following the gradual shrinking of the coal mining industry in 1950–1975, the industry enjoyed a period of rapid growth. Government endeavoured to regulate production volume, coal prices and energy sales. The Third National Energy Plan, implemented in 1984, provided for a further increase in coal mining and government subsidies. After Spain joined the EU, pressure increased to reduce subsidies to the coal industry. A plan to cut employment and mining activity was implemented in 1985 and continued into the 1990s, also as a consequence of pressure from the environmental lobby against mining from opencast mines. As a result, by 2020, only one small mine was in operation in Spain.

At the present time, Germany (with a share of 33.3%), France (8.8%), Spain (4.5%) and the United Kingdom (5.1%) are the leading coal importers in Europe and are beginning increasingly to appreciate the role of this raw material in shaping their energy security.

The restructuring of the hard coal mining industry in Poland has been ongoing since 1989, that is, from the beginning of the systemic transformation and the transition to a market economy [48] (p. 242). Currently, Poland faces the challenge of creating a long-term energy policy that will ensure a balance between the security of its energy supplies, the efficiency of economic processes and an appropriate standard of environmental protection [49]. According to the plan, hard coal mining in Poland will come to an end by 2049 (restructuring programs are discussed together with an assessment of the achievement of the objectives in Section 3.1).

1.3. Poland's Energy Transition and Its Implications

The Polish energy sector is primarily based on the combustion of hard coal and lignite. According to Eurostat databases [50] (all data concerning the structure of electricity generation in Poland and EU countries comes from Eurostat databases) regarding energy in 1990, 96% of electricity and derived heat was produced using coal (56% from hard coal and 40% from lignite). In 2020, this fuel source still accounted for 68% of the country's electricity supply (44% from hard coal and 24% from lignite), which represents a decrease of 28 pp..b.

Electricity generation was completely different in form in the "Old Union" (EU15). In these countries, electricity obtained from coal accounted for only 35% of total output in 1990, and less than 8% in 2020. It should be emphasised, however, that in the case of the EU15, restructuring of the mining industry was completed earlier or is currently at an advanced stage (see Section 1.3). Of course, we need to be aware that these countries have diversified access to fossil fuels, including coal. As a result, in the years 1990–2020, these countries underwent more profound changes than Poland in terms of their energy mix. During this period, although the share of nuclear energy decreased from 33% to 25%, the share of renewable energy sources increased from 14% to 42%, and the share of natural gas rose from 7% to 22%. Therefore, it can be argued that, compared to the EU15 countries, Poland is an example of a country that has failed to adapt to the requirements of energy transition [51] (p. 10).

In this context, however, it is worth looking at the situation in those countries that were admitted to the European Union alongside Poland as part of its fifth enlargement (EU11). In the case of these countries, in 1990, coal accounted for 55% of total electricity generated, and in 2020, its share still remained at 39%. Thus, progress in reducing the importance of coal (by 16 pp.) in the EU11 countries has been slower than in Poland. It should also be noted that in 1990, the share of nuclear energy in the energy mix of many of these countries was significant, amounting on average to 17.5%, and by 2020 this share was as high as 22%. In turn, the share of energy from natural gas increased in this period from 10% to 12%, and from renewable energy it had risen from less than 7% to reach 23%.

The above observations lead to the conclusion that Poland does not differ significantly from other EU11 countries when it comes to the pace of change in its energy mix during this period [52]. Of course, this does not constitute grounds for a generally positive assessment in light of the delays in transformation observed in this group of countries. The reasons for this delay can partly be found in the insufficient financial resources allocated to the transformation, but also, as in the case of Poland, in the considerable influence exerted by the social and political environment [53].

Despite the fact that coal continues to account for a high share of Poland's energy mix, for the most part it is the process of adapting to EU requirements that had, and still has, a decisive influence on the country's energy policy, and thus on a gradual reduction in the share of coal [54]. The foundations of energy sector reform and the energy transition in Poland in general are, primarily, the following:

- the process of adapting Polish law to the legislation of the European Union as part of pre-accession negotiations (since 1998) [55],
- the assumptions of the accession treaty obliging Poland to adopt a number of energy and climate directives in force in the Union (including, inter alia, the obligation to reduce emissions [56] and increase the share of renewable energy sources (RES) in its energy mix to 7.5% by 2010 [57]),
- the Energy and Climate Package [58] launched in 2008, which includes the "20-20-20 Program", obliging EU countries, inter alia, to reduce greenhouse gas emissions by 20% compared to 1990 and increase their share of renewable energy sources to 20% of primary energy by 2020 [59,60],
- further packages resulting from arrangements reached at the "climate summits" (including the "Paris Agreement [61]—2015 and the so-called "winter package" [62]—2016), which set even more ambitious targets in terms of emissions and the share of renewable energy sources,
- the European Green Deal (COM/2019/640-2019) [63] and its development—the "Fit for 55 package" (COM/2021/550-2020 and 2021) [64].

Along with these arrangements, subsequent phases in the European Emissions Trading System (EU ETS) introduced in 2003 by Directive 2003/87/EC [65] have also been implemented, which in the following years would have a significant impact on the profitability of energy production from conventional sources [66].

Returning to our assessment of changes in the structure of electricity generation sources in Poland, it should be emphasised that although they have been significant in the case of coal (a decrease of 28 pp, i.e., by 29.1%), in absolute values, in the case of actual coal consumption, these changes are no longer so great. According to Eurostat data, in the years 1990–2020, the consumption of coal in the power industry decreased by only 9%. This means that the changes in the energy mix were achieved by covering the increase in energy demand (rising by 16%) through the greater use of non-coal energy sources (8.5 times). This was the case primarily with natural gas (a 16-fold increase) and renewable energy (a 15-fold increase). The use of gas was characterised by large fluctuations connected with the dates when large and medium-sized power plants and combined heat and power plants were commissioned. Gas consumption increased at its fastest rate in the years 1998–2005 (average annual growth of 49%) and in 2015–2020 (average annual growth of 22%). Renewable sources developed much later (apart from the existing large, commercial hydropower plants), with wind playing the most important role. The beginnings of the wind energy sector date back to 1997, but it only began to develop on a larger scale from 2001 onwards (average annual growth of 50%). The most rapidly developing renewable source is photovoltaics, the origins of which in Poland date back to 2011 (average annual growth of 182%), and the annual maximum occurred in 2015 (722%).

To sum up, the position enjoyed by coal as the strategic anchor of Poland's energy security has undoubtedly been unshakeable for decades [67]. This was very much confirmed by the findings of successive documents setting out Poland's energy policy (PEP) over the next decades [68–71]. These policies (adopted in 1990, 1995, 2000 and 2005, respectively) predicted that demand for hard coal and lignite for the energy sector would remain at a similar level or even increase. Moreover, some of these forecasts (PEP 2020, PEP 2025) were based directly on findings from previously approved mining reform programs. This leads to the thesis that the country's energy policy is dependent on the assumptions of reform of only one sector of the economy, i.e., mining. Only the energy policy adopted in 2009 (PEP 2030) [72] anticipated a significant and steady decline in the use of hard coal and lignite in electricity production. According to forecasts, the consumption of hard coal in 2020 would be nearly 30% lower than the 2006 base, and lignite consumption would decline by 26%. Therefore, such a significant reduction in coal consumption should have resulted in a reduction in output in domestic mines and thus have constituted a strong impulse for their restructuring.

1.4. Identified Research Deficits

The problem of the energy transition has been at the forefront of the European Union's policy in the recent years. The adaptation of economies and industry to changing climate goals is the leitmotif of many scientific and expert studies of a cross-cutting nature. They concern the analysis of changes in all EU countries or groups thereof [73–75], or locally concern only individual countries, including, for example, Germany [46], Spain [76] and Denmark [77]. The object of similar research was and still is also Poland. So far, detailed studies have focused on the determinants of the energy transition and its pace [78], its costs [79] or its impact on individual industry sectors [80].

The fact that Poland is a traditionally hard coal mining country forces research on the restructuring process of the entire coal mining industry and individual mining companies.

Previous studies have strongly touched upon the theoretical aspect of the mining restructuring process and the creation of restructuring programs [81]. The research was limited only to a review (qualitative description) of newly created and already implemented programs [82]. Sometimes, they only reviewed the objectives, legitimacy and complementarity of the tasks performed [83]. To some extent, the research also concerned the assessment of the degree of implementation of mining restructuring programs. However, it was carried out only from the perspective of assessing the assumed effects [84], sometimes also in relation to political conditions [85]. The research conducted so far has attempted to periodise the restructuring process, but its basis was only the periods derived from

legal acts and related to subsequent programs. Such a division did not take into account endogenous factors and interdependencies between them. Many times, the authors of publications focused on the basic production, technical, economic [86] and financial [87] indicators and their absolute change [88]. However, they have not developed and used any multidimensional, discriminatory models. This is a strong deficit, especially regarding the high rank of these models (especially logit ones) and the intense growth of interest in their application. Moreover, no studies concerned changes in economic structures and the assessment of their impact on the measures as dependent variables [89]. The analysis of mining enterprises [90] so far has focused mainly on the assessment of changes in employment [91,92] or changes in sales and production [93]. These analyses, however, were fragmentary and did not take into account the complexity of the assessment of the complex restructuring process. A significant part of the publication focuses on the assessment of the technical conditions of extraction [94] and the assessment of changes in production parameters. Some authors have turned their attention to the designation of possible restructuring strategies [95,96] and assessed management actions [97]. However, their studies do not contain an analysis of the economic and financial effects of the restructuring measures taken. In the past, attempts have also been made to assess financial ratios [98], but only in absolute terms. Furthermore, there was no attempt to perform a comprehensive analysis and evaluation of changes using a synthetic model. Sojda [99] made such an attempt at statistical analysis, but in an isolated approach, concerning only a few, selected financial indicators. However, he did not analyse the cause-and-effect implications.

Each determinant as a category, relation or measure of the assessment of economic results and financial condition, being a target in restructuring programs, can be the basis for calculating the change in the structure that characterises it. Few studies, however, attempted such a detailed analysis, despite the fact that structural research is crucial for most scientific disciplines [100,101]. Usually, such research concerns only change in the structure of employment [102,103], investments, assets or sold production. However, there is no research on the directions of transformations, assessment of the dynamics (intensity) of structural changes and indication of those components of structures that intensify or anticipate the changes to the greatest extent. This is a significant deficit because restructuring is closely related to structural changes [104] (pp. 11–12), which restore the ability to develop [105]. This development concerns not only the potential (size), but especially the structures [106]. These are its components and determinants [107] (p. 19), which forces the necessity to fill this deficiency in the research on the complex structure of coal mining enterprises.

There is a particularly clear deficit in research at the interface between mining and energy transition. Although the issue of EU climate policy appears in the above-mentioned studies (especially in those published after 2008—the 3 × 20 climate and energy package), it usually constitutes only a research background. So far, the authors have not addressed the problem that can be described by the question: are the pace and effects of the restructuring of the coal mining sector sufficient from the point of view of the desired pace of energy transition? This problem is the focus of the research in this article.

The review of the literature revealed a number of significant research gaps at the theory-cognitive, methodological and empirical levels. In the first case, no parallel approach has been developed for assessing the course and effects of the restructuring of the coal mining industry and changes in the energy sector from the perspective of its transformation, and, as a consequence, changes in the energy mix. At the methodological level, there is clearly lacking a method for measuring structural changes in coal mining, as well as their direction and variability or their correlation with operational effectiveness. Moreover, until now, researchers have not used aggregated measures to assess a company's financial condition, which are the most specific barometers of its operational health. This concerns in particular indicators predicting the financial risk of a going concern. Nor has any comprehensive, multi-layered method been developed for assessing the effects of restructuring, based on the relationship between causes (operating economics) and effects (financial results), which

is important from the point of view of assessing the mechanism by which these results are achieved. Meanwhile, at the empirical level, no research results have been published that cover a longer timeframe, i.e., the period from the beginning of the economic transformation in Poland (1990) up to the present day. Moreover, most of the available research results were obtained with the use of a research sample, which limits the formulation of general and universal conclusions regarding the coal mining sector as a whole.

1.5. Research Problem, Goals and Properties of Research

The research problem that emerges from the above-identified deficits is the consistency (follow-up) between the course and effects of the restructuring of coal mining companies in Poland and changes in the composition of the country's energy mix. It shows the main goal of the research, which is to provide a multidimensional assessment of the forms and effects of therestructuring of coal mining companies in the context of the ongoing energy transition. The main goal was achieved through the implementation of the following sub-goals:

- Measure the impact of key factors on the financial condition of coal mining companies,
- Aggregate the partial determinants of this financial condition as a basis for assessing the financial risk to a going concern (barometer),
- Gauge the impact of restructuring programs on organisational and structural changes in coal mining companies,
- Identify and measure the interdependence between structural changes and the effectiveness of coal mining companies' operations,
- Identify and measure the impact on production volume of changes in the structure of energy generation.

The research problem and research objectives are sublimated within the main hypothesis: (H) The effective and efficient restructuring of coal mining companies results in accelerated changes in the energy mix. This in turn gives rise to the following questions: has the restructuring carried out so far ensured a level of efficiency sufficient for the hard coal mining industry to compete on sustainable terms on the open market, and to what extent, if at all, have the objectives of restructuring been achieved in the context of changes in the energy mix?

The main hypothesis was supported by three partial hypotheses resulting from the partial goals and the "atomisation" of the research problem:

H1. *The restructuring of coal mining companies resulted in the achievement of the primary goal of sustainable profitability and increased productivity, with labour as the main factor*;

H2. *Hard coal restructuring has brought about significant changes in the structure of employment, assets, capital expenditure and sales*;

H3. *The effects of restructuring coal mining companies based on a multidimensional approach are determined by time intervals characterised by elements of homogeneity (time series periodisation).*

The research covered all the enterprises included in the "Mining and coal mining" section of the PKD (PKD—Polish Classification of Activities). This constitutes an exhaustive compilation of all enterprises included in the official statistics. These are long-term studies and cover the period 1990–2020. These two factors provide a firm basis for formulating general conclusions and assessments that extend beyond the specific problem of the research sample. They also make it possible to identify real, and, as a consequence, long-term, trends and changes in structures as well as interdependencies (correlations) and regression relationships.

The research framework included two initial planes of inquiry, supported by appropriate methodological pillars. The first involved a multidimensional assessment of restructuring based on the features of a certain economic model. This model reveals the mechanism used by coal mining companies to achieve results, understood as a combina-

tion of causes (economics of operation) and effects (financial results). The second level of research provides insights into the intensity of changes in the structures of coal mining companies and their interdependence with changes in operating efficiency. The resulting third level of research consisted in assessing the effects and forms of restructuring of coal mining companies according to the degree of consistency with the effects of implementing the goals of energy transition examined in the two previous planes.

For the needs of the research goals, hypotheses and framework, numerous research methods were used, including versions of multivariate financial analysis, together with an estimated logit model for predicting the degree of financial risk to a going concern (a universal barometer of an enterprise's financial condition ensuring a dynamic measurement). In turn, to study changes in structures, the authors used taxonomic methods to assess the structural dissimilarities (changes in intensity) and their concentration. The occurrence of dependencies in terms of the economic effects of coal mining restructuring, changes in structures, efficiency and transition of the energy mix was investigated by means of statistical correlation and regression measures (see the Materials and Methods section).

The added value of the research lies in the following: (1) its uniqueness in terms of its subject (covering all the enterprises in the sector) as well as time (it is a long-term study, dating from the beginning of the economic transformation); (2) its use of a wide range of research methods (including logistic regression and structure taxonomy) and multi-layered analyses; (3) the fact that it assesses the coherence (follow-up) between the forms and effects of the restructuring of coal mining companies with changes in the energy mix resulting from energy transition. It is also important to emphasise the universality of both the methods used and in particular the structure of the RS—thanks to which it can be used in an international context (in coal-mining countries)—and thus also the universal applicability of the research itself and the comparability of the obtained results, something which had not been achieved previously.

2. Materials and Methods

The research presented in the article covered all enterprises included in the PKD classification section 10/5—"Mining and coal mining" (PKD—Polish Classification of Activities; PKD section 10 up until 2006 and PKD section 5 from 2007—a change in the classification). These are, for the most part, large, multi-plant enterprises. They constitute a full set of the enterprises included in the official statistics. The research was a long-term project, launched back in 1990 (the beginning of the economic transformation in Poland) and ending in 2020. As a consequence, they cover a period of 31 years, during which coal mining companies underwent deep and extensive restructuring. Thanks to the availability of comparable figures and information, the structural changes were assessed during the period 1992–2020 (for fixed assets from 2004).

As regards the ordering of the numerical data, it should be pointed out that the PKD section entitled "Mining and coal mining" classifies enterprises into two groups, i.e., hard coal mining and lignite mining. The former group occupies a dominant position in terms of the number of people it employs (95.9%), total assets (96.6%), sales revenues (96.7%) and net financial result (99.5%). This is due to the fact that lignite mines are a branch of energy companies (power plants), and only one small mine (operating to satisfy heating needs) functions as an independent enterprise. Generally speaking, this means that coal mining companies determine the results of the entire "Mining and coal extraction" section.

To provide a synthetic assessment of the financial condition of restructured coal mining enterprises, the author made use of a proprietary logit model [108] (Table 1), which was developed in response to the shortcomings of hitherto available models, i.e., their historicity (obsolescence), limited number of training sets and overestimated predictions, limitations in their application (dynamic measurements) and traditional estimation techniques (pairwise comparability only) [109] (pp. 31–42), [110]. The research did not apply any foreign models which had a suboptimal structure and which were inadequate with regards to the operating conditions of enterprises in Poland [111] (pp. 129–172).

The logistic regression models (logit models) are classic tools for predicting the degree of financial threat [112]. However, when compared to newer-generation methods (such as neural networks or random forests), they are more transparent and their results are easier to interpret and compare. In addition, those models in many cases achieve a comparable predictive ability [113]. Other advantages of the logistic regression model are the lack of assumptions on the probabilistic nature of explanatory variables and a user-friendly interpretation of the estimated model parameters.

The model was estimated on the basis of a training data set consisting of 13,047 active production companies and 1377 failed entities. These were all production enterprises covered by the official statistics in Poland (companies with more than 9 employees). The total number of observation objects for the years 2007–2012 amounted to 130,204. The companies were matched using the case-control technique [114] (pp. 145–162). The explanatory variables (out of a total of 29 financial indicators) were selected by means of step methods and the best subset method [115]. The criterion for assessing the fit of the model to the data was the AIC (Akaike Information Criterion) measure. The logistic regression model used was Firth [116,117]. This model involves changing the form of the standard likelihood function $L(\theta)$ to the form $L^*(\theta) = L(\theta)|I_\theta|^{1/2}$, where I_θ is the information matrix and θ is the vector of structural parameters [118]. This is the penalised likelihood function. Firth's logistic regression model has a Bayesian counterpart [119]. It is equivalent to the classical model with Jeffreys non-informative prior distribution superimposed on the parameters [120,121]. As a result of this modification, the estimation of the parameters in this model is almost unbiased (a particular improvement is observed in small samples), while the confidence intervals are characterised by better probabilistic properties. The predictive capacity of the model was measured using the sensitivity, specificity and the AUC (Area Under Curve) measure as the area under the Receiver Operating Characteristic (ROC) curve. The value of AUC = 0.914 confirms that the estimated model has very high predictive capabilities.

The measure derived from the model (FTD) expresses the degree of financial risk to a going concern and the danger of bankruptcy (annual advance, calibration against the bankruptcy rate, value given per 10,000 companies). It can be treated as a barometer of a company's financial condition [122,123]—the more favourable the situation, the lower the value of the FTD measure. In addition, it has two specific properties: it allows for a dynamic analysis and relativises its result in relation to the risk of bankruptcy.

Table 1. Estimated prediction logit model of the financial threat degree.

Financial Ratio Name (Predictor)	Predictor Symbol	Parameter Estimate
Intercept	-	−5.85
Operating return on assets	R_1	−1.231
Debt payment capacity	R_3	−0.492
Operating return on sales	R_6	−1.947
Total debt ratio	R_9	+0.62
Short-term liabilities cycle	R_{13}	+0.004
$FTD = \frac{1}{1+\exp[-(-5.85+(-1.231 \cdot R_1 - 0.492 \cdot R_3 - 1.947 \cdot R_6 + 0.62 \cdot R_9 + 0.004 \cdot R_{13}))]} \cdot 10000$		

Source: [124] (pp. 117–131).

To analyse the interdependence of time series (as well as regression interdependencies), a critical significance level of $\alpha = 0.05$ was adopted, compared with a p-value test probability. A value lower than the critical level of significance means that one can proceed ad hoc, as if the null hypothesis that no correlation exists has been rejected. The degree of correlation as a numerical value is given in the text only when the condition of p-value < α is met. Detailed results of the regression analysis are provided in Appendix C. The correlation was measured using the Pearson r coefficient (degrees of correlation: <0.1 slight; 0.1–0.3 weak; 0.3–0.5 average; 0.5–0.7 strong; 0.7–0.9 very strong; >0.9 an almost full correlation). The mea-

sure of variability applied was the standard deviation and the coefficient of variation (the ratio of the standard deviation to the mean).

A linear regression model was adopted to analytically illustrate the relationship between an explained (dependent) variable and an explanatory (independent) variable and to determine the nature of this relationship [125]. The choice of a linear regression model was based on its simplicity, expressed by the easy interpretability of the results. Nevertheless, before choosing the linear model, an analysis of the distribution of observations was carried out using scatter diagrams. The point clouds took on a pattern indicating their distribution with respect to a straight line. Moreover, the analysis of the variables did not reveal the existence of outliers that would interfere with the determination of this model. The fit for the regression equation was established using the determination coefficient R2 (fit levels: 0.0–0.5 unsatisfactory, 0.5–0.6 weak, 0.6–0.8 satisfactory, 0.8–0.9 good 0.9–1.0 very good).

In their detailed assessment of the potential and financial results of coal mining enterprises, the authors resorted to numerous indicators of financial analysis covering the following areas: potential, results, debt, financial liquidity, profitability, effectiveness, and efficiency. Because these are commonly known and have been widely described in the available literature on the subject, they are not explained in detail in the present article [126–128] (a general description is included in the Appendix A).

To assess structural changes, economic structures were used that enabled an evaluation of the transformations resulting from mining restructuring processes, i.e., regarding employment, net fixed assets, investment outlays, sales and the structure of electricity generation as an interdependent element. The intensity of change (NPS), also referred to as the degree of structural dissimilarity, was measured by means of a taxonomic approach. This made it possible to determine the absolute and relative differences between the shares of individual structural components and the total impact of these changes in the same or many different structural elements at comparable moments in time [129,130]. Using the taxonomy of structures, it is possible to determine, more unambiguously and comprehensively than by means of a traditional over time comparison of individual structural indicators, the degree of transformation of the structures under study and to carry out a periodisation of their development with regards to the criterion of the degree of intensity (dynamics) of structural changes [131]. Thus, taxonomy makes it possible to determine the directions of structural change [132], its dynamics (intensity) and its determinants (also as anticipation). In addition, it allows the evaluation of the similarity of structures to each other and over time.

$$NPS = 1 - \sum_{i=1}^{n} min(p_{i0}, p_{i1}) \quad (1)$$

where:

NPS—intensity of structural change (dissimilarity),

min—minimum value of the components of the structure,

p_{i0}—share of the i-th component of the structure in time t_0,

p_{i1}—share of the i-th component of the structure in time t_1.

The NPS measure assumes values in the range of $\langle 0, 1 \rangle$ where a value equal to zero means no structural changes while the value 1 denotes a complete change in the structure [133]. The NPS parameter makes it possible to determine the intensity of structural changes in relation to past periods, but not to determine the direction of change. The latter is gauged by means of the concentration measure, understood as the degree of deconcentration or consolidation of a given phenomenon in one component of the structure. For this purpose, the degree of structural concentration was measured by means of the Herfindahl-Hirschman index (HHI). The latter is calculated as the sum of the squared shares of all the components of the structure:

$$\mathrm{HHI} = \sum_{i=1}^{N} x^2 \quad (2)$$

where:

x—component share,

N—number of components.

The HHI index lies within the range of $\langle 0, 1 \rangle$. The higher the HHI value, the greater the concentration. It is calculated in such a way that the value of the components has a greater impact on the value of the HHI than their number [134].

3. Results

3.1. Extent to Which the Goals of Coal Mining Restructuring Programs in Poland Have Been Achieved

Coal mining companies in Poland were already being broken up and then commercialised in the first years of the systemic transformation. This strategy was expected to create competition on the market and give impetus to bottom-up restructuring [135]. These changes took place against a backdrop of top-down government coal pricing, the abolition of subsidies and, later, the introduction of temporary export restrictions, as well as barriers raised by new public laws. All these factors resulted in the systematic deterioration of the financial condition of mining enterprises, which soon gave rise to social unrest. To prevent escalation, successive governments took steps to improve the economic health of the mines. These actions were reflected in a number of government-sponsored mining restructuring programs. These steps were taken for various economic, social and political reasons [136]. In the years 1990–2020, nine programs, together with various modifications, were drawn up, adopted and implemented (a list of them is included in the Appendix B) [137].

An analysis of these restructuring programs reveals a radical shift in their main objectives, an increase in the number of specific objectives and a high degree of deconcentration. A reorientation was observed away from goals heavily focused on protecting mining companies from bankruptcy, towards the goals of privatisation, rationalisation of resource exploitation, profitability and energy security.

The general objective of restructuring was to ensure the independent, market-driven adjustment of coal mining companies to the conditions of a free market economy. This is because these concerns had been established during the years of a centralised economy characterised by an overdeveloped non-productive infrastructure, low levels of operating efficiency, high energy consumption and technological backwardness. The first steps were taken in May 1992. It was assumed that, when competing with each other, only a few inefficient mining enterprises would be liquidated. Unfortunately, the financial state of most mining enterprises deteriorated with each year that passed, leading to the financial collapse of 1998. In the years 1991–2002, none of the implemented mining restructuring programs achieved its main goal, that is, they failed to ensure the economic efficiency of the hard coal mining industry [138]. The reasons for this failure were, inter alia, unfavourable changes and structural dependencies between the main factors: employment, assets, capital expenditure, output and sales and electricity generation.

With the aim not only of saving mining enterprises from bankruptcy, but also of averting a crisis in an industrially important region of the country, the Polish government adopted the idea of consolidation. In 2003, the largest mining company in Europe (Kompania Węglowa S.A, Katowice, Poland) was established. Then, in 2015, the remaining mining concerns were merged with energy companies, while inefficient mines were transferred to a separate enterprise earmarked for liquidation (Spółka Restrukturyzacji Kopalń S.A., Bytom, Poland).

The year 2006 marked a particular turning point. Up until then, the rationalisation of employment was constantly listed among the specific objectives of each program, which was justified by the industry's high employment levels, which in turn was due to technological backwardness and an excessive focus on non-mining activities. In the first 6 years of restructuring alone, employment declined significantly (by approximately 41%, i.e., 140,000 employees), which, however, did not result in any social unrest. The post-2006 programs no longer provided for any cutbacks in employment, the more so as the employment level planned in the previous programs had only been achieved in two years, while in the remaining years, employment levels were slightly hight than the targets set.

The reasons for discontinuing employment reduction plans were as follows: [139,140]

- delays in organisational changes, in particular in the expected closure of mines in the first years of implementing such changes (1990–1994),
- generous redundancy packages, in particular in the form of financial incentives, which encouraged miners to change profession or take advantage of special mining leaves,
- an inadequate workforce due to an aging mining population and earlier job cuts,
- no investment-intensive policy aimed at upgrading machinery, supporting manual labour and promoting technical efficiency.

Overall, after 2006, restructuring programs no longer listed any specific measures [141]. Instead, these programs focused on the strategic directions of mining development, the aim of which was to set priorities in the strategies and action plans of enterprises. Natural breakdowns became a way to further reduce employment. Unfortunately, the unfavourable age structure of the industry (an "aging" workforce) was becoming an ever more acute problem. In 2008, employment increased in almost all employee groups (excluding administration employees).

The objective of the program for 2007–2010 was the rational and effective management of coal deposits. The employment policy pursued in 2007–2015 focused on optimising the use of internal reserves and ensuring the correct balance between wage increases and economic results. Council Decision No. 787 of the European Union of 10 December 2010, which limited the time allotted to supporting unprofitable mines and adopted increasingly restrictive standards regarding carbon dioxide emissions and environmental protection, had a decisive impact on the restructuring process. These solutions have become the core determinants shaping the functioning of the mining industry. In 2015, the government continued to assume that hard coal mining would be competitive in the new market conditions.

In April 2016, Polska Grupa Górnicza (PGG) was established to strengthen Poland's energy security [8] and function as a recovery plan for the failing Kompania Węglowa S.A. Another major crisis in the mining industry forced the government to conclude an agreement (24 September 2020) with trade unions and other interest groups and set 2049 as the final date for the closure of the mines.

The goal of most of the restructuring programmes was to make the mining industry profitable, but in only three programs was this actually the main objective (Table 1). The dominant features of all the programmes were the following: adjusting production capacity to demand, cutting mining costs, rationalising employment, increasing labour productivity and improving working conditions. All of them likewise envisaged a systematic reduction in production, mainly through the liquidation of highly inefficient mines, as well as those mines facing the most serious problems and natural hazards and thus incurring high output costs. The remaining goals of the restructuring programs involved changes in organisational structures, production volume and financial conditions. The former mainly involved privatisation, mining infrastructure and mine closures. Changes at the management level consisted in the creation of new supervisory structures. Changes in production resulted from a reduction in coal mining due to weaker demand, which in turn was a consequence of lower energy consumption in industry. Another important task was to restructure technological processes by modernising machinery and mining methods. Financial restructuring focused on improving profitability and reducing the indebtedness of mining enterprises. Efficiency was to be improved through investments in equipment and machines (longwall and road shearers or coal streams), as well as other equipment in the longwall complex in the form of powered supports, longwall conveyors and other devices (Table 2).

Table 2. Objectives and anticipated effects of the implementation of the hard coal mining restructuring programs in Poland in 1993–2020.

Objectives of the Programs/Programs	Programme I 1993	Programme II 1993	Programme III 1994–1995	Programme IV 1996–2000	Programme V 1998–2002	Programme VI 2003–2006	Programme VII 2004–2010	Programme VIII 2007–2015	Programme IX 2018–2030
Improving profitability, competitiveness, timely payment of liabilities									
Mitigating the effects of the current and planned restructuring of employment									
Protection of mining against collapse (debt reduction)									
Employment rationalisation, increase in labour productivity, improvement of working conditions									
Adaptation of production capacity, efficiency improvement, reduction of output costs									
Rational and effective management of coal beds									
Reducing the harmful effects on the natural environment									
Ensuring the country's energy security									
Privatisation of mining enterprises									
Optimisation of the organisational structures of the mining industry									
Diversification of coal use and maintaining export									
Vertical integration of mining and power industries									
Development of employee skills and innovations in mines									
Elimination of the negative effects of restructuring									
Maintaining the competitiveness of the mining sector									
The scope of planned coal sales (mill. Mg/year)	124–130	119–125	134–134	127–125	116–110	94–87	97–80	93–90	-
The planned Investment outlays (mill. PLN/programme)	588	-	1490	5488	5988	-	7921	2200	26,738
The scope of planned employment (thousand people, at the end of the year)	300	287	273–253	256–194	219–138	130–114	117	-	-
The scope of the planned capacity (Mg/employee/year)	437	-	463–515	508–529	525–773	725–806	795–810	-	-
The scope of the planned coal production (mill. Mg/year)	126–131	-	135–132	130–128	121–112	95–89	95–100	95–91	-

Notes: grey colour means main objectives, green colour specific objectives. Source: own study based on data from hard coal mining restructuring programs in Poland in the years 1993–2020 (Appendix B), materials of the Ministry of Economy. Available online: www.gov.pl (accessed on 2 February 2022).

3.2. Assessment of the Results of Coal Mining Enterprises

Partial hypothesis H1. *The restructuring of coal mining companies resulted in the achievement of the primary goal of sustainable profitability and increased productivity, with labour as the main factor.*

The overall results of coal mining companies in Poland in the years 1990–2020 were very poor. Accumulated revenues of PLN 729.6 billion generated a net profit of only PLN 1.1 billion, i.e., 0.15% (a weak correlation between results and revenues, i.e., r = 0.25). Until 1998, revenues grew rapidly, but costs increased at a much faster rate, which only exacerbated loses, despite essentially linear price growth. The subsequent suppression of costs yielded positive results that lasted until 2013 despite a resurgence in cost dynamics. Unfortunately, this trend continued despite worsening price conditions, which led to losses in 2014–2016. Costs have stabilised in recent years, and this trend has continued despite declining revenues, resulting in the highest ever annual losses (PLN—4.4 billion in 2020). The share of exports was subject to cyclical changes, with this share at its lowest when results had relatively stabilised, with an average, indeed for the most part negative, correlation with financial results (r = −0.45) (Figure 1).

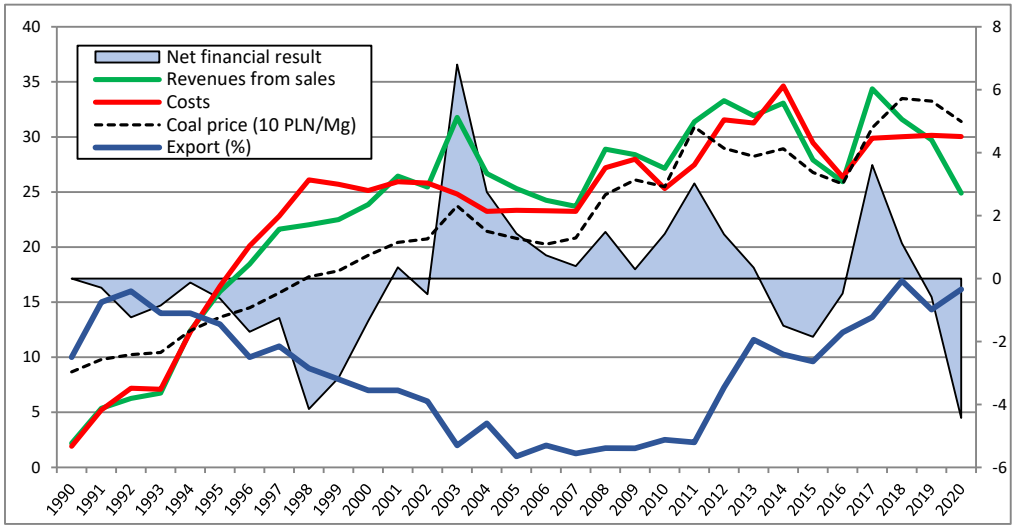

Figure 1. Financial results of coal mining enterprises in 1990–2020 (bn PLN). Note: net financial result and export—right axis. Source: authors' research based on GUS in Warsaw (Statistical Head Office in Warsaw, Poland)—databases of limited access. Available online: https://stat.gov.pl/en/databases/ (accessed on 4 February 2022); Pont Info Warsaw—Gospodarka SŚDP—commercial databases. Available online: http://baza.pontinfo.com.pl/index.php (accessed on 2 February 2022).

Labour costs accounted for constantly the largest share in the overall cost structure (average—41.9%, coefficient of variation 10.0%). Energy consumption costs remained relatively stable (average 5.7%), while the costs of materials decreased (average annual rate −1.9%, final share—10.0%) and the share of external services varied (average 19.0%, coefficient of variation 19.9%). Due to its dominant share in costs, the labour factor requires in-depth analysis.

The undoubted outcome of the restructuring of Polish coal mining companies in the years 1990–2020 was a reduction in employment, declining from 393,900 at the beginning of this period to 78,500 at its end. (−80.1%). Employment shrank by an average rate of −5.2%, with the most significant decline occurring up until 1998, and the process as a whole finished in 2016. Revenues from sales, varying periodically but increasing in the long-term, contrasted with a dwindling workforce, which resulted in higher labour productivity (an average annual rate of 14.4%), which collapsed just after 2016, based only on a reduction in the number of employees. However, unit labour costs are of greater

importance when it comes to assessing how efficiently an enterprise's labour resources are being used. Unfortunately, this was not characterised by any upward trend (an average annual rate of −0.02%), and this measure of productivity remained relatively unchanged in 2020 compared to 1990. On average, therefore, PLN 100 in remuneration costs produced PLN 245.8 in sales revenues.

The main production and technical factor driving change in the coal industry was the volume of production. It decreased in an essentially linear fashion (average annual rate −3.3%), declining in total by 63.1%, and only in brief periods was it propped up by successive restructuring plans. An almost total correlation existed between this factor and the number of people employed in the industry (r = 0.96). In general, technical efficiency followed a similar path to that of labour, although at a much slower rate (average annual rate of 2.1%). What is especially noticeable is that after 2016, first technical efficiency and then labour efficiency deteriorated significantly. The correlation between technical efficiency and unit labour costs slightly exceeded the lower limit of the average (r = 0.39) (Figure 2).

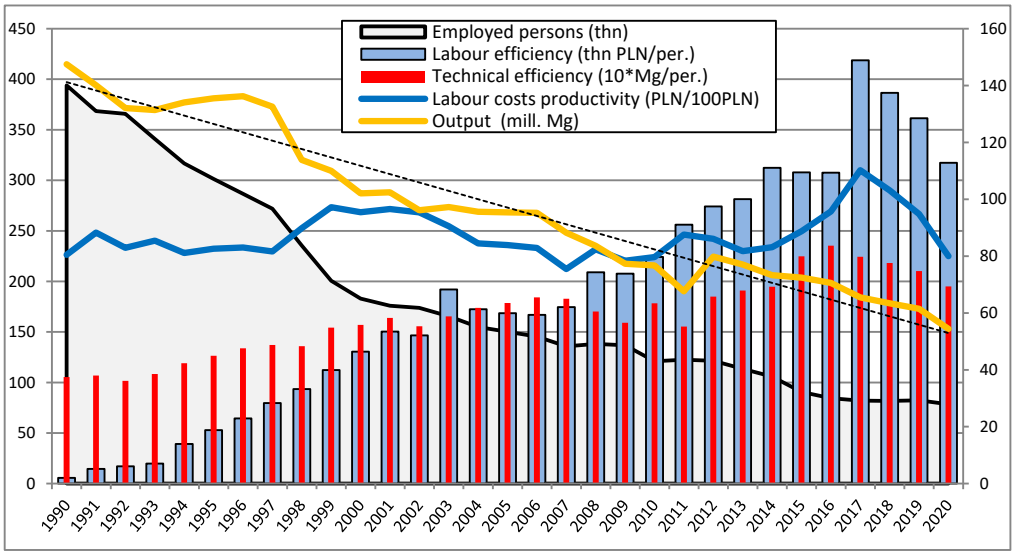

Figure 2. Employed persons, labour efficiency and labour costs productivity of coal mining enterprises in 1990–2020. Note: output and technical efficiency—right axis. Source: as in Figure 1.

Fixed and current assets grew fairly evenly until 2013, after which both declined. Investment expenditures increased linearly until 2011, but the ratio of investment expenditure to depreciation only increased in the years 1999–2011, after which the ratio decreased. By 2014, it was less than unity, so even a simple renewal of assets failed to be achieved. In the case of current assets, fluctuations intensified after 2011 as part of an overall upward trend, while, in general, receivables grew faster than inventories. Recently, a decline in receivables has brought about a reduction in short-term liabilities, but at the same time a disproportionate increase in receivables.

The period up until 2002 saw an alarmingly rapid increase in debt, especially short-term debt, which rose above what was deemed a safe level of liquidity at which liabilities can be settled. Moreover, ever higher losses led to negative equity in the years 1999–2002—coal mining companies began to suffer dramatic financial collapse (a debt level of 123.9% in 2002). The debt relief provided for these concerns through the restructuring process resulted in medium-term stabilisation, but after 2012 liabilities began to rise once more (reaching a debt level of 74.5% in 2020). Two further periods of losses reduced the value of equity, leading to a situation in which the value of the net assets of the coal mining industry as a whole stood at only PLN 8.5 billion in 2020, i.e., 1/3 of its annual revenues. What is more, since 2003, value transfers to the economic system (a component of GDP)

gradually decreased (with significant fluctuations), from 59.1% of the rate of value added to 26.6% in 2020. (Figure 3).

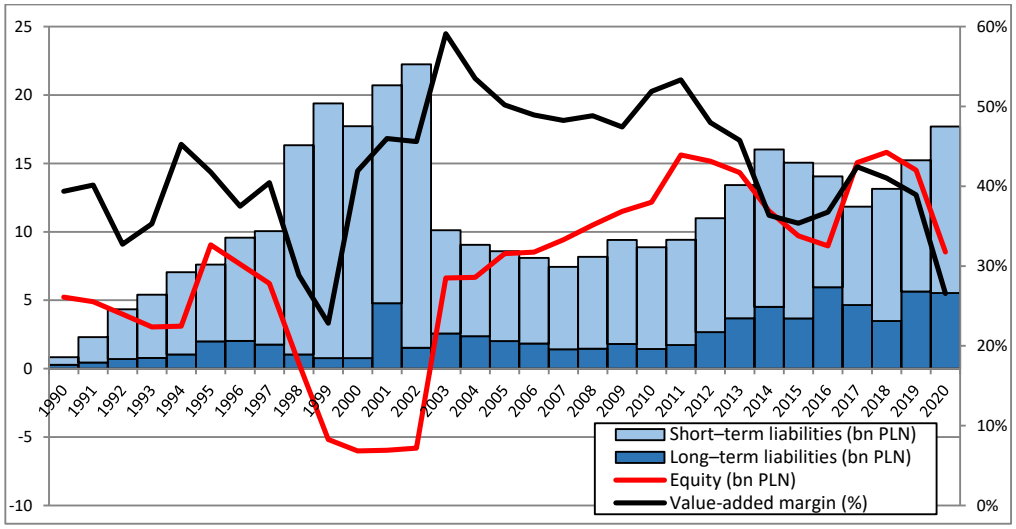

Figure 3. Short and long-term liabilities, equity and value-added margin of coal mining enterprises in 1990–2020. Note: value-added margin—right axis. Source: as in Figure 1.

The asset-capital structure (ACSR) is generally viewed as negative, for at least several reasons. Firstly, in the first four years of restructuring, the ACSR index decreased 7.5-fold, and in the years 1999–2002, it stood at unprecedented, negative levels (negative equity). Secondly, during the years of improvement and relative stabilisation (up until 2012), its average value nevertheless remained extremely low (an average of 0.17 compared to the reference value 1.0). Thirdly, various factors show no indications of any improvement in the asset and capital structure.

This image of a flawed overall structure overlaps with assessments of static and dynamic liquidity and solvency. An almost total correlation can be observed between current and quick liquidity ratios (r = 0.99), close to the level (average value: current liquidity—0.71, quick ratio—0.58) due to the relatively small impact of inventories and above all significantly different *in minus* from the reference values. The correlation between changes in current liquidity and the ACSR ratio was very high (r = 0.81), which is proof of the transfer of defective asset and capital relations from the overall level to the level of working capital management. The operating cash flow and cash flow coverage ratios were negative, which occurred again in 2020. Their level was critically low: PLN 1 of revenues generated on average a financial surplus of PLN 0.03, while PLN 1 covered PLN 0.06 of total liabilities. The solvency ratio based only on the net financial result and depreciation was also very low (on average 0.10), and the correlation with current liquidity was average (r = 0.46). With relatively stable inventory and receivable conversion cycles in terms of their length, the working capital cycle was always negative (due to the length of the short-term liabilities cycle) and reached its peak value of −278 days in 2002, and then, as a result of debt reduction, it was reduced to an average of −63 days.

Efficiency can be measured in terms of profitability and productivity. An assessment of operating profitability in the branch reveals three periods characterised by similar properties: the period up to 2002, when coal mining companies were highly unprofitable concerns; the 2003–2012 period, characterised by positive results with considerable volatility and the 2013–2020 period, when the profitability of these enterprises was shaken twice, and which ended in further major losses. Cost productivity provides support for profitability. Unfortunately, this was not the case with the surveyed companies. Firstly, this was because until 2002 the value of this indicator was lower than 1 (mean value—0.96, minimum—0.84). This situation repeated itself in the years 2019–2020. Secondly, throughout this entire period, an expenditure stream equal to PLN 1 yielded average revenues of just PLN 1.01.

Thirdly, with some fluctuations (a coefficient of variation 9.6%), cost productivity was on a downward path (average annual rate of −1.1%). Asset productivity only grew at any significant rate until 1997, and began to decline after 2003, assuming values below 1 (an average value of 0.81, minimum—0.55). The decline in these values was more pronounced than in the case of cost productivity. The correlation between asset productivity and the operating profitability of assets was slight (r = 0.08), while there was an almost complete correlation between cost productivity and the operating profitability of sales (r = 0.99) (Figure 4).

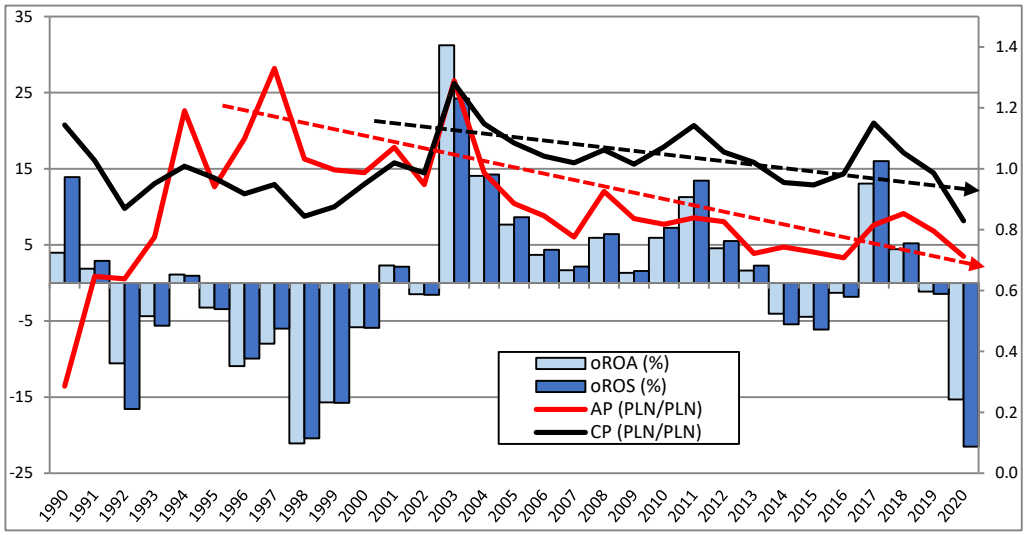

Figure 4. Productivity of assets (AP) and costs (CP), and operating return on assets (oROA) and sales (oROS) of coal mining enterprises in 1990–2020. Note: productivity of assets and costs—right axis. Source: as in Figure 1.

Proof of partial hypothesis H1. The above-mentioned results for the years 1990–2020 provide a legitimate and unquestionable basis for providing a negative verification of the partial hypothesis (H1). In other words, the restructuring of coal mining companies has not achieved its basic goal of sustainable profitability and increasing productivity, including with regards to its main factor, i.e., labour productivity. □

3.3. Assessment of the Structural Changes of Coal Mining Enterprises

Partial hypothesis H2. *Hard coal restructuring has brought about significant changes in the structure of employment, assets, capital expenditure and sales.*

A reduction in underground employment of 75% and a reduction of 85% above ground did not significantly change the employment structure (details in Appendix C) in coal mining companies (NPS = 0.11 compared to 1992). The increase in structural variability observed in 1992–1996 slowed down to a complete stop. The limited volatility of the employment structure is also confirmed by the low volatility of the HHI concentration index (0.459 in 1992 and 0.453 in 2020). The relatively high value of concentration resulted from a significant share of underground workers (63.73% in 1992; 64.37% in 2020). No correlation was observed between the intensity of change in the employment structure and the rate of change in production (r = 0.004), which confirms the lack of any correlation between changes in the employment structure and changes in the volume of production (no cause-and-effect relationship) (Figure 5).

Changes in the volume of hard coal sales varied from year to year, and only in 3 out of the 28 years during this period (1996, 1997, 2004) did actual production exceed the targets. In the remaining years, no mining output and sales targets were set, and, since 2017, sales volume has not been planned at all. The significant decline in sales and mining output

was reflected in changes in the sales structure (commercial power engineering, industrial power engineering, industrial and municipal heating plants, other industrial customers, coking plants and other domestic customers). A strong correlation was observed between changes in the sales structure and the sales volume, which was mainly a consequence of the declining share of other domestic recipients, with the exception of the commercial power and heating industries (industry and coking plants). These changes are confirmed in the strong upward trend in the HHI index since 2016. In 2020, the sale of coal to the commercial power industry accounted for as much as 67% of total sales (37% in 1992) (Figure 6).

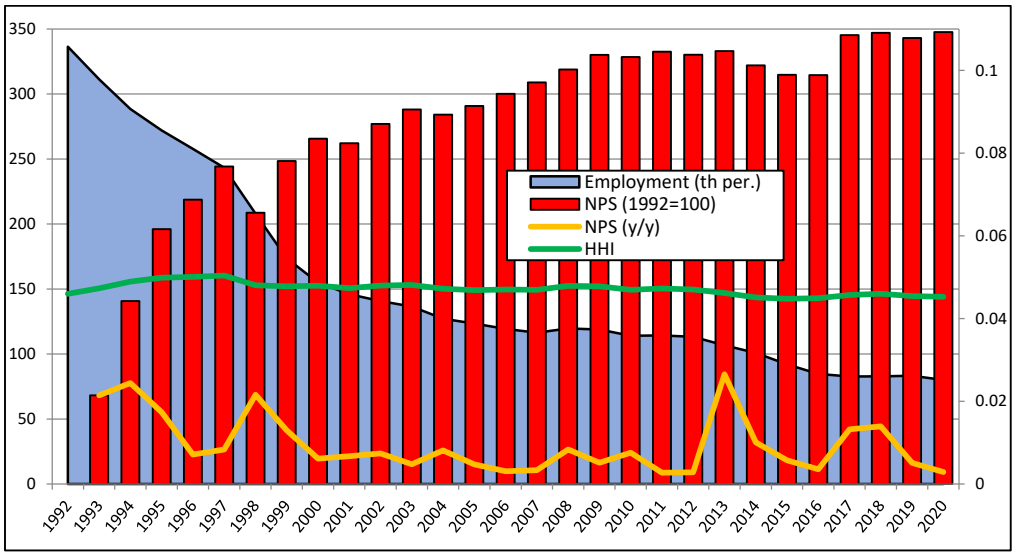

Figure 5. Employment, intensity of structure changes (NPS 1992 = 100%, NPS y/y), concentration (HHI) for coal mining enterprises in 1992–2020. Comments: employment—left axis, HHI—standardised quantity. Comparable data available only since 1992. Source: own study based on data provided by ARP S.A. Katowice. Available online: https://polskirynekwegla.pl/ (accessed on 10 February 2022).

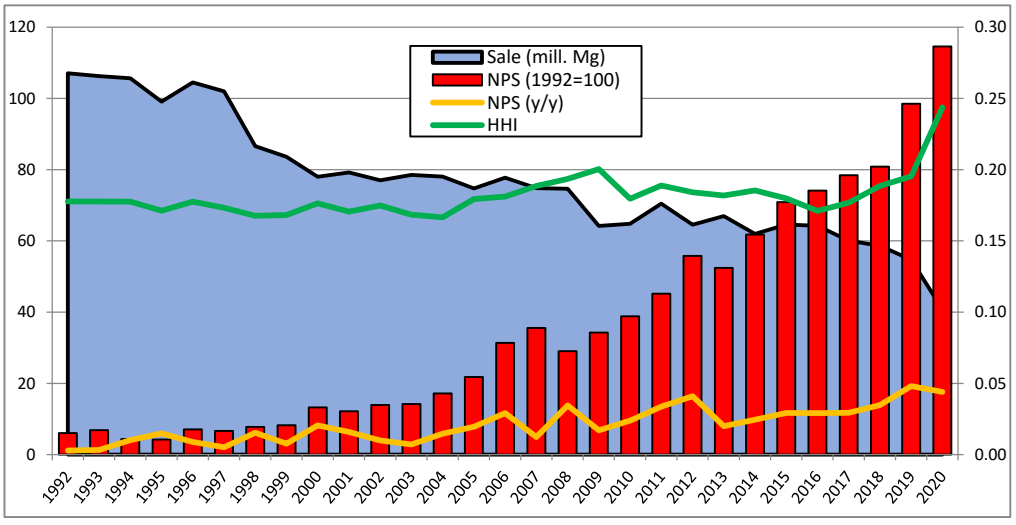

Figure 6. Coal sales, intensity of sales structure transformations ((NPS 1992 = 100%, NPS y/y), concentration (HHI) for coal mining enterprises in 1992–2020. Comments: coal sales—left axis. Other remarks as to Figure 5. Source: as in Figure 5.

The restructuring programs implemented in the years 1993–2007 set specific investment outlay targets to adapt mines to the ongoing technical and technological changes, adjust extracted and mechanically process coal to market needs and reconstruct and mod-

ernise machinery and devices. On the other hand, investments in the drilling of mine workings exceeded spending targets for the years 1995–1997 and 2004–2006. Since 2007, neither the size nor the structure of investment outlays has been planned, which was reflected in a greater deconcentration of the structure of investment outlays.

In 1996 and 2004, structural change increased in intensity, which was a consequence of a significant increase in expenditure on the purchase of machinery and equipment. The value of the HHI indicator confirms the high degree of diversification in investment outlays (which covered pits, coal mechanical processing plants, environmental protection, purchases of machinery and equipment and other things) and the lack of any clear direction. The biggest structural change (y/y) occurred in 2004, when there was a sharp reduction in other forms of capital expenditure. Since 2005, the pace and scale of change (annual average NPS = 0.077) in the structure of investment outlays has been waning (Figure 7).

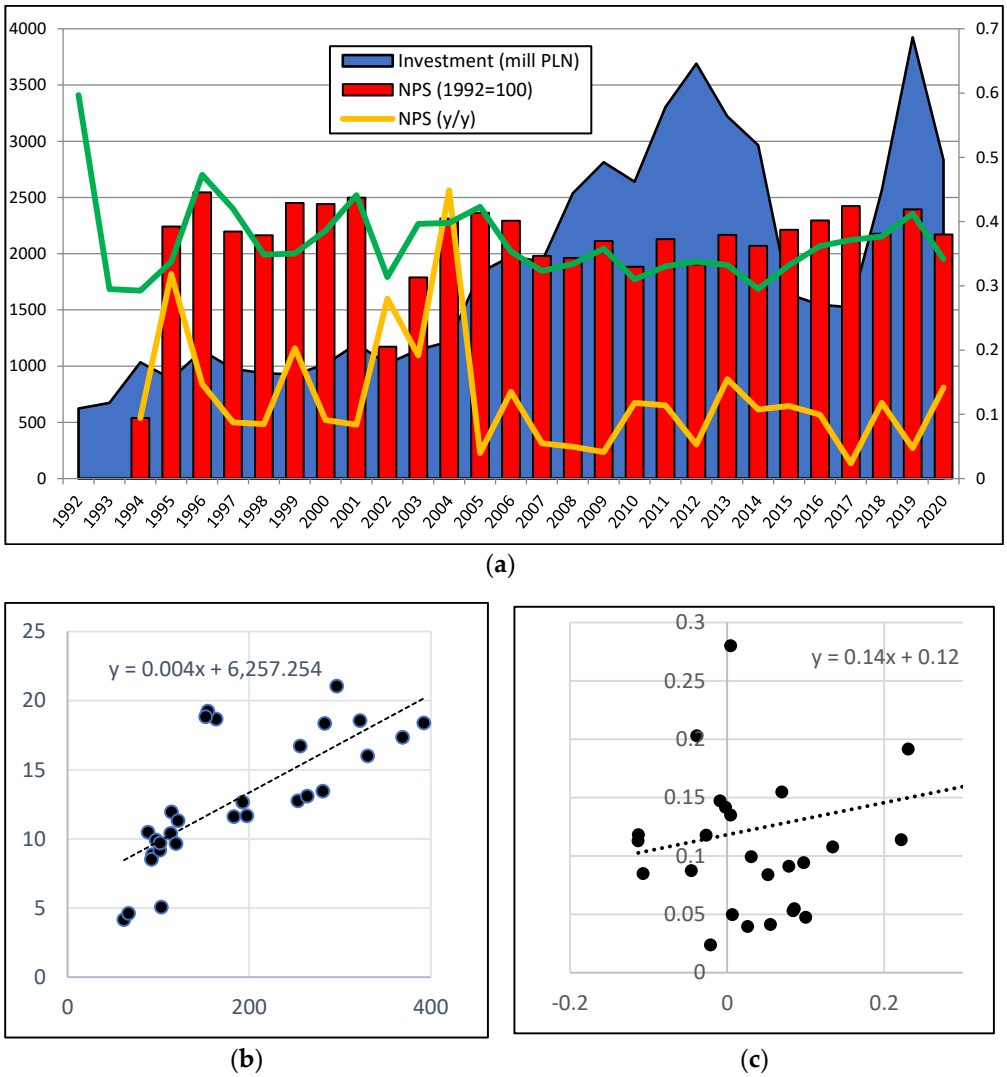

Figure 7. Investment outlays for mining enterprises in Poland in 1992–2020; (**a**) Capital expenditure, intensity of structure changes (NPS 1992 = 100, NPS y/y), and concentration (HHI); (**b**) Regression curve for investment outlays and net fixed assets values; (**c**) Regression curve of the intensity of changes in the structure of investment outlays and the rate of changes in the net fixed assets. Notes: investment outlays—left axis. Remaining remarks as to Figure 5. Source: as in Figure 5.

A weak correlation was observed between the pace and scale of changes in the structure of investment outlays and the value of net fixed assets (r = 0.25). An average correlation existed between the NPS of the investment structure and the rate of change in the value of

net fixed assets (r = 0.31), and a slight correlation was noted with the NPS of the structure of assets (r = 0.08), with no regression relationship specified. This indicates that the purpose of the investments was not to further modernise the property structure but rather to continue current operations, and their main focus was the maintenance of mine workings (38% in 2020).

An analysis of the variability of the structure of fixed assets (land, buildings, premises and civil engineering facilities, machinery and technical equipment, means of transport and other fixed assets) reveals slight changes (annual average NPS = 0.018). The high and sustained level of concentration (average HHI = 0.49) was due to a constantly high share of buildings, premises and water engineering facilities (average—63.73%). A very strong negative correlation (r = −0.86) and a satisfactory fit of the regression curve (R^2 = 0.75) for the value of assets and the volume of coal output means that an increase of PLN 1000 PLN in the value of assets resulted in a decrease in output of 0.16 thousand tonnes. A weak correlation (r = 0.24) was observed between the intensity of changes in the structure of assets and the change in the structure of employment. This confirms the lack of any common restructuring policy for these areas. An average correlation with the pace and scale of changes in the asset structure and total productivity (r = 0.41), a weak correlation with productivity per underground worker (r = 0.13) and a weak correlation with the rate of change in productivity (r = 0.14) clearly confirm that the restructuring of fixed assets did not result in any improvement in the operating efficiency of mining enterprises (Figure 8).

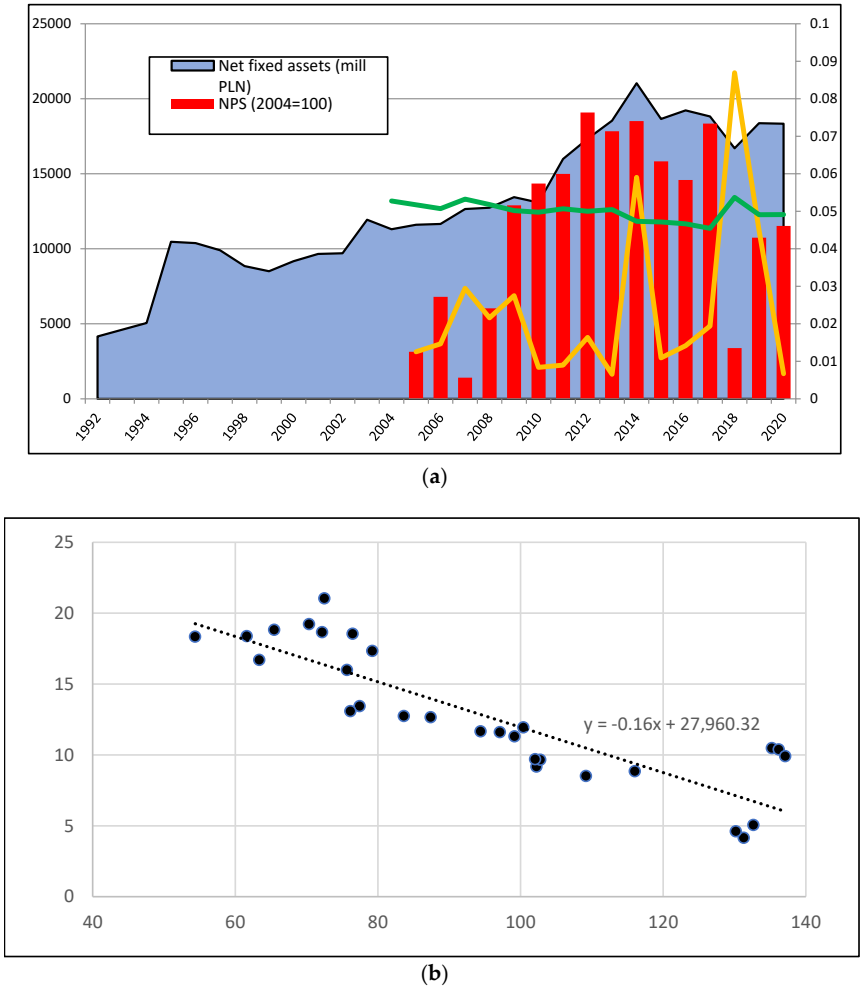

Figure 8. Net fixed assets in coal mining companies in Poland in 1992–2020; (**a**) Net fixed assets in 1992–2020, intensity of structure changes (NPS 2004 = 100, NPS y/y), and concentration (HHI) in 2004–2020; (**b**) The regression curve of the net fixed assets and the hard coal output in Poland in 1992–2020. Notes: net fixed assets—left axis. Remaining remarks as to Figure 5. Source: as in Figure 5.

Proof of partial hypothesis H2. The results outlined above provide an unequivocal basis for nullifying the partial hypothesis (H2). This means that the restructuring of hard coal enterprises did not help to achieve the basic goal of rationalising employment. No correlation was observed between changes in the employment structure, the size and rate of coal output and changes in the structure of fixed assets, and mines were not adapted to the technical and technological changes that took place during this period. □

A basic goal of every restructuring program was a reduction in liabilities, first so as to prevent insolvency and liquidation and then to ensure growth. All the programs provided for debt reduction through the implementation of composition and bank settlement proceedings, spreading out and postponing overdue payments or cancelling overdue interest and payments owed to the state. The introduction of special laws regulating the restructuring of hard coal mining debt had the effect of drastically lowering liabilities by over 62% in 2003. Overall, thanks to debt cutting measures based on special provisions introduced in 1998 [142] and 2003 [143], over PLN 18 billion (EUR 3.9 billion) of the debt owed by the hard coal mining industry was written off [144] (see conclusions in Section 3.2).

3.4. Assessment of Changes in the Structure of Electricity Generation vs. Hard Coal Mining

Partial hypothesis H3. *The effects of restructuring coal mining companies based on a multidimensional approach are determined by time intervals characterised by elements of homogeneity (time series periodisation).*

Changes introduced in the structure of electricity generation in Poland (hard coal, lignite, natural gas, heating oil, RES) were small in scale (NPS = 0.097, annual average 0.012) up until 2010 (compared to 1990). In the years 2010–2020, the intensity of change in the generation structure was already twice as high (NPS = 0.286 in 2020, 0.032 annually on average) as in the previous 20 years. A very high and negative correlation was observed between changes in the structure of electricity generation (NPS) and (1) sales of steam coal ($r = 0.66$, unsatisfactory regression fit $R^2 = 0.43$), (2) coal output ($r = 0.88$, a satisfactory regression fit $R^2 = 0.78$) and (3) the volume of steam coal production ($r = 0.91$, a good regression fit $R^2 = 0.84$).

The regression relationship outlined above should be interpreted in such a way that a change in the structure of energy production in 1990–2020 by 1% (NPS) resulted in a decrease in thermal coal production by 1.09%, i.e., in a decline in thermal coal production amounting to 2,332,000 tonnes. (Figure 9). This indicates that external factors (i.e., non-mining factors) exerted a significant influence on the volume of coal mined and the nature of changes in its output (mainly with regards to the ways in which increased demand for electricity was covered from sources other than coal.

For the purposes of reinforcing and interpreting the results obtained so far, the authors applied the model system of inequalities [145]. This approach is based on the existence of interdependencies between the dynamics underpinning the main categories that determine the economic condition of an enterprise and its rational (efficient) functioning. Changes in the structure of employment and fixed assets (the resources of enterprises) were first assessed, followed by an evaluation of the changes in the sale and mining of steam coal, total productivity and productivity per underground worker (as effects of operation), as well as the structure of energy production and investments (as external stimulants of changes). A very strong and negative correlation was observed between changes in the structure of the energy mix and sales (SCE) ($r = -0.84$, a matching regression relationship $R^2 = 0.71$) on the one hand and coal mining (MCE) ($r = -0.92$, matching the relationship regression $R^2 = 0.84$) on the other. A strong, negative correlation was observed between changes in the structure of electricity generation (EN) and changes in the employment structure ($r = -0.70$, adjustment of the regression relationship $R^2 = 0.50$) as well as changes in the structure of fixed assets ($r = 0.70$, adjustment of the regression relationship $R^2 = 0.50$). In the remaining cases, the correlation was weak or slight (Figure 10).

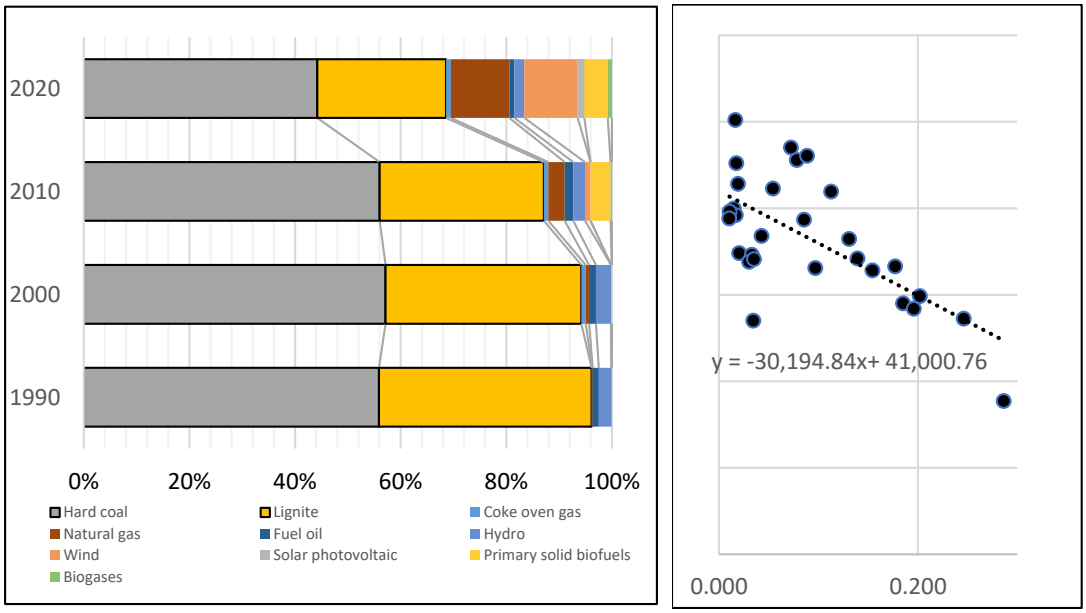

Figure 9. Electricity production sources in Poland in 1990–2020; (**a**) The structure of electricity generation in Poland in 1990, 2000, 2010 and 2020; (**b**) The regression curve of the intensity of changes in the structure of electricity generation and the coal production in Poland in 1990–2020 Source: own study based on Eurostat. Available online: https://ec.europa.eu/eurostat/data/database (accessed on 22 February 2022).

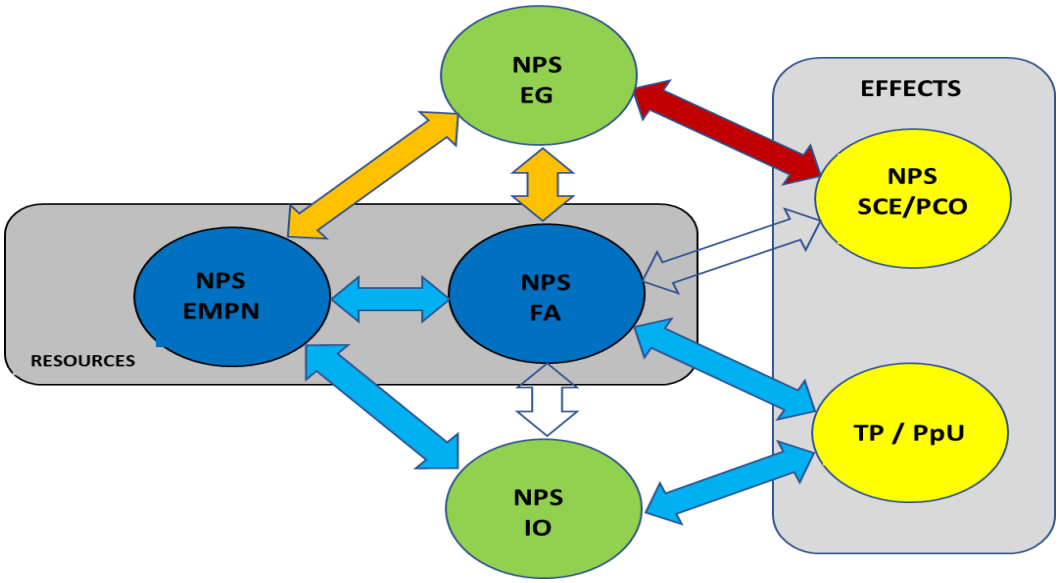

Figure 10. Strength of dependence of selected interdependencies for coal mining enterprises in Poland. Notes: NPS—intensity of structure changes, FA—fixed assets; EMPN—employment, IO—investment outlays; TP—total productivity, PpU—productivity per underground worker; EG—energy generation; PCE—steam coal output; SCE—sale of steam coal. The colour of the arrow indicates the degree of correlation: <0.1 weak (no colour); 0.1–0.3 weak (blue); 0.3–0.5 average (green); 0.5–0.7 high (yellow); 0.7–0.9 very high (orange); >0.9 almost full (red). Source: own study based on data provided by ARP S.A. Katowice branch; own study based on data from hard coal mining restructuring programs in Poland in the years 1993–2020 (Appendix B), materials of the Ministry of Economy. Available online: www.gov.pl (accessed on 2 February 2022), and ARP Katowice. Available online: https://polskirynekwegla.pl/ (accessed on 10 February 2022).

The shape of the steam coal sales curve made it possible to distinguish three distinct periods: (1) 1992–2002 (a decrease in sales with a simultaneous slight change in the structure of electricity generation; annual average NPS = 0.006 and NPS = 0.035 compared to 1992), (2) 2003–2008 (an increase in sales with a simultaneous weak increase in the intensity of changes in the structure of electricity generation, annual average NPS = 0.017 and NPS = 0.073 compared to 1992) and (3) 2009–2020 (a clear downward trend in sales with an equally strong trend towards structural change; annual average NPS = 0.029 and NPS = 0.286 compared to 1992). In addition, sales declined significantly in 2019–2020, which was accompanied by significant changes in the structure of electricity generation compared to 1992 (Figure 11).

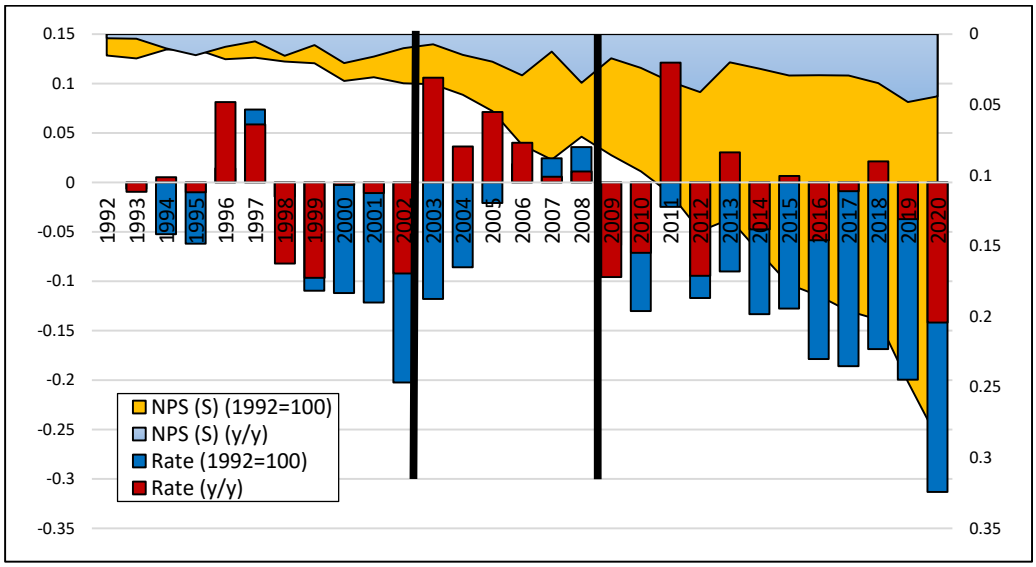

Figure 11. The rate of changes in the sales of steam coal volume, and the variability of changes in the structure of electricity generation in Poland (NPS 1992 = 100, NPS y/y) in 1992–2020. Source: as in Figure 10.

The above results lead to the conclusion that in the years 1992–2020, a strong and negative correlation existed between changes in the structure of electricity generation and steam coal sales volume (r = 0.66), with this structure having a noticeable impact on the sales volume (R^2 = 0.43). An analysis of this relationship in all three of these periods yields the following results:

- 1992–2002—a very strong and negative correlation (r = −0.89, R^2 = 0.79) with production volume and a strong and negative correlation with sales of steam coal (r = −0.67, R^2 = 0.45);
- 2003–2008—a strong and positive correlation with production volume (r = 0.80, R^2 = 0.64) and a very strong and positive correlation with steam coal sales volume (r = 0.93, R^2 = 0.87);
- 2009–2020—a very strong and negative correlation with production volume (r = −0.93, R^2 = 0.88) and a strong and negative correlation with sales of steam coal (r = −0.90, R^2 = 0.81).

Proof of partial hypothesis H3. In conclusion, an assessment of changes in the structure of electricity generation in the years 1992–2020 as well as indicators of changes in hard coal sales for electricity needs (the NPS indicator) confirms partial hypothesis (H3). This means that the restructuring period can be divided into intervals of time with their own homogenous characteristics. □

4. Discussion

When discussing the results of coal mining companies that have undergone continuous restructuring, several factors need to be distinguished [146]. The first is the composition of the determinants of the outcome, especially in operational terms, and concerns not only absolute differences in revenues and costs but also their dynamics and the cost structure [147,148]. The labour factor exerted considerable pressure on costs during times of economic prosperity, which made it impossible to limit such expenditure in periods of falling prices, which in turn led to poorer results and higher losses [149]. Another problem was that operating costs were burdened with capital expenditure; faced with problems of low creditworthiness, enterprises made use of a widening result field and increased their costs through investments, which also could not be quickly brought under control during times of recession.

In the years 1990–2020, productivity suffered a linear and substantial decline [150] with the rapidly shrinking workforce (with a positive or negative deviation from production dynamics) [151]. The costs connected with cutting employment constituted the main component of cost-cutting measures in mining in general [152]. Labour productivity, measured in terms of revenues, increased overall, but from the point of view of efficiency, this indicator turns out to be misleading, as it is based on a quantitative reduction in the volume of production and labour [153]. After 2003, total cost productivity began to decline, and asset productivity at an even faster pace. In these circumstances, the next recessions (2014–2016 and the even sharper downturn of 2019–2020) were inevitable, and they were triggered by a slight correction in coal prices.

Low productivity and operational efficiency are quickly and quite strongly reflected in levels of solvency and liquidity as well as in working capital cycles [154]. Debt increases rapidly, and an enterprise's ability to pay its liabilities decreases. In these conditions, enterprises are no longer capable of self-financing and expect public assistance in the form of subventions and government subsidies [155]. Plans to shift away from direct government-initiated restructuring after 2006 remained a fact for only a few years and became utter fiction after 2013 [156]. To keep coal mining companies operating in order to supply power plants with raw material, further large subsidies were needed [157].

Using the logit model for predicting the degree of financial risk for a going concern (FTD), a synthesis was constructed of partial assessments of the results of coal mining enterprises. This model is a multidimensional tool for assessing the financial situation of an enterprise, as was previously mentioned, and functions as a kind of barometer of this financial condition [158]. The results of the findings are, firstly, that the level of risk for coal mining companies significantly exceeds the results of all industrial enterprises (including those involved in the mining of other natural resources). On average, this indicator was 1.8 times higher than for industry as a whole. Secondly, this is a highly volatile measure (volatility coefficient of 63.7%), which is particularly evident when considering the stabilisation of the industry observed since 2009. Thirdly, the course of the FTD curve makes it possible to distinguish three characteristic periods in the course and effects of restructuring in the coal mining industry: (1) 1990–2002 (achieving financial independence and profitability), (2) 2003–2013 (relative stabilisation and departure from direct restructuring measures), (3) 2014–2020 (a return to conditions of crisis). Particularly visible are the effects of the debt reduction (measures implemented in 2002–2003) and the return of crisis (2019–2020) (Figure 12).

In conclusion, the results of restructuring coal mining companies in 1990–2020 assessed by means of the multi-component FTD measure is further evidence in favour of adopting partial hypothesis (H3). This means that it is possible to periodise the tested time series, which was reinforced by the previously demonstrated occurrence of close (convergent) time intervals distinguished according to the intensity of changes in the structure of electricity generation in connection with changes in hard coal output for energy purposes (see Section 3.4).

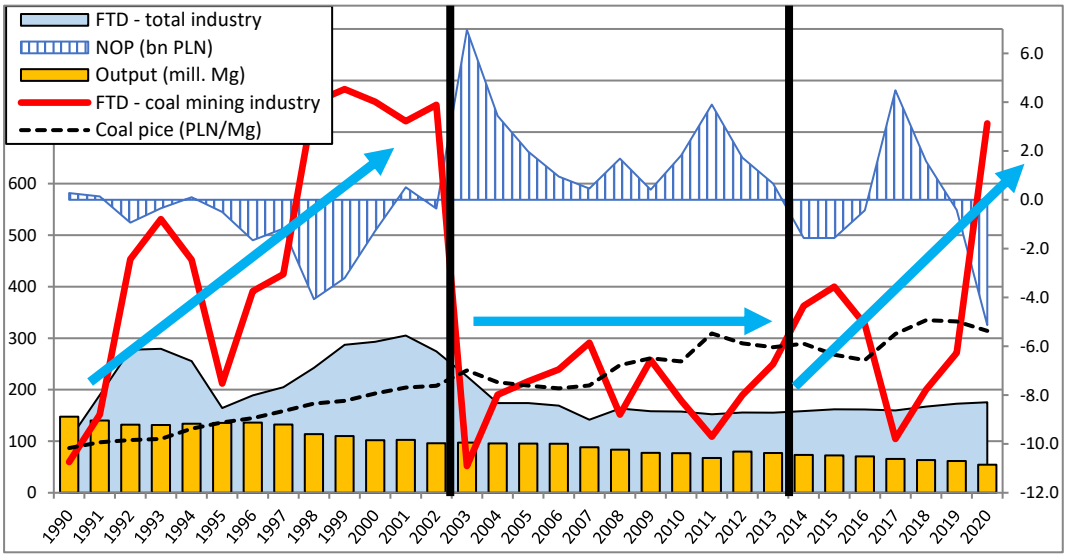

Figure 12. Financial threat degree of going concern (FTD) against key economic criteria for coal mining enterprises in 1990–2020. Note: net operating profit (NOP)—right axis. Source: as in Figure 1.

No restructuring can be a stand-alone undertaking [159], especially when it concerns an entire economic sector. The key tasks of restructuring in the case of the hard coal mining industry were to achieve profitability, modernise mining technology, increase productivity and efficiency and promote efficient management practices [160]. Unfortunately, the long-term effects of these measures have been negative. Moreover, the future situation will be conditioned by the interplay of a number of factors, which will give rise to two opposing relationships:

- the current state of hard coal resources will, with rational management (without embarking on the exploitation of new deposits), ensure its supply up to 2049 [161],
- the current difficult financial state of the mining industry poses a serious barrier to, if not makes impossible, the implementation of the necessary development investments that would ensure an adequate supply of raw materials in the future [162].

A more detailed discussion of the effects of the restructuring programmes launched in the branch after 1990, led to the following conclusions:

1. The restructuring activities carried out during this period did not bring the expected results, as is evidenced by the poor condition of mining enterprises [163].
2. None of the 1992–1997 programs were fully successful, and most did not live up to the hopes placed in them [164,165] because of the inconsistent implementation of restructuring programs. Makieła [166] tried to prove it earlier but limited his research only to the analysis of the magnitude differentiation of only three measures, without attempting a comprehensive evaluation.
3. Organisational changes in mining enterprises were not always accompanied by planned job cuts [167]. Gumiński [168] previously tried to confirm this conclusion in research on the effective use of human resources, but he limited himself only to research and evaluation of selected measures.
4. The main methods used to reduce employment were natural redundancy, restrictions on admissions and, to a small extent, retirement incentives (early retirement, retraining courses, relocations, etc.), which was also noted in the research conducted by Bluszcz [169], which pointed out the lack of employment alternatives elsewhere.
5. The absence of major changes in employment structures and fixed assets indicates a lack of any decisive policy or ongoing modernisation of these structures. Earlier, Gumiński [170] and Grzybek [171] tried to assess it, but they did not use any statistical evaluation analysis tools with features of coherence.

6. A strong and negative correlation was observed between changes in the form and structure of fixed assets and the volume of mining output, with no improvement in the operating efficiency of mining enterprises. The lack of any correlation between the structure of assets and productivity and employment structure clearly indicates that the restructuring measures implemented during this period had no economic effect.
7. The failure to achieve the desired changes was a consequence of exogenous processes, namely the task of creating legal and environmental regulations as well as the fact that political pressures did not take into account the economic conditions in which mining enterprises functioned [39].
8. Since 2007, the authorities have abandoned the idea of setting coal output and sales targets due to their inconsistency with market trends and the objectives of energy policy [172]. No effective measures were taken in a timely manner to adjust mining enterprises to the changing market situation, which was also confirmed in the studies conducted by Turek & Jelonek-Kowalska [173]. This was due to a number of factors, including geopolitical [174], economic [175] and social [176] factors.
9. The cut-back in mining operations and coal output came as a result of the need to abruptly adapt to the declining need for coal, which was only to a small extent caused by the energy transition, and shrinking demand for steam coal. Gumiński, Karbownik and Włodarski [91] came to a similar conclusion, but they did not take into account the analysis of interdependencies carried out in this article.
10. Although, as was shown in the research, an important element of the above restructuring programs was ensuring the country's energy security, especially given the insufficient capacity provided by alternative energy sources [177–179], this security has not been adequately guaranteed. This was pointed out by Kaliski et al. [180] in their research, but they did not attempt to indicate the direction of policy changes, which in the current situation is of key importance for Poland.

Proof of main hypothesis. The research findings presented so far, including the verification of sub-hypotheses H1–H3 and their initial discussion, have denied the validity of the main hypothesis. This means that the restructuring of hard coal enterprises, being neither effective nor efficient, failed to accelerate changes in the energy mix. □

A number of studies on mining conducted so far have concerned only the analysis, and in part the evaluation, of the changes that have taken place in the context of a single programme being implemented, or have concerned a limited scope, number and type of measures. The most extensive research on changes in mining was conducted by Makieła [166], Turek and Jonek-Kowalska [173]. They focused only on selected, isolated areas, without trying to build a comprehensive assessment. This deficit was filled by the research in the article through the use of a logit model, which allowed, in synthetic terms, a comprehensive, objective and multidimensional assessment of financial health and risk in the long term. This assessment showed that the restructuring of coal mining companies failed to achieve the primary objective of sustainable profitability and productivity growth. A multidimensional diagnosis of the employment structure and the assessment of differences between individual plants in the hard coal mining industry, carried out by Frankowski et al. [176], included only a detailed analysis of the area of employment and its structure. This article strengthens the method of evaluating the changes in the structure of employment using the taxonomy of structures and evaluating the interdependence with other resources of the enterprises, showing negligible changes in the structure of employment, assets, capital expenditures and sales. Gumiński [168], in his research, focused on studies on selected objects of analysis (questionnaire surveys), which as a result prevented the identification of endogenous and exogenous factors affecting the changes that occurred. This missing area was filled in the article using taxonomic analysis, which was supported by regression analysis. A definite weakness of previous studies is the short time horizon, which covered only short periods, mostly limited to specific restructuring programmes,

and the low cross-sectionality of the analysis. The long-term studies conducted allowed the determination of the time intervals with the features of homogeneity (periodisation of the time series). The added value of the research in the article is the analysis of the full restructuring period and all restructuring programmes, as well as the wide range of measures analysed. This article reinforces the assessment by conducting research that provides clear findings in this regard, which were verified using objective assessment tools. As in the past, the authors have referred in their research mainly to the analyses concerning the development of the renewable energy market [181–183], technologies related to the production of energy from RES [184], the socio-environmental effects of energy use and the importance of the conditions related to the limits of pollutant emissions [185], accepting (postulatively) the direction of decarbonisation in energy production [186] and departing from the issue of the necessary coherence of restructuring changes in the mining and power industries. This relationship was demonstrated in the conducted research by confirming the high correlation between changes in the energy mix and changes in the structures characterising mining companies. The results of the research described in the article indicate a very important issue. In order to accelerate the change in the energy mix, the restructuring of the coal mining industry should support the restructuring of the energy sector.

If we consider the last of the above conclusions in a broader context, it was thought [68] that energy security (as defined in 1990) required meeting three conditions simultaneously: ensuring security of the energy supply, maintaining socially justified energy prices and minimising environmental damage. To guarantee energy security understood in this way, it was necessary, inter alia, to ensure (as was confirmed in the goals of subsequent energy policies (PEP)) the possibility of satisfying demand for coal from domestic sources. This was to be achieved by measures aimed at modernising technologies connected with mining and preparing coal for electricity purposes, as well as by creating incentive mechanisms encouraging the maintenance and development of suitable production capacities [72] (p. 10). Unfortunately, the results of the present analysis show that underinvestment in the modernisation of production assets and the exploitation of new deposits places in doubt the ability of the country to meet its needs for coal up until 2049. The situation is serious even despite the predicted gradual decline in demand for coal for electricity generation purposes (set to decline by over 40% in 2040 compared to 2020), according to the forecasts presented in PEP 2040 [49].

On the other hand, the ongoing energy transition in Europe, which is taking place in an expanding common European energy market (Regulation 2019/943/EU) [187], poses another threat to Poland's energy security. Delays in the simultaneous reform of the power engineering and coal mining sectors, as well as prolonging the use of coal as the country's basic fuel while other EU countries are rapidly developing renewable energy sources, may result in the displacement of domestic energy from the power system due to the "merit order" effect [188–190]. This means that priority in the energy system is given to energy with the lowest variable cost of production. In a common energy market where neighbouring countries engage in large scale production from renewable sources, imported energy will be the first to be accepted into the Polish energy system. Renewable energy is characterised by negligible variable costs (it does not use fuel and does not require manpower). This will put the conventional energy sector in a difficult economic situation.

Much will also depend on the pace of development of the Polish RES sector. The key question seems to be whether Poland will maintain the relatively high pace of RES development, already presented in the article. The government's forecasts included in the Energy Policy of Poland by 2040 [49] assume an increase in electricity production from RES by only 13% during the current decade (until 2030). This should increase the share of renewable energy sources in electricity production to 32%. Growth is expected to occur—at different rates—in all renewable sources, as evidenced by official [49] and independent studies [191,192]. However, the development of RES is highly dependent on legal solutions and may be quickly stopped or accelerated [191,193] depending on the political will of the government.

Returning to the conventional energy sector, on the basis of the aforementioned regulations regarding the internal energy market, in 2025 EU member states will no longer be able to support producers of coal-generated electricity via, for example, a system of capacity payments, which currently constitutes an important source of financing for conventional power plants [194,195]. Indirectly, this will have a significant impact on mining through a wave-like reduction in demand for coal—along with the exclusion of subsequent power plants from the system. The financial condition of coal mining companies will deteriorate further, and they will be cut off from funds needed for investments. As a result, the Polish economy will become dependent on energy imports, despite theoretically having significant domestic energy resources at its disposal. This is another argument in favour of not slowing down the pace of energy transition, despite the problems caused by the war in Ukraine and subsequent increases in gas prices, which are treated as a transition fuel for a target zero-emission economy. In conclusion, it can be argued that by lagging behind in the energy transition process, Poland faces a significant threat to its energy security in the medium term.

Every research project has certain limitations. These can be mitigated by ensuring the coherence and consistency of the research framework, as well as by using advanced research methods and databases and applying multiple arguments and long-term timeframes. In the present research, above all else, there were no problems regarding the representativeness of the study (the study population comprised all enterprises in the sector). One limitation was the lack of data availability to conduct structure taxonomy and regression analyses for all measures and the full period (31 years). An additional limitation was the heterogeneity, large cross-sectional variation and discrepancies in the secondary data sets, the mitigation of which was attempted by accessing the primary data. In addition, the depth structural and ownership changes (liquidations, mergers of mines and mining companies) made it difficult to maintain comparability of analysis. The abandonment since 2007 of quantitative target setting in restructuring programmes has weakened the clear assessment of the effects achieved. In part, this problem was solved in the study by using taxonomic analysis to determine the intensity of changes occurring and objective comparisons. As a consequence, generalising conclusions can be drawn with a high level of reliability. This also applies to the trends and dependencies observed in the research due to its very long and exhaustive time horizon (31 years). Methodological limitations were overcome by applying multi-sectional sub-measures, a multi-dimensional logistic regression measure and taxonomic measures of structure variability. Of course, other methods may produce different results, but it can be argued that the general trends, relationships and structures would not be significantly different. Furthermore, there is no limitation on the degree of applicability of the research. It is intended as a universal diagnostic tool. Both the methods used and the research framework enable its use in a broad, international application. This represents the value of universality of the research and comparability of the results obtained, which has not been achieved so far.

The conclusion that the restructuring of hard coal enterprises, being neither effective nor efficient, did not accelerate changes in the energy mix, provides the platform for further research. The latter will focus on the task of identifying and measuring the factors that influenced the dynamic though still insufficient development of non-coal energy sources, in particular renewable energy sources. Specifically, this research will address:

- an assessment of the effectiveness of the use of lignite for power generation to date and the prospects for maintaining it,
- identification of determinants and barriers for the development of renewable energy sources,
- an assessment of the economically justifiable life of coal-fired power and heat generation sources given the need for energy security,
- evaluation of the limits of the efficiency (upgrades and creation of new ones) of energy generation sources as a relation of effects and expenditures (with the considered use of non-parametric methods: DEA or FDH),

- selection of energy generation sources for the mix as a relativisation of their efficiency to the energy security factor.

The present research, which has the character of a diagnosis of the state of dependence of the effects of coal mining restructuring and changes in the power industry, as indicated, is the first stage of a widely conducted study. The next step will involve a comparative analysis of the efficiency boundaries (the relationship between effects and expenditures) of all generation sources. Combining the current diagnosis with such an efficiency analysis (non-parametric approach) will allow the formulation of the main building blocks for a new energy transition policy. Already now, however, after the first stage of the diagnosis concerning hard coal mining, the main pillars (directions) of this policy can be formulated:

- removal of regulatory barriers to the development of wind and solar power generation (e.g., reduction of the minimum distance of windmills from buildings, return to net metering, not just net billing);
- government investments into the expansion and upgrade of electricity grid infrastructure, which is a bottleneck for RES development;
- acceleration of design work and investment contracts for the construction of a nuclear power plant, which is a stable source of energy demand coverage in the face of the significant amplitude of fluctuations inherent in RES;
- upgrading of coal-powered generating units in large power plants using new, already available technologies that reduce the burden on the environment and the amount of emission fees;
- use of accumulated funds from the sale of the EU ETS and their increase using government subsidies for the purpose of accelerating the development of RES and "leapfrogging" the hitherto planned natural gas phase;
- setting new targets and activities in the field of the restructuring of hard coal and lignite mining resulting from (following) the developed new energy policy (increase in efficiency, new technologies, intensification of structural reconstruction), based on the optimisation of the energy mix and the context of energy security.

The results of the research conducted so far, the diagnosis made on their basis and the above-mentioned pillars of the future energy policy prove that the pace of Poland's energy transition should be accelerated. The prospect of abandoning coal by 2049 is too distant, not only because of environmental factors, but also in view of the country's energy security. In the conditions of the single EU energy market, the merit order effect is in force, and, at the same time, given that state support for the capacity market is now prohibited and prices of emission allowances are above EUR 60, conventional energy may be forced out of the market, and the ability to generate revenues sufficient to cover operating costs will be lost.

5. Conclusions

The research results presented and discussed in the present article yield several general conclusions. First, coal mining companies have not achieved sustainable profitability and competitiveness on the open coal market. Secondly, restructuring has not brought about any significant structural changes in any of the basic economic categories: employment, assets, capital expenditure and sales. Third, no significant technical and technological progress has been achieved.

The main dependency shown in the article is that a 1 pp. change in the structure of electricity generation resulted in a 2.04 pp reduction in coal output and a 1.09 pp decrease in sales of steam coal. When assessing this dependency, it should be borne in mind that coal output, especially in terms of its consumption for energy purposes, only declined by a few percent in the years 1990–2020. This means that the changes in the energy mix were only possible by covering higher energy demand by increasing the use of non-coal energy sources (8.5 times, including 15 times RES). What is more, the share of these sources only began to increase rapidly (exponentially) at the beginning of the 21st century (gas), and later

only in the case of energy from renewable sources (wind farms), and from photovoltaics the most, but only after 2011.

The linear decline in hard coal production as well as the exponential share of renewable energy sources in the total energy mix further highlights the argument presented in the detailed conclusions, namely that the restructuring of hard coal enterprises, being neither effective nor efficient, failed to accelerate changes in the energy mix. In particular, this means that there was no consistency (follow-up) between the forms and effects of restructuring applied to coal mining companies in Poland and modifications in the country's energy mix in response to the energy transition.

The negative assessment of restructuring presented above is reinforced by the fact that in 1990–2020, very significant sums to the amount of EUR 57.3 billion (9.3% of GDP in 2020) were set aside in the budget for subventions, subsidies and other encumbrances for the sector. Moreover, the cost of maintaining the hard coal mining industry until 2049 will require an additional approximately EUR 69.7 billion (11.3% of GDP in 2020). Such expenditure, both incurred already and still planned, should be considered wasted in the sense that it failed to accelerate the dynamics of the energy transition.

Author Contributions: Conceptualization, J.K., K.K. and W.S.; methodology, J.K. and K.K.; validation, W.S.; investigation, J.K., K.K. and W.S.; resources, J.K., K.K. and W.S.; data curation, J.K., K.K. and W.S.; writing—original draft preparation, J.K. (transition and restructuring; productivity and effectiveness; financial and threat prediction analysis), K.K. (coal mining restructuring in Europe and polish government restructuring programs; structure and concentration analysis) and W.S. (energy transition in EU, energy mix sources, polish energy policy); writing—review and editing, J.K., K.K. and W.S.; visualization, J.K. and K.K.; supervision, J.K. Authorship is limited only to those who have contributed substantially to the research and article. All authors have read and agreed to the published version of the manuscript.

Funding: This research and publication was funded by a subvention granted to the Cracow University of Economics.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Restrictions apply to the availability of these data. Data were obtained from: GUS Warszawa (Statistical Head Office in Warsaw)—databases are of limited access and are available (Statistics Poland Databases; available online: https://stat.gov.pl/en/databases/ accessed on 4 February 2022) for a fee and with the permission of GUS, Warsaw; Pont Info Warsaw (Poland), Gospodarka SŚDP—commercial databases are available (Gospodarka SŚDP; available online: http://baza.pontinfo.com.pl/index.php accessed on 2 February 2022) for a fee and with the permission of Pont Info, Warsaw; EUROSTAT—unlimited public access databases (available online: https://ec.europa.eu/eurostat/data/database accessed on 22 February 2022); Agencja Rozwoju Przemysłu (ARP—Industrial Development Agency)—commercial databases are available (available online: https://polskirynekwegla.pl/ accessed on 10 February 2022) for a fee and with the permission of ARP.

Conflicts of Interest: The authors declare no conflict of interest. The funder had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A

The financial standing and restructuring effect evaluation measures for coal mining enterprises:

- resources: fixed and total assets, accumulated depreciation, inventories, receivables, short-term liabilities, number of employees, net working capital,
- flows: revenues from sales, operating and total costs, net operating and financial results, investment expenditures, depreciation, export sales,
- rates of use:

  - general financial standing: ACSR asset-capital structure ratio,
  - debt: STDR—short-term debt ratio, TDR—total debt ratio,
  - static liquidity and solvency: CLR—current liquidity ratio, QLR—quick liquidity ratio, SR—solvency ratio,
  - dynamic liquidity: SCER—sales cash efficiency ratio, CFCR—cash flow coverage ratio,
  - working capital management: IC—inventories cycle, RC—receivables cycle, STLC—short-term liabilities cycle, NWCC—net working capital cycle,
  - profitability: oROS—operating return on sales, oROA—operating return on assets, ROE—return on equity, VAM—value-added margin,
- efficiency and effectiveness: LE—labour effectiveness, LP—labor productivity, AP—assets productivity, CP—cost productivity, AR—fixed asset renewal.

The intensity of structural changes standing and restructuring effect evaluation measures for coal mining enterprises:

- resources: fixed assets, employment, hard coal production,
- flows: hard coal sales, investment outlays, electricity generation.
- rates of use:
  - fixed assets FA,
  - employment EMPN,
  - investment outlays IO,
  - total productivity TP,
  - productivity per underground worker PpU,
  - energy generation EG,
  - power coal mining PCM,
  - sale of energy coal SCE.

Appendix B

Hard coal restructuring programs:

1. Program I—*Restrukturyzacja górnictwa węgla kamiennego w Polsce (Hard coal mining restructuring in Poland)—the implementation of the first stage in 1993, within the financial capacity of the state)—realizacja pierwszego etapu w 1993 roku w ramach możliwości finansowych państwa* (przyjęty przez Radę Ministrów w dniu 15 marca 1993 roku.
2. Program II—*Program powstrzymania upadłości górnictwa węgla kamiennego w Polsce (The program to stop the bankruptcy of hard coal mining in Poland) (realizacja w okresie 15.07–31.12.1993 roku)* przekazany Komitetowi Ekonomicznemu Rady Ministrów w dniu 2 sierpnia 1993 roku.
3. Program III—*Restrukturyzacja górnictwa węgla kamiennego. Część II. Program dla realizacji II etapu w okresie 1994–1995 roku (Hard coal mining restructuring. Part II. Program for the implementation of the 2nd stage in the period 1994–1995)* zaakceptowany przez Komitet Ekonomiczny Rady Ministrów w dniu 18 lutego 1994 roku.
4. Program IV—*Górnictwo węgla kamiennego, polityka państwa i sektora na lata 1996–2000. Program dostosowania górnictwa węgla kamiennego do warunków gospodarki rynkowej i międzynarodowej konkurencji (Hard coal mining, state and sector policy for 1996–2000. Program of adjusting the hard coal mining to the conditions of the market economy and international competition)* przyjęty przez Radę Ministrów w dniu 30 kwietnia 1996 roku.
5. Program V—*Reforma górnictwa węgla kamiennego w Polsce w latach 1998–2002 (The reform of hard coal mining in Poland in 1998–2002)* przyjęta przez Radę Ministrów w dniu 30 czerwca 1998 roku wraz z Korektę rządowego programu *Reforma górnictwa węgla kamiennego w Polsce w latach 1998–2002 (The reform of hard coal mining in Poland in 1998–2002)* przyjęta przez Radę Ministrów w dniu 21 grudnia 1999 roku.
6. Program VI—*Program restrukturyzacji górnictwa węgla kamiennego w Polsce w latach 2003*–2006 z wykorzystaniem ustaw antykryzysowych i zainicjowaniem prywatyzacji niektórych kopalń *(Hard coal mining restructuring program in Poland in the years*

2003–2006 with the use of anti-crisis acts and initiation of privatization of some mines) przyjęty przez Radę Ministrów w dniu 20 listopada 2002 roku (z korektami wynikającymi z Porozumienia strony rządowej ze stroną związkową z dnia 11 grudnia 2002 roku oraz korektami wynikającymi ze stanu prawnego sektora na dzień 10 stycznia 2003 roku), przyjęty przez Radę Ministrów w dniu 28 stycznia 2003 roku.

7. Program VII—*Restrukturyzacja górnictwa węgla kamiennego w latach 2004–2006 oraz strategia na lata 2007–2010 (Hard coal mining restructuring in 2004–2006 and the strategy for 2007–2010)* przyjęta przez Radę Ministrów w dniu 27 kwietnia 2004 roku.
8. Program VIII—*Strategia działalności górnictwa węgla kamiennego w Polsce w latach 2007*–2015 *(Strategy of hard coal mining activity in Poland in the years 2007–2015)* przyjęta przez Radę Ministrów w dniu 31 lipca 2007 roku wraz z Korektą programu rządowego przyjętą przez Radę Ministrów w dniu 24 lipca 2009 roku.
9. Program IX—*Program dla sektora górnictwa węgla kamiennego w Polsce do 2030 roku (Program for the hard coal mining sector in Poland until 2030)* przyjęty przez Radę Ministrów w dniu 23 stycznia 2018 roku.

Appendix C

Table A1. Intensity of changes in the structure of employment (NPS) in mining enterprises in Poland in 1992–2020.

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.000	0.021	0.044	0.062	0.069	0.077	0.066	0.078	0.084	0.082	0.087	0.091	0.089	0.091	0.094	0.097	0.100	0.104	0.103	0.105	0.104	0.105	0.101	0.099	0.099	0.109	0.109	0.108	0.109
0.021	0.000	0.024	0.041	0.048	0.056	0.046	0.058	0.064	0.063	0.067	0.071	0.070	0.072	0.075	0.077	0.081	0.084	0.084	0.085	0.084	0.087	0.093	0.095	0.093	0.095	0.093	0.097	0.100
0.044	0.024	0.000	0.017	0.024	0.033	0.027	0.040	0.044	0.048	0.048	0.050	0.057	0.061	0.063	0.066	0.061	0.065	0.072	0.070	0.072	0.080	0.086	0.087	0.086	0.088	0.086	0.090	0.092
0.062	0.041	0.017	0.000	0.007	0.015	0.021	0.034	0.038	0.043	0.042	0.044	0.051	0.056	0.057	0.060	0.055	0.059	0.066	0.064	0.066	0.072	0.080	0.082	0.080	0.081	0.080	0.084	0.087
0.069	0.048	0.024	0.007	0.000	0.008	0.020	0.029	0.033	0.038	0.037	0.039	0.046	0.051	0.052	0.055	0.050	0.054	0.061	0.059	0.061	0.067	0.075	0.076	0.075	0.076	0.075	0.079	0.082
0.077	0.056	0.033	0.015	0.008	0.000	0.022	0.024	0.028	0.033	0.032	0.034	0.041	0.046	0.047	0.050	0.045	0.049	0.056	0.054	0.056	0.063	0.070	0.072	0.070	0.071	0.070	0.074	0.077
0.066	0.046	0.027	0.021	0.020	0.022	0.000	0.013	0.018	0.021	0.021	0.025	0.030	0.034	0.036	0.039	0.035	0.039	0.045	0.043	0.045	0.054	0.060	0.061	0.059	0.062	0.059	0.063	0.065
0.078	0.058	0.040	0.034	0.029	0.024	0.013	0.000	0.006	0.008	0.011	0.016	0.019	0.024	0.025	0.028	0.025	0.030	0.034	0.033	0.033	0.045	0.051	0.052	0.048	0.053	0.046	0.050	0.052
0.084	0.064	0.044	0.038	0.033	0.028	0.018	0.006	0.000	0.007	0.005	0.009	0.014	0.019	0.020	0.023	0.019	0.024	0.029	0.029	0.029	0.043	0.049	0.050	0.047	0.051	0.045	0.048	0.049
0.082	0.063	0.048	0.043	0.038	0.033	0.021	0.008	0.007	0.000	0.007	0.011	0.011	0.015	0.017	0.019	0.021	0.026	0.025	0.025	0.025	0.041	0.047	0.048	0.045	0.049	0.043	0.046	0.047
0.087	0.067	0.048	0.042	0.037	0.032	0.021	0.011	0.005	0.007	0.000	0.005	0.009	0.014	0.015	0.018	0.014	0.019	0.024	0.024	0.024	0.041	0.047	0.048	0.044	0.049	0.042	0.045	0.047
0.091	0.071	0.050	0.044	0.039	0.034	0.025	0.016	0.009	0.011	0.005	0.000	0.008	0.012	0.013	0.016	0.011	0.016	0.022	0.020	0.022	0.041	0.047	0.048	0.045	0.049	0.042	0.046	0.047
0.089	0.070	0.057	0.051	0.046	0.041	0.030	0.019	0.014	0.011	0.009	0.008	0.000	0.005	0.006	0.009	0.012	0.016	0.015	0.016	0.015	0.036	0.042	0.043	0.040	0.045	0.037	0.041	0.042
0.091	0.072	0.061	0.056	0.051	0.046	0.034	0.024	0.019	0.015	0.014	0.012	0.005	0.000	0.003	0.006	0.011	0.014	0.012	0.014	0.012	0.033	0.039	0.040	0.037	0.042	0.034	0.038	0.039
0.094	0.075	0.063	0.057	0.052	0.047	0.036	0.025	0.020	0.017	0.015	0.013	0.006	0.003	0.000	0.003	0.008	0.011	0.009	0.011	0.009	0.033	0.039	0.040	0.037	0.041	0.034	0.037	0.039
0.097	0.077	0.066	0.060	0.055	0.050	0.039	0.028	0.023	0.019	0.018	0.016	0.009	0.006	0.003	0.000	0.008	0.009	0.006	0.009	0.007	0.031	0.037	0.038	0.034	0.039	0.032	0.035	0.037
0.100	0.081	0.061	0.055	0.050	0.045	0.035	0.025	0.019	0.021	0.014	0.011	0.012	0.011	0.008	0.008	0.000	0.005	0.011	0.010	0.011	0.035	0.042	0.043	0.039	0.043	0.036	0.039	0.041
0.104	0.084	0.065	0.059	0.054	0.049	0.039	0.030	0.024	0.026	0.019	0.016	0.016	0.014	0.011	0.009	0.005	0.000	0.008	0.006	0.008	0.034	0.043	0.044	0.041	0.041	0.034	0.037	0.039
0.103	0.084	0.072	0.066	0.061	0.056	0.045	0.034	0.029	0.025	0.024	0.022	0.015	0.012	0.009	0.006	0.011	0.008	0.000	0.003	0.001	0.027	0.035	0.037	0.033	0.034	0.027	0.030	0.032
0.105	0.085	0.070	0.064	0.059	0.054	0.043	0.033	0.029	0.025	0.024	0.020	0.016	0.014	0.011	0.009	0.010	0.006	0.003	0.000	0.003	0.029	0.038	0.039	0.036	0.036	0.028	0.032	0.033
0.104	0.084	0.072	0.066	0.061	0.056	0.045	0.033	0.029	0.025	0.024	0.022	0.015	0.012	0.009	0.007	0.011	0.008	0.001	0.003	0.000	0.027	0.035	0.036	0.033	0.033	0.026	0.030	0.031
0.105	0.087	0.080	0.072	0.067	0.063	0.054	0.045	0.043	0.041	0.041	0.041	0.036	0.033	0.033	0.031	0.035	0.034	0.027	0.029	0.027	0.000	0.010	0.013	0.014	0.009	0.013	0.015	0.017
0.101	0.093	0.086	0.080	0.075	0.070	0.060	0.051	0.049	0.047	0.047	0.047	0.042	0.039	0.039	0.037	0.042	0.043	0.035	0.038	0.035	0.010	0.000	0.006	0.007	0.008	0.017	0.013	0.015
0.099	0.095	0.087	0.082	0.076	0.072	0.061	0.052	0.050	0.048	0.048	0.048	0.043	0.040	0.040	0.038	0.043	0.044	0.037	0.039	0.036	0.013	0.006	0.000	0.004	0.012	0.016	0.011	0.013
0.099	0.093	0.086	0.080	0.075	0.070	0.059	0.048	0.047	0.045	0.044	0.045	0.040	0.037	0.037	0.034	0.039	0.041	0.033	0.036	0.033	0.014	0.007	0.004	0.000	0.013	0.013	0.009	0.011
0.109	0.095	0.088	0.081	0.076	0.071	0.062	0.053	0.051	0.049	0.049	0.049	0.045	0.042	0.041	0.039	0.043	0.041	0.034	0.036	0.033	0.009	0.008	0.012	0.013	0.000	0.014	0.012	0.015
0.109	0.093	0.086	0.080	0.075	0.070	0.059	0.046	0.045	0.043	0.042	0.042	0.037	0.034	0.034	0.032	0.036	0.034	0.027	0.028	0.026	0.013	0.017	0.016	0.013	0.014	0.000	0.005	0.007
0.108	0.097	0.090	0.084	0.079	0.074	0.063	0.050	0.048	0.046	0.045	0.046	0.041	0.038	0.037	0.035	0.039	0.037	0.030	0.032	0.030	0.015	0.013	0.011	0.009	0.012	0.005	0.000	0.003
0.109	0.100	0.092	0.087	0.082	0.077	0.065	0.052	0.049	0.047	0.047	0.047	0.042	0.039	0.039	0.037	0.041	0.039	0.032	0.033	0.031	0.017	0.015	0.013	0.011	0.015	0.007	0.003	0.000

Table A2. Intensity of changes in the structure (NPS) of investment outlays in mining enterprises in Poland in 1993–2020.

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.000	0.094	0.392	0.446	0.385	0.379	0.429	0.427	0.437	0.205	0.313	0.405	0.414	0.401	0.346	0.343	0.370	0.330	0.373	0.333	0.379	0.362	0.387	0.402	0.424	0.381	0.419	0.380
0.094	0.000	0.318	0.387	0.312	0.284	0.335	0.333	0.343	0.175	0.283	0.310	0.319	0.307	0.252	0.249	0.275	0.270	0.278	0.239	0.320	0.303	0.328	0.308	0.330	0.287	0.325	0.286
0.392	0.318	0.000	0.147	0.164	0.139	0.285	0.230	0.272	0.432	0.547	0.253	0.252	0.293	0.322	0.320	0.323	0.412	0.298	0.306	0.433	0.475	0.419	0.347	0.352	0.279	0.279	0.344
0.446	0.387	0.147	0.000	0.087	0.144	0.313	0.243	0.214	0.460	0.575	0.238	0.200	0.322	0.350	0.348	0.351	0.440	0.326	0.334	0.461	0.503	0.447	0.375	0.381	0.302	0.255	0.372
0.385	0.312	0.164	0.087	0.000	0.085	0.249	0.182	0.140	0.373	0.488	0.150	0.113	0.234	0.263	0.261	0.263	0.353	0.239	0.247	0.373	0.416	0.359	0.287	0.293	0.215	0.168	0.284
0.379	0.284	0.139	0.144	0.085	0.000	0.203	0.135	0.158	0.316	0.446	0.118	0.123	0.177	0.206	0.204	0.207	0.296	0.182	0.190	0.317	0.359	0.303	0.231	0.236	0.158	0.140	0.228
0.429	0.335	0.285	0.313	0.249	0.203	0.000	0.091	0.167	0.288	0.480	0.145	0.174	0.076	0.090	0.128	0.129	0.138	0.113	0.156	0.147	0.197	0.133	0.063	0.068	0.154	0.160	0.059
0.427	0.333	0.230	0.243	0.182	0.135	0.091	0.000	0.084	0.291	0.483	0.062	0.091	0.084	0.108	0.121	0.108	0.212	0.123	0.138	0.224	0.288	0.219	0.132	0.138	0.081	0.078	0.129
0.437	0.343	0.272	0.214	0.140	0.158	0.167	0.084	0.000	0.280	0.470	0.043	0.034	0.132	0.167	0.156	0.144	0.260	0.160	0.145	0.272	0.336	0.267	0.168	0.180	0.094	0.046	0.177
0.205	0.175	0.432	0.460	0.373	0.316	0.288	0.291	0.280	0.000	0.192	0.257	0.264	0.240	0.198	0.182	0.208	0.165	0.211	0.172	0.210	0.194	0.218	0.240	0.263	0.220	0.258	0.230
0.313	0.283	0.547	0.575	0.488	0.446	0.480	0.483	0.470	0.192	0.000	0.449	0.456	0.431	0.390	0.367	0.393	0.350	0.396	0.357	0.388	0.302	0.402	0.425	0.448	0.404	0.443	0.422
0.405	0.310	0.253	0.238	0.150	0.118	0.145	0.062	0.043	0.257	0.449	0.000	0.040	0.101	0.125	0.124	0.113	0.228	0.129	0.116	0.241	0.304	0.235	0.137	0.148	0.064	0.025	0.136
0.414	0.319	0.252	0.200	0.113	0.123	0.174	0.091	0.034	0.264	0.456	0.040	0.000	0.135	0.160	0.159	0.150	0.262	0.163	0.148	0.275	0.338	0.269	0.175	0.182	0.102	0.055	0.172
0.401	0.307	0.293	0.322	0.234	0.177	0.076	0.084	0.132	0.240	0.431	0.101	0.135	0.000	0.055	0.067	0.053	0.127	0.065	0.081	0.140	0.203	0.134	0.053	0.062	0.077	0.094	0.063
0.346	0.252	0.322	0.350	0.263	0.206	0.090	0.108	0.167	0.198	0.390	0.125	0.160	0.055	0.000	0.050	0.049	0.103	0.053	0.082	0.116	0.180	0.113	0.069	0.085	0.085	0.132	0.054
0.343	0.249	0.320	0.348	0.261	0.204	0.128	0.121	0.156	0.182	0.367	0.124	0.159	0.067	0.050	0.000	0.041	0.104	0.030	0.032	0.130	0.180	0.138	0.084	0.102	0.063	0.110	0.102
0.370	0.275	0.323	0.351	0.263	0.207	0.129	0.108	0.144	0.208	0.393	0.113	0.150	0.053	0.049	0.041	0.000	0.118	0.044	0.055	0.129	0.198	0.132	0.070	0.086	0.050	0.098	0.091
0.330	0.270	0.412	0.440	0.353	0.296	0.138	0.212	0.260	0.165	0.350	0.228	0.262	0.127	0.103	0.104	0.118	0.000	0.114	0.114	0.058	0.081	0.058	0.108	0.119	0.166	0.213	0.104
0.373	0.278	0.298	0.326	0.239	0.182	0.113	0.123	0.160	0.211	0.396	0.129	0.163	0.065	0.053	0.030	0.044	0.114	0.000	0.053	0.135	0.181	0.124	0.086	0.100	0.067	0.114	0.105
0.333	0.239	0.306	0.334	0.247	0.190	0.156	0.138	0.145	0.172	0.357	0.116	0.148	0.081	0.082	0.032	0.055	0.114	0.053	0.000	0.155	0.193	0.163	0.116	0.130	0.071	0.111	0.134
0.379	0.320	0.433	0.461	0.373	0.317	0.147	0.224	0.272	0.210	0.388	0.241	0.275	0.140	0.116	0.130	0.129	0.058	0.135	0.155	0.000	0.108	0.014	0.105	0.097	0.179	0.226	0.104
0.362	0.303	0.475	0.503	0.416	0.359	0.197	0.288	0.336	0.194	0.302	0.304	0.338	0.203	0.180	0.180	0.198	0.081	0.181	0.193	0.108	0.000	0.113	0.168	0.180	0.242	0.290	0.168
0.387	0.328	0.419	0.447	0.359	0.303	0.133	0.219	0.267	0.218	0.402	0.235	0.269	0.134	0.113	0.138	0.132	0.058	0.124	0.163	0.014	0.113	0.000	0.099	0.091	0.173	0.220	0.099
0.402	0.308	0.347	0.375	0.287	0.231	0.063	0.132	0.168	0.240	0.425	0.137	0.175	0.053	0.069	0.084	0.070	0.108	0.086	0.116	0.105	0.168	0.099	0.000	0.024	0.094	0.121	0.025
0.424	0.330	0.352	0.381	0.293	0.236	0.068	0.138	0.180	0.263	0.448	0.148	0.182	0.062	0.085	0.102	0.086	0.119	0.100	0.130	0.097	0.180	0.091	0.024	0.000	0.118	0.133	0.044
0.381	0.287	0.279	0.302	0.215	0.158	0.154	0.081	0.094	0.220	0.404	0.064	0.102	0.077	0.085	0.063	0.050	0.166	0.067	0.071	0.179	0.242	0.173	0.094	0.118	0.000	0.047	0.116
0.419	0.325	0.279	0.255	0.168	0.140	0.160	0.078	0.046	0.258	0.443	0.025	0.055	0.094	0.132	0.110	0.098	0.213	0.114	0.111	0.226	0.290	0.220	0.121	0.133	0.047	0.000	0.142
0.380	0.286	0.344	0.372	0.284	0.228	0.059	0.129	0.177	0.230	0.422	0.136	0.172	0.063	0.054	0.102	0.091	0.104	0.105	0.134	0.104	0.168	0.099	0.025	0.044	0.116	0.142	0.000

Table A3. Intensity of changes in the structure (NPS) of the sales in mining enterprises in Poland in 1992–2020.

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.000	0.001	0.003	0.035	0.042	0.078	0.133	0.103	0.111	0.107	0.071	0.156	0.196	0.226	0.218	0.255	0.242	0.293	0.250	0.258	0.269	0.251	0.280	0.257	0.234	0.256	0.297	0.317	0.396
0.001	0.000	0.004	0.035	0.042	0.079	0.133	0.104	0.112	0.107	0.072	0.156	0.197	0.226	0.218	0.255	0.242	0.294	0.250	0.259	0.269	0.252	0.281	0.258	0.235	0.256	0.297	0.318	0.397
0.003	0.004	0.000	0.032	0.039	0.075	0.130	0.100	0.109	0.104	0.069	0.153	0.193	0.223	0.215	0.252	0.238	0.290	0.247	0.255	0.266	0.248	0.278	0.254	0.232	0.253	0.294	0.315	0.393
0.035	0.035	0.032	0.000	0.028	0.050	0.105	0.075	0.081	0.072	0.043	0.129	0.166	0.195	0.186	0.220	0.214	0.265	0.215	0.230	0.234	0.217	0.246	0.222	0.200	0.221	0.262	0.283	0.368
0.042	0.042	0.039	0.028	0.000	0.045	0.108	0.064	0.097	0.089	0.059	0.145	0.178	0.204	0.196	0.233	0.213	0.252	0.228	0.235	0.247	0.229	0.259	0.235	0.213	0.234	0.275	0.296	0.355
0.078	0.079	0.075	0.050	0.045	0.000	0.062	0.025	0.055	0.046	0.022	0.104	0.135	0.159	0.151	0.188	0.168	0.215	0.183	0.189	0.202	0.184	0.213	0.190	0.167	0.189	0.230	0.250	0.318
0.133	0.133	0.130	0.105	0.108	0.062	0.000	0.045	0.035	0.036	0.076	0.064	0.083	0.099	0.095	0.129	0.119	0.161	0.120	0.127	0.140	0.122	0.151	0.128	0.105	0.127	0.167	0.188	0.264
0.103	0.104	0.100	0.075	0.064	0.025	0.045	0.000	0.058	0.047	0.047	0.107	0.126	0.141	0.138	0.171	0.158	0.190	0.164	0.171	0.183	0.166	0.195	0.172	0.149	0.170	0.211	0.232	0.293
0.111	0.112	0.109	0.081	0.097	0.055	0.035	0.058	0.000	0.017	0.047	0.050	0.092	0.120	0.111	0.146	0.139	0.191	0.140	0.155	0.160	0.142	0.171	0.148	0.125	0.147	0.187	0.208	0.293
0.107	0.107	0.104	0.072	0.089	0.046	0.036	0.047	0.017	0.000	0.041	0.062	0.099	0.128	0.120	0.151	0.148	0.197	0.145	0.162	0.162	0.144	0.173	0.150	0.127	0.149	0.190	0.210	0.300
0.071	0.072	0.069	0.043	0.059	0.022	0.076	0.047	0.047	0.041	0.000	0.086	0.132	0.167	0.158	0.189	0.185	0.237	0.185	0.202	0.203	0.185	0.214	0.191	0.168	0.190	0.231	0.251	0.340
0.156	0.156	0.153	0.129	0.145	0.104	0.064	0.107	0.050	0.062	0.086	0.000	0.055	0.118	0.113	0.142	0.143	0.200	0.145	0.164	0.163	0.139	0.157	0.136	0.110	0.140	0.178	0.193	0.299
0.196	0.197	0.193	0.166	0.178	0.135	0.083	0.126	0.092	0.099	0.132	0.055	0.000	0.066	0.061	0.090	0.091	0.148	0.093	0.111	0.110	0.087	0.105	0.084	0.058	0.088	0.126	0.141	0.247
0.226	0.226	0.223	0.195	0.204	0.159	0.099	0.141	0.120	0.128	0.167	0.118	0.066	0.000	0.009	0.036	0.033	0.083	0.032	0.046	0.053	0.034	0.063	0.042	0.039	0.040	0.080	0.101	0.182
0.218	0.218	0.215	0.186	0.196	0.151	0.095	0.138	0.111	0.120	0.158	0.113	0.061	0.009	0.000	0.040	0.033	0.088	0.037	0.051	0.058	0.038	0.068	0.046	0.044	0.044	0.085	0.105	0.187
0.255	0.255	0.252	0.220	0.233	0.188	0.129	0.171	0.146	0.151	0.189	0.142	0.090	0.036	0.040	0.000	0.028	0.058	0.027	0.021	0.026	0.017	0.030	0.026	0.050	0.030	0.045	0.066	0.157
0.242	0.242	0.238	0.214	0.213	0.168	0.119	0.158	0.139	0.148	0.185	0.143	0.091	0.033	0.033	0.028	0.000	0.058	0.044	0.030	0.052	0.041	0.058	0.054	0.057	0.057	0.065	0.086	0.157
0.293	0.294	0.290	0.265	0.252	0.215	0.161	0.190	0.191	0.197	0.237	0.200	0.148	0.083	0.088	0.058	0.058	0.000	0.056	0.037	0.045	0.064	0.069	0.069	0.091	0.072	0.063	0.072	0.103
0.250	0.250	0.247	0.215	0.228	0.183	0.120	0.164	0.140	0.145	0.185	0.145	0.093	0.032	0.037	0.027	0.044	0.056	0.000	0.023	0.024	0.014	0.043	0.023	0.037	0.024	0.048	0.071	0.155
0.258	0.259	0.255	0.230	0.235	0.189	0.127	0.171	0.155	0.162	0.202	0.164	0.111	0.046	0.051	0.021	0.030	0.037	0.023	0.000	0.022	0.031	0.042	0.037	0.058	0.039	0.041	0.065	0.138
0.269	0.269	0.266	0.234	0.247	0.202	0.140	0.183	0.160	0.162	0.203	0.163	0.110	0.053	0.058	0.026	0.052	0.045	0.024	0.022	0.000	0.028	0.030	0.033	0.055	0.036	0.033	0.057	0.139
0.251	0.252	0.248	0.217	0.229	0.184	0.122	0.166	0.142	0.144	0.185	0.139	0.087	0.034	0.038	0.017	0.041	0.064	0.014	0.031	0.028	0.000	0.030	0.013	0.035	0.016	0.047	0.067	0.160
0.280	0.281	0.278	0.246	0.259	0.213	0.151	0.195	0.171	0.173	0.214	0.157	0.105	0.063	0.068	0.030	0.058	0.069	0.043	0.042	0.030	0.030	0.000	0.023	0.052	0.030	0.023	0.038	0.145
0.257	0.258	0.254	0.222	0.235	0.190	0.128	0.172	0.148	0.150	0.191	0.136	0.084	0.042	0.046	0.026	0.054	0.069	0.023	0.037	0.033	0.013	0.023	0.000	0.030	0.011	0.043	0.060	0.166
0.234	0.235	0.232	0.200	0.213	0.167	0.105	0.149	0.125	0.127	0.168	0.110	0.058	0.039	0.044	0.050	0.057	0.091	0.037	0.058	0.055	0.035	0.052	0.030	0.000	0.032	0.068	0.083	0.191
0.256	0.256	0.253	0.221	0.234	0.189	0.127	0.170	0.147	0.149	0.190	0.140	0.088	0.040	0.044	0.030	0.057	0.072	0.024	0.039	0.036	0.016	0.030	0.011	0.032	0.000	0.047	0.064	0.161
0.297	0.297	0.294	0.262	0.275	0.230	0.167	0.211	0.187	0.190	0.231	0.178	0.126	0.080	0.085	0.045	0.065	0.063	0.048	0.041	0.033	0.047	0.023	0.043	0.068	0.047	0.000	0.025	0.141
0.317	0.318	0.315	0.283	0.296	0.250	0.188	0.232	0.208	0.210	0.251	0.193	0.141	0.101	0.105	0.066	0.086	0.072	0.071	0.065	0.057	0.067	0.038	0.060	0.083	0.064	0.025	0.000	0.147
0.396	0.397	0.393	0.368	0.355	0.318	0.264	0.293	0.293	0.300	0.340	0.299	0.247	0.182	0.187	0.157	0.157	0.103	0.155	0.138	0.139	0.160	0.145	0.166	0.191	0.161	0.141	0.147	0.000

Table A4. Intensity of changes in the structure(NPS) of net fixed assets in mining enterprises in Poland in 2004–2020.

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.000	0.013	0.027	0.006	0.024	0.052	0.057	0.060	0.076	0.071	0.074	0.063	0.058	0.073	0.014	0.043	0.046
0.013	0.000	0.015	0.015	0.013	0.040	0.046	0.048	0.065	0.060	0.063	0.056	0.058	0.072	0.017	0.030	0.034
0.027	0.015	0.000	0.029	0.009	0.026	0.032	0.034	0.051	0.046	0.058	0.056	0.059	0.072	0.031	0.016	0.019
0.006	0.015	0.029	0.000	0.022	0.049	0.056	0.059	0.075	0.070	0.075	0.064	0.061	0.078	0.010	0.044	0.047
0.024	0.013	0.009	0.022	0.000	0.028	0.036	0.038	0.055	0.050	0.061	0.059	0.062	0.079	0.025	0.025	0.028
0.052	0.040	0.026	0.049	0.028	0.000	0.008	0.012	0.027	0.022	0.061	0.059	0.062	0.080	0.051	0.026	0.020
0.057	0.046	0.032	0.056	0.036	0.008	0.000	0.009	0.019	0.014	0.059	0.058	0.064	0.082	0.053	0.030	0.024
0.060	0.048	0.034	0.059	0.038	0.012	0.009	0.000	0.016	0.011	0.059	0.059	0.071	0.091	0.051	0.032	0.027
0.076	0.065	0.051	0.075	0.055	0.027	0.019	0.016	0.000	0.007	0.064	0.069	0.083	0.096	0.067	0.048	0.043
0.071	0.060	0.046	0.070	0.050	0.022	0.014	0.011	0.007	0.000	0.059	0.064	0.078	0.095	0.062	0.043	0.038
0.074	0.063	0.058	0.075	0.061	0.061	0.059	0.059	0.064	0.059	0.000	0.011	0.023	0.039	0.067	0.059	0.060
0.063	0.056	0.056	0.064	0.059	0.059	0.058	0.059	0.069	0.064	0.011	0.000	0.014	0.032	0.058	0.058	0.058
0.058	0.058	0.059	0.061	0.062	0.062	0.064	0.071	0.083	0.078	0.023	0.014	0.000	0.019	0.068	0.061	0.061
0.073	0.072	0.072	0.078	0.079	0.080	0.082	0.091	0.096	0.095	0.039	0.032	0.019	0.000	0.087	0.068	0.069
0.014	0.017	0.031	0.010	0.025	0.051	0.053	0.051	0.067	0.062	0.067	0.058	0.068	0.087	0.000	0.045	0.048
0.043	0.030	0.016	0.044	0.025	0.026	0.030	0.032	0.048	0.043	0.059	0.058	0.061	0.068	0.045	0.000	0.007
0.046	0.034	0.019	0.047	0.028	0.020	0.024	0.027	0.043	0.038	0.060	0.058	0.061	0.069	0.048	0.007	0.000

Table A5. Intensity of changes in the structure (NPS) of electricity generation in Poland in 1990–2020.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.000	0.013	0.015	0.017	0.011	0.011	0.018	0.017	0.019	0.021	0.033	0.030	0.035	0.035	0.043	0.054	0.078	0.089	0.073	0.086	0.097	0.113	0.139	0.131	0.154	0.177	0.185	0.196	0.202	0.246	0.286
0.013	0.000	0.003	0.005	0.009	0.022	0.028	0.026	0.021	0.027	0.045	0.039	0.045	0.049	0.051	0.065	0.090	0.100	0.079	0.089	0.109	0.113	0.139	0.131	0.155	0.178	0.186	0.197	0.204	0.247	0.287
0.015	0.003	0.000	0.003	0.008	0.021	0.028	0.027	0.021	0.027	0.045	0.038	0.044	0.050	0.052	0.067	0.092	0.102	0.081	0.091	0.110	0.113	0.139	0.130	0.154	0.177	0.185	0.196	0.202	0.246	0.286
0.017	0.005	0.003	0.000	0.010	0.024	0.030	0.029	0.023	0.029	0.047	0.040	0.047	0.052	0.054	0.069	0.093	0.104	0.083	0.092	0.112	0.112	0.139	0.131	0.154	0.177	0.185	0.197	0.203	0.247	0.286
0.011	0.009	0.008	0.010	0.000	0.015	0.022	0.021	0.014	0.020	0.037	0.030	0.038	0.043	0.046	0.061	0.086	0.096	0.075	0.085	0.104	0.110	0.137	0.129	0.152	0.174	0.182	0.194	0.200	0.244	0.284
0.011	0.022	0.021	0.024	0.015	0.000	0.009	0.009	0.015	0.013	0.024	0.023	0.028	0.030	0.039	0.051	0.073	0.083	0.069	0.082	0.093	0.109	0.135	0.127	0.150	0.173	0.182	0.192	0.198	0.242	0.282
0.018	0.028	0.028	0.030	0.022	0.009	0.000	0.005	0.018	0.013	0.017	0.021	0.025	0.026	0.035	0.047	0.064	0.075	0.065	0.078	0.089	0.105	0.132	0.124	0.148	0.170	0.178	0.190	0.196	0.240	0.280
0.017	0.026	0.027	0.029	0.021	0.009	0.005	0.000	0.015	0.010	0.019	0.019	0.023	0.024	0.033	0.047	0.067	0.076	0.063	0.077	0.087	0.103	0.131	0.123	0.147	0.169	0.176	0.189	0.195	0.239	0.279
0.019	0.021	0.021	0.023	0.014	0.015	0.018	0.015	0.000	0.008	0.028	0.020	0.029	0.034	0.037	0.054	0.077	0.086	0.065	0.075	0.094	0.101	0.129	0.121	0.145	0.167	0.175	0.188	0.195	0.239	0.278
0.021	0.027	0.027	0.029	0.020	0.013	0.013	0.010	0.008	0.000	0.020	0.013	0.022	0.026	0.029	0.047	0.070	0.079	0.059	0.073	0.087	0.099	0.127	0.119	0.142	0.165	0.173	0.186	0.192	0.236	0.275
0.033	0.045	0.045	0.047	0.037	0.024	0.017	0.019	0.028	0.020	0.000	0.016	0.015	0.016	0.027	0.041	0.052	0.061	0.056	0.071	0.080	0.097	0.125	0.116	0.139	0.161	0.169	0.182	0.188	0.232	0.272
0.030	0.039	0.038	0.040	0.030	0.023	0.021	0.019	0.020	0.013	0.016	0.000	0.010	0.014	0.019	0.037	0.060	0.069	0.049	0.063	0.076	0.092	0.120	0.111	0.135	0.156	0.164	0.177	0.183	0.227	0.267
0.035	0.045	0.044	0.047	0.038	0.028	0.025	0.023	0.029	0.022	0.015	0.010	0.000	0.007	0.013	0.028	0.051	0.061	0.043	0.057	0.068	0.086	0.114	0.105	0.128	0.151	0.159	0.171	0.177	0.221	0.261
0.035	0.049	0.050	0.052	0.043	0.030	0.026	0.024	0.034	0.026	0.016	0.014	0.007	0.000	0.015	0.029	0.046	0.055	0.041	0.056	0.065	0.085	0.113	0.104	0.127	0.149	0.157	0.169	0.176	0.220	0.260
0.043	0.051	0.052	0.054	0.046	0.039	0.035	0.033	0.037	0.029	0.027	0.019	0.013	0.015	0.000	0.020	0.042	0.053	0.033	0.047	0.061	0.076	0.104	0.096	0.119	0.141	0.150	0.162	0.169	0.213	0.252
0.054	0.065	0.067	0.069	0.061	0.051	0.047	0.047	0.054	0.047	0.041	0.037	0.028	0.029	0.020	0.000	0.029	0.041	0.022	0.034	0.047	0.062	0.091	0.083	0.106	0.129	0.137	0.150	0.157	0.201	0.240
0.078	0.090	0.092	0.093	0.086	0.073	0.064	0.067	0.077	0.070	0.052	0.060	0.051	0.046	0.042	0.029	0.000	0.012	0.031	0.034	0.046	0.062	0.093	0.093	0.111	0.129	0.137	0.150	0.156	0.201	0.239
0.089	0.100	0.102	0.104	0.096	0.083	0.075	0.076	0.086	0.079	0.061	0.069	0.061	0.055	0.053	0.041	0.012	0.000	0.035	0.038	0.039	0.056	0.096	0.096	0.115	0.123	0.130	0.143	0.150	0.194	0.233
0.073	0.079	0.081	0.083	0.075	0.069	0.065	0.063	0.065	0.059	0.056	0.049	0.043	0.041	0.033	0.022	0.031	0.035	0.000	0.017	0.034	0.044	0.072	0.064	0.088	0.111	0.119	0.132	0.138	0.183	0.223
0.086	0.089	0.091	0.092	0.085	0.082	0.078	0.077	0.075	0.073	0.071	0.063	0.057	0.056	0.047	0.034	0.034	0.038	0.017	0.000	0.024	0.030	0.061	0.061	0.080	0.098	0.106	0.120	0.126	0.170	0.209
0.097	0.109	0.110	0.112	0.104	0.093	0.089	0.087	0.094	0.087	0.080	0.076	0.068	0.065	0.061	0.047	0.046	0.039	0.034	0.024	0.000	0.034	0.074	0.073	0.092	0.099	0.095	0.115	0.121	0.160	0.199
0.113	0.113	0.113	0.112	0.110	0.109	0.105	0.103	0.101	0.099	0.097	0.092	0.086	0.085	0.076	0.062	0.062	0.056	0.044	0.030	0.034	0.000	0.041	0.046	0.062	0.068	0.078	0.102	0.108	0.144	0.181
0.139	0.139	0.139	0.139	0.137	0.135	0.132	0.131	0.129	0.127	0.125	0.120	0.114	0.113	0.104	0.091	0.093	0.096	0.072	0.061	0.074	0.041	0.000	0.020	0.027	0.044	0.066	0.090	0.094	0.132	0.169
0.131	0.131	0.130	0.131	0.129	0.127	0.124	0.123	0.121	0.119	0.116	0.111	0.105	0.104	0.096	0.083	0.093	0.096	0.064	0.061	0.073	0.046	0.020	0.000	0.024	0.050	0.065	0.087	0.092	0.129	0.164
0.154	0.155	0.154	0.154	0.152	0.150	0.148	0.147	0.145	0.142	0.139	0.135	0.128	0.127	0.119	0.106	0.111	0.115	0.088	0.080	0.092	0.062	0.027	0.024	0.000	0.029	0.051	0.073	0.077	0.114	0.150
0.177	0.178	0.177	0.177	0.174	0.173	0.170	0.169	0.167	0.165	0.161	0.156	0.151	0.149	0.141	0.129	0.129	0.123	0.111	0.098	0.099	0.068	0.044	0.050	0.029	0.000	0.029	0.049	0.060	0.090	0.127
0.185	0.186	0.185	0.185	0.182	0.182	0.178	0.176	0.175	0.173	0.169	0.164	0.159	0.157	0.150	0.137	0.137	0.130	0.119	0.106	0.095	0.078	0.066	0.065	0.051	0.029	0.000	0.029	0.034	0.069	0.109
0.196	0.197	0.196	0.197	0.194	0.192	0.190	0.189	0.188	0.186	0.182	0.177	0.171	0.169	0.162	0.150	0.150	0.143	0.132	0.120	0.115	0.102	0.090	0.087	0.073	0.049	0.029	0.000	0.035	0.053	0.092
0.202	0.204	0.202	0.203	0.200	0.198	0.196	0.195	0.195	0.192	0.188	0.183	0.177	0.176	0.169	0.157	0.156	0.150	0.138	0.126	0.121	0.108	0.094	0.092	0.077	0.060	0.034	0.035	0.000	0.048	0.091
0.246	0.247	0.246	0.247	0.244	0.242	0.240	0.239	0.239	0.236	0.232	0.227	0.221	0.220	0.213	0.201	0.201	0.194	0.183	0.170	0.160	0.144	0.132	0.129	0.114	0.090	0.069	0.053	0.048	0.000	0.044
0.286	0.287	0.286	0.286	0.284	0.282	0.280	0.279	0.278	0.275	0.272	0.267	0.261	0.260	0.252	0.240	0.239	0.233	0.223	0.209	0.199	0.181	0.169	0.164	0.150	0.127	0.109	0.092	0.091	0.044	0.000

Table A6. Results of the univariate regression analysis (significant results only).

Dependent Variables	Independent Variables (Explanatory Variables)							
	Constant	**Coefficient**	**Pearson**	**Standard Error of Regression**	**R-Squared**	***p*-Value**	**F Statistics (F-Value)**	**Observations**
				NPS EN				
NPS EMPN	0.188	−0.071	0.705	0.015	0.496	0.000	25.637	28
NPS FA	0.033	0.103	0.701	0.004	0.491	0.041	1.261	16
NPS SCO	0.086	1.125	0.846	0.057	0.716	0.000	65.581	28
SCE	41,000.760	−30,194.844	0.661	2745.697	0.437	0.000	20.922	29
TP	120,245.936	−285,045.130	0.884	12,096.489	0.781	0.000	96.061	29
PCO	98,946.869	−233,262.379	0.919	8,025.344	0.844	0.000	146.150	29
				NPS EMPN				
NPS FA	0.098	0.085	0.385	0.005	0.148	0.000	2.437	16
				NPS IO				
NPS EMPN	0.064	0.074	0.328	0.016	0.108	0.001	3.012	28
NPS FA	0.063	−0.041	0.080	0.025	0.003	0.005	0.036	16
TP	68,104.311	61,423.965	0.303	18,673.687	0.092	0.013	2.519	28
PpU	0.712	0.498	0.298	0.119	0.089	0.000	2.429	28
				NPS FA				
NPS EMPN	0.098	0.085	0.385	0.005	0.148	0.000	2.437	16
TP	84,490.058	−190,457.361	0.395	10,935.424	0.156	0.000	2.586	16
PpU	0.981	−0.630	0.199	0.076	0.040	0.000	0.580	16
				FA				
PCO	27,960.320	−0.160	0.866	2384.262	0.750	0.000	81.151	29
				IO				
FA	6257.254	0.004	0.741	2205.773	0.549	0.000	32.824	29
				NPS IO				
rFA	0.118	0.137	0.317	0.092	0.101	0.000	2.796	28

References

1. Tutak, M.; Brodny, J.; Siwiec, D.; Ulewicz, R.; Bindzár, P. Studying the Level of Sustainable Energy Development of the European Union Countries and Their Similarity Based on the Economic and Demographic Potential. *Energies* **2020**, *13*, 6643. [CrossRef]
2. Rodrigues, J.F.D.; Wang, J.; Behrens, P.; de Boer, P. Drivers of CO_2 emissions from electricity generation in the European Union 2000–2015. *Renew. Sustain. Energy Rev.* **2020**, *133*, 110104. [CrossRef]
3. Kaczmarek, J.; Krzemiński, P.; Litwa, P.; Szymla, W. *Procesy Zmian W Okresie Transformacji Systemowej. Prywatyzacja, Restrukturyzacja, Rynek Kapitałowy (Processes of Change during Systemic Transformation. Privatization, Restructuring, Capital Market)*; Wydawnictwo Akademii Ekonomicznej w Krakowie: Kraków, Poland, 2005; pp. 102–103.
4. Fischer, S.; Sahay, R.; Vegh, C.A. Stabilization and Growth in Transition Economies: The Early Experience. *J. Econ. Perspect.* **1996**, *10*, 45–66. [CrossRef]
5. Blanchard, O. Assesment of the Economic Transition in Central and Eastern Europe—Theoretical Aspects of Transition. *Am. Econ. Rev.* **1996**, *86*, 117–122. Available online: https://www.jstor.org/stable/i337086 (accessed on 12 January 2022).
6. Åslund, A.; Boone, P.; Johnson, S. How to Stabilize: Lessons from Post-Communist Countries. *Brook. Pap. Econ. Act.* **1996**, *1*, 217–313. [CrossRef]
7. Kuznets, S. Economic Growth of Nations. In *Total Output and Production Structure*; HUP Belknap Press Imprint: Cambridge, UK, 2013; pp. 10–18.
8. Kaczmarek, J. The Role of Structural Policies in Counteracting the Crisis. In *Moving from the Crisis to Sustainability. Emerging Issues in the International Context*; Calabro, G., D'Amico, A., Lanfranchi, M., Moschella, G., Pulejo, L., Salomone, R., Eds.; Edizioni Franco Angeli: Milano, Italy, 2011; pp. 45–54.
9. Peres, W.; Primi, A. *Theory and Practice of Industrial Policy: Evidence from the Latin American Experience*; UN Cepal: Santiago, Chile, 2009; Volume 187, pp. 1–51. Available online: https://www.cepal.org/en/publications/4582-theory-and-practice-industrial-policy-evidence-latin-american-experience (accessed on 12 January 2022).
10. Kaczmarek, J. The Stance, Factors, and Composition of Competitiveness of SMEs in Poland. *Sustainability* **2022**, *14*, 1788. [CrossRef]
11. Hübner, D. Transformacja i rozwój (Transformation and development). In *Gospodarka Polski W Procesie Transformacji*; IRiSS: Warszawa, Poland, 1992; p. 153.
12. Koźmiński, A.; Obłój, K. *Zarys Teorii Równowagi Organizacyjnej (Outline of Organizational Balance Theory)*; PWE: Warszawa, Poland, 1989; ISBN 832080728X.
13. Singh, H. Challenges in Researching Corporate Restructuring. *J. Manag. Stud.* **1993**, *30*, 147–172. [CrossRef]
14. Stoner, J.A.F.; Freeman, R.E.; Gilbert, D.R. *Management*; Prentice Hall: Hoboken, NJ, USA, 1995; pp. 260–269.
15. Griffin, R.W. *Management*; Cengage Learning: Boston, MA, USA, 2016; pp. 392–397.
16. Porter, M.E. *Competitive Adventage: Creating and Sustaining Superiorer Performance*; The Free Press: New York, NY, USA, 1998; pp. 50–62.
17. Slatter, S. *Corporate Recovery: A Guide to Turnaround Management*; Penguin Business: London, UK, 1984; pp. 81–92.
18. Copeland, T.; Koller, T.; Murrin, J. *Valuation—Measuring and Managing the Values of Companies*; John Wiley Sons: New York, NY, USA, 2000; pp. 301–308.
19. Danovi, A.; Magno, F.; Dossena, G. Pursuing Firm Economic Sustainability through Debt Restructuring Agreements in Italy: An Empirical Analysis. *Sustainability* **2018**, *10*, 4830. [CrossRef]
20. Ho, L.-H.; Tsai, C.-C. A Model Constructed to Evaluate Sustainable Operation and Development of State-Owned Enterprises after Restructuring. *Sustainability* **2018**, *10*, 2354. [CrossRef]
21. Lis, A. Typologia restrukturyzacji (Typology of restructuring). *Przegląd Organ.* **2004**, *4*, 9–12. [CrossRef]
22. Nogalski, B.; Hałaczkiewicz, M.; Witt, J. *Restrukturyzacja Procesowa W Zarządzaniu Małymi I Średnimi Przedsiębiorstwami (Process-oriented Restructuring in the Management of Small and Medium Enterprises)*; OPO TNOiK: Bydgoszcz, Poland, 1999; pp. 10–23.
23. Kaczmarek, J. The concept and Measurement of Creating Excess Value in Listed Companies. *Eng. Econ.* **2018**, *29*, 1392–2785. [CrossRef]
24. Gajdzik, B.; Gawlik, R. Choosing the Production Function Model for an Optimal Measurement of the Restructuring Efficiency of the Polish Metallurgical Sector in Years 2000–2015. *Metals* **2018**, *8*, 23. [CrossRef]
25. Christensen, C.M.; Marx, M.; Stevenson, H.H. The tools of cooperation and change. *Harv. Bus. Rev.* **2006**, *84*, 72–80. Available online: https://hbr.org/2006/10/the-tools-of-cooperation-and-change (accessed on 8 January 2022). [PubMed]
26. Kaczmarek, J. The Mechanisms of Creating Value vs. Financial Security of Going Concern-Sustainable Management. *Sustainability* **2019**, *11*, 2278. [CrossRef]
27. Slatter, S.; Lovett, D. *Restrukturyzacja Firmy. Zarządzanie Przedsiębiorstwem W Sytuacjach Kryzysowych (Restructuring of Enterprise. Managing a Company in Crisis Situations)*; WIG-Press: Warszawa, Poland, 2001; pp. 42–48.
28. Mączyńska, E. Upadłość przedsiębiorstw w kontekście ekonomii kryzysu (Bankruptcy of enterprises in the context of crisis economics). In *Zarządzanie Przedsiębiorstwem W Kryzysie*; Morawska, S., Ed.; SGH: Warszawa, Poland, 2011; pp. 10–31.
29. Kaczmarek, J. Measurement of Creating Corporate Value for Shareholders—Development of Measurements and Improvement of Management Competence and Skills. *Pol. J. Manag. Stud.* **2014**, *9*, 72–83. Available online: http://oaji.net/articles/2014/1384-1416997716.pdf (accessed on 21 January 2022).

30. Platt, H.D.; Platt, M.B. Predicting Corporate Financial Distress: Reflection on Choice-Based Sample Bias. *J. Econ. Financ.* **2002**, *26*, 184–199. [CrossRef]
31. Altman, E.I.; Narayanan, P. An International Survey of Business Failure Classification Models. *Financ. Mark. Inst. Instrum.* **1997**, *6*, 1–57. [CrossRef]
32. Pociecha, J. Model logitowy jako narzędzie prognozowania bankructwa—Jego zalety i wady (The logit model as a tool for predicting bankruptcy—Its advantages and disadvantages). In *Spotkania Z Królową Nauk*; Malawski, A., Tatar, J., Eds.; Uniwersytet Ekonomiczny w Krakowie: Kraków, Poland, 2012; pp. 60–74.
33. Pavitt, K. Sectoral patterns of technical change: Towards a taxonomy and a theory. *Res. Policy* **1984**, *13*, 343–374. [CrossRef]
34. Timmer, M.P.; Szirmai, A. Productivity Growth in Asian Manufacturing: The structural bonus hypothesis examined. *Struct. Chang. Econ. Dyn.* **2000**, *11*, 371–392. [CrossRef]
35. Kukuła, K. *Statystyczne Metody Analizy Struktur Ekonomicznych (Statistical Methods of the Analysis of Economic Structures)*; Wydawnictwo Edukacyjne: Cracow, Poland, 1996; pp. 9, 15–17.
36. Hambrick, D.C. Taxonomic approaches to studying strategy: Some conceptual and methodological issues. *J. Manag.* **1984**, *10*, 27–41. [CrossRef]
37. Consoli, D.; Rentocchini, F. A taxonomy of multi-industry labour force skills. *Res. Policy* **2015**, *44*, 1116–1132. [CrossRef]
38. Archibugi, D. Pavitt's taxonomy sixteen years on: A review article. *Econ. Innov. New Technol.* **2001**, *3*, 415–425. [CrossRef]
39. Kotelska, J. Restructuring Conditions for Traditional Industry Enterprises in Poland. *Zesz. Naukowe. Organ. I Zarządzanie/Politech. Śląska* **2019**, *134*, 93–108. [CrossRef]
40. Brauers, H.; Oei, P.-Y.; Walk, P. Comparing coal phase-out pathways: The United Kingdom's and Germany's diverging transitions. *Environ. Innov. Soc. Transit.* **2020**, *37*, 238–253. [CrossRef] [PubMed]
41. Burns, A.; Winterton, J.; Newby, M. The restructuring of the British coal industry. *Camb. J. Econ.* **1985**, *9*, 93–110. [CrossRef]
42. Turnheim, B.; Geels, F.W. The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British Coal Industry (1913–1967). *Res. Policy* **2013**, *42*, 1749–1767. [CrossRef]
43. Sovacool, B.K.; Noel, L.; Orsato, R.J. Stretching, embeddedness, and scripts in a sociotechnical transition: Explaining the failure of electric mobility at better place (2007–2013). *Technol. Forecast. Soc. Chang.* **2017**, *123*, 24–34. [CrossRef]
44. Bankier.pl, Kontrowersje Wokół Budowy Pierwszej Od 34 Lat Kopalni Węgla Kamiennego W Wielkiej Brytanii (Controversy over the Construction of the First Hard Coal Mine in Great Britain in 34 Years). Available online: https://www.bankier.pl/wiadomosc/Wielka-Brytania-rozwaza-budowe-pierwszej-od-34-lat-kopalni-wegla-Beda-konsultacje-publiczne-8073599.html (accessed on 21 January 2022).
45. Oei, P.-Y.; Brauers, H.; Herpich, P. Lessons from Germany's hard coal mining phase-out: Policies and transition from 1950 to 2018. *Clim. Policy* **2020**, *20*, 963–979. [CrossRef]
46. Ohlhorst, D. Germany's energy transition policy between national targets and decentralized responsibilities. *J. Integr. Environ. Sci.* **2015**, *12*, 303–322. [CrossRef]
47. Rogge, K.S.; Pfluger, B.; Geels, F.W. Transformative policy mixes in socio-technical scenarios: The case of the low-carbon transition of the German electricity system (2010–2050). *Technol. Forecast. Soc. Chang.* **2020**, *151*, 119259. [CrossRef]
48. Jonek-Kowalska, I.; Wolny, M.; Sojda, A. Analiza trendów i korelacji cen węgla kamiennego na rynkach międzynarodowych w erze dekarbonizacji (Analysis of coal prices trends and correlations in international markets in era of decarbonization). *Zesz. Nauk. Politech. Śląskiej Ser. Organ. I Zarządzanie* **2014**, *74*, 185–197. Available online: https://bibliotekanauki.pl/articles/323139 (accessed on 21 January 2022).
49. PEP 2040. Polityka Energetyczna Polski Do 2040 Roku. (PEP 2040. Energy Policy of Poland until 2030). Ministerstwo Klimatu I Środowiska, Warsaw, February 2021. Available online: https://www.gov.pl/attachment/62a054de-0a3d-444d-a969-90a89502df94 (accessed on 22 February 2022).
50. Eurostat. Eurostat Data Browser. Production of Electricity and Derived Heat by Type of Fuel. Available online: https://ec.europa.eu/eurostat/databrowser/explore/all/envir?lang=en&subtheme=nrg.nrg_quant.nrg_quanta.nrg_bal&display=list&sort=category&extractionId=NRG_BAL_PEH__custom_2069571 (accessed on 22 February 2022).
51. Toborek-Mazur, J.; Wójcik-Jurkiewicz, M. Multi-Energy Concern as an Example of the Implementation of Agenda 2030: Poland as a Case Study. *Energies* **2022**, *15*, 1669. [CrossRef]
52. Kryk, B.; Guzowska, M.K. Implementation of Climate/Energy Targets of the Europe 2020 Strategy by the EU Member States. *Energies* **2021**, *14*, 2711. [CrossRef]
53. Gadowska, K. *The Phenomenon of Political and Economic Clientelism: A Systemic Analysis of the Network Connections in the Case of the Transformation of the Mining Sector in Poland*; Wydawnictwo Uniwersytetu Jagiellońskiego: Cracow, Poland, 2002.
54. Czech, A. Conditions of Polish Energy Policy in the Context of Sustainable Development Postulate. *Studia Ekon.* **2016**, *269*, 50–61. Available online: https://www.ue.katowice.pl/fileadmin/user_upload/wydawnictwo/SE_Artyku%C5%82y_251_270/SE_269/04.pdf (accessed on 22 February 2022).
55. Wensierski, P. Poszerzenie Unii Europejskiej: Proces akcesji Polski (Enlargement of the European Union: The process of Poland's accession). *Słupskie Studia Hist.* **2003**, *10*, 227–248. Available online: https://bazhum.muzhp.pl/media/files/Slupskie_Studia_Historyczne/Slupskie_Studia_Historyczne-r2003-t10/Slupskie_Studia_Historyczne-r2003-t10-s227-248/Slupskie_Studia_Historyczne-r2003-t10-s227-248.pdf (accessed on 22 February 2022).

56. European Commission. Directive 2001/80/EC. Available online: https://eur-lex.europa.eu/legal-content/PL/ALL/?uri=CELEX%3A32001L0080 (accessed on 22 February 2022).
57. European Commission. Directive 2001/77/EC. Available online: https://eur-lex.europa.eu/legal-content/PL/ALL/?uri=CELEX%3A32001L0077 (accessed on 22 February 2022).
58. European Commission. 2020 Climate & Energy Package. Available online: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2020-climate-energy-package_en (accessed on 22 February 2022).
59. Szymla, W. Influence of the Climate and Energy Package on the Conditions of Functioning of the Power Sector Enterprises in Poland. In *Contemporary Economies in the Face of New Challenges: Economic, Social and Legal Aspects*; Borowiecki, R., Jaki, A., Rojek, T., Eds.; Foundation of the Cracow University of Economics: Cracow, Poland, 2013; pp. 751–761.
60. Kowalke, K.; Prochownik, M. The Impact of Climate and Energy Package on the Process of Modernization the Polish Energy Sector. *J. Manag. Financ.* **2014**, *12*, 229–245. Available online: http://zif.wzr.pl/pim/2014_4_15.pdf (accessed on 22 February 2022).
61. Liobikienė, G.; Butkus, M. The European Union possibilities to achieve targets of Europe 2020 and Paris agreement climate policy. *Renew. Energy* **2017**, *106*, 298–309. [CrossRef]
62. Rosenow, J.; Cowart, R.; Bayer, E.; Fabbri, M. Assessing the European Union's energy efficiency policy: Will the winter package deliver on 'Efficiency First'? *Energy Res. Soc. Sci.* **2017**, *26*, 72–79. [CrossRef]
63. European Commission. Delivering the European Green Deal. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en#key-steps (accessed on 22 February 2022).
64. European Commission. Fit for 55% Package. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0550 (accessed on 22 February 2022).
65. European Commission. Directive 2003/87/EC. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32003L0087 (accessed on 22 February 2022).
66. Verbruggen, A.; Laes, E.; Woerdman, E. Anatomy of Emissions Trading Systems: What is the EU ETS? *Environ. Sci. Policy* **2019**, *98*, 11–19. [CrossRef]
67. Szymla, W. The effects of the restructuring of power sector companies in terms of maintaining the energy security in Poland after 1989. *Zarządzanie Publiczne* **2013**, *4*, 20–33. Available online: https://zarzadzaniepubliczne.pl/index.php/zpub/article/view/280/195 (accessed on 22 February 2022).
68. ZPEP 1990-2010. Założenia Polityki Energetycznej Polski Na Lata 1990–2010 (PEP 1990–2010. Energy Policy of Poland for 1990–2010). Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WMP19900430332 (accessed on 22 February 2022).
69. ZPEP 2010. Założenia Polityki Energetycznej Polski Do 2010 R. (PEP 2010. Energy Policy of Poland until 2010). Dokument Rządowy, Warsaw, October 1995. Available online: https://www.prawo.pl/akty/m-p-1990-43-332,16823035.html (accessed on 22 February 2022).
70. PEP 2020. Założenia Polityki Energetycznej Polski Do 2020 r (PEP 2020. Energy Policy of Poland until 2020), Warsaw, February 2000. Available online: http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000000109211 (accessed on 22 February 2022).
71. PEP 2025. Polityka Energetyczna Polski Do 2025 Roku. (PEP 2025. Energy Policy of Poland until 2025). Ministerstwo Gospodarki I Pracy, Warsaw, July 2005. Available online: https://sip.lex.pl/akty-prawne/mp-monitor-polski/polityka-energetyczna-panstwa-do-2025-r-17205399 (accessed on 22 February 2022).
72. PEP 2030. Polityka Energetyczna Polski Do 2030 Roku. (PEP 2030. Energy Policy of Poland until 2030). Ministerstwo Gospodarki, Warsaw, November 2009. Available online: https://sip.lex.pl/akty-prawne/mp-monitor-polski/polityka-energetyczna-panstwa-do-2030-r-17589536 (accessed on 22 February 2022).
73. Europe's Energy Transition: A Common Challenge. Report. Institute Montaigne, September 2021. Available online: https://www.institutmontaigne.org/en/publications/europes-energy-transition-common-challenge (accessed on 22 April 2022).
74. Nies, S. (Ed.) The European Energy Transition. In *Actors, Factors, Sectors*; Claeys & Casteels: Deventer, The Netherland, 2019. Available online: https://author.energy-community.org/enc-author-prd/dam/jcr:9a2c264d-766f-445b-8ffd-1cd1a2893622/SS19_Nies_08_2019.pdf (accessed on 22 April 2022).
75. Tagliapietra, S.; Zachmann, G.; Edenhofer, O.; Glachant, J.M.; Linares, P.; Loeschel, A. The European union energy transition: Key priorities for the next five years. *Energy Policy* **2019**, *132*, 950–954. [CrossRef]
76. Peña-Ramos, J.; del Pino-García, M.; Sánchez-Bayón, A. The Spanish Energy Transition into the EU Green Deal: Alignments and Paradoxes. *Energies* **2021**, *14*, 2535. [CrossRef]
77. Foxon, T. Managing the transition to renewable energy: Theory and practice from local, regional and macro perspectives. *Environ. Sci.* **2008**, *5*, 286–288. [CrossRef]
78. Gawlik, L.; Mokrzycki, E. Changes in the Structure of Electricity Generation in Poland in View of the EU Climate Package. *Energies* **2019**, *12*, 3323. [CrossRef]
79. Grubišić Šeba, M.; Flora, A. Poland's Energy Transition—Caught between Lobbying and Common (Economic) Sense, IEEFA Europe, January 2022. Available online: http://ieefa.org/wp-content/uploads/2022/01/Polands-Energy-Transition-Caught-Between-Lobbying-and-Common-Economic-Sense_January-2022.pdf (accessed on 22 April 2022).
80. Lew, G.; Sadowska, B.; Chudy-Laskowska, K.; Zimon, G.; Wójcik-Jurkiewicz, M. Influence of Photovoltaic Development on Decarbonization of Power Generation—Example of Poland. *Energies* **2021**, *14*, 7819. [CrossRef]

81. Bednorz, J. Charakterystyka programów rządowych w latach 1989–2010 i ich wpływ na producentów węgla kamiennego w Polsce (Characteristics of government programs in 1989–2010 and their impact on hard coal producers in Poland). In *Bezpieczeństwo Energetyczne—Rynki Surowców I Energii*; Kwiatkiewicz, P., Ed.; Wydawnictwo Wyższej Szkoły Bezpieczeństwa: Poznań, Poland, 2011; pp. 207–237.
82. Marszowski, R. Działania restrukturyzacyjne wobec górnictwa węgla kamiennego i ich wpływ na otoczenie społeczno-gospodarcze. Stan i perspektywy (Restructuring actions to coal mining and its impact on socio-economic environment. State and perspectives). *Humanum. Int. J. Soc. Humanit. Stud.* **2017**, *3*, 113–124. Available online: http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.mhp-2470d1d5-c621-4986-9992-9c917edbcd06 (accessed on 25 April 2022).
83. Paszcza, H. Procesy restrukturyzacji w polskim górnictwie węgla kamiennego w aspekcie zrealizowanych przemian i zmiany bazy zasobowej (Restructuring processes in the Polish hard coal mining industry in terms of the implemented changes and changes in the resource base). *Górnictwo I Geoinżynieria* **2010**, *34*, 63–82. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-AGHM-0014-0004 (accessed on 25 April 2022).
84. Zabierowski, J. Wybrane problemy restrukturyzacji polskiego górnictwa węgla kamiennego (Selected problems of restructuring of the Polish hard coal mining industry). *Wiadomości Górnicze* **1996**, *3*, 5–9.
85. Kamola-Cieślik, M. Bezpieczeństwo energetyczne Polski a sytuacja ekonomiczna Kompanii Węglowej SA po 2014 roku (Poland's energy security and the economic situation of Kompania Węglowa SA after 2014). *Bezpieczeństwo. Teor. I Prakt.* **2016**, *1*, 133–148. Available online: http://hdl.handle.net/11315/20277 (accessed on 25 April 2022).
86. Karbownik, A.; Wodarski, K. Efekty restrukturyzacji polskiego górnictwa węgla kamiennego w latach 1990–2004 (The effects of restructuring of the Polish hard coal mining industry in 1990–2004). *Wiadomości Górnicze* **2005**, *56*, 274–281. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BGPK-1139-4504?q=bwmeta1.element.baztech-volume-0043-5120-wiadomosci_gornicze-2005-vol__56_nr_6;0&qt=CHILDREN-STATELESS (accessed on 25 April 2022).
87. Tkocz, M. Efekty restrukturyzacji górnictwa węgla kamiennego w Polsce (Effects of restructuring of the hard coal mining industry in Poland). *Pr. Kom. Geogr. Przemysłu* **2006**, *9*, 28–39. Available online: http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-f7429231-225e-4197-ba15-1b528977bdb9 (accessed on 25 April 2022).
88. Przybyłka, A. Spadek zatrudnienia wśród górników węgla kamiennego w kolejnych etapach restrukturyzacji branży na Górnym Śląsku (Decline in employment among hard coal miners in the subsequent stages of industry restructuring in Upper Silesia). *Studia I Materiały. Misc. Oeconomicae* **2011**, *1*, 99–108. Available online: https://tuudi.net/wp-content/uploads/2017/03/A.-Przyby%C5%82ka-Spadek-zatrudnienia-w%C5%9Br%C3%B3d-g%C3%B3rnik%C3%B3w-w%C4%99gla-kamiennego-w-kolejnych-etapach-restrukturyzacji-bran%C5%BCy-na-G%C3%B3rnym-%C5%9Al%C4%85sku..pdf (accessed on 25 April 2022).
89. Bluszcz, A.; Kijewska, A.; Sojda, A. Analiza efektywności zarządzania wartością przedsiębiorstwa górniczego (Analysis of the effectiveness of managing the value of a mining enterprise). *Zesz. Nauk. Uniw. Szczecińskiego. Finans. Rynk. Finans. Ubezpieczenia* **2013**, *64*, 87–96. Available online: http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.ekon-element-000171281001 (accessed on 25 April 2022).
90. Sojda, A. Perspektywy i zagrożenia dla rozwoju zasobów ludzkich w górnictwie węgla kamiennego (Prospects and threats for the development of human resources in hard coal mining). *Studia Ekon.* **2014**, *196*, 185–195. Available online: http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.ekon-element-000171355831 (accessed on 25 April 2022).
91. Gumiński, A.; Karbownik, A.; Wodarski, K.; Jędrychowski, S. Restrukturyzacja zatrudnienia w polskim górnictwie węgla kamiennego w latach 1998–2006 (Employment restructuring in the Polish hard coal mining industry in 1998–2006). *Wiadomości Górnicze* **2008**, *59*, 166–174. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BGPK-2100-7971?q=bwmeta1.element.baztech-volume-0043-5120-wiadomosci_gornicze-2008-vol__59_nr_3;0&qt=CHILDREN-STATELESS (accessed on 25 April 2022).
92. Hibner, M. Restrukturyzacja zatrudnienia w górnictwie węgla kamiennego w latach 2004–2014 (Employment restructuring in the hard coal mining industry in 2004–2014). *Zesz. Nauk. Państwowej Wyższej Szkoły Zawodowej Im. Witelona W Legn.* **2016**, *19*, 39–50. Available online: https://bazhum.muzhp.pl/czasopismo/449/?idvol=11224 (accessed on 25 April 2022).
93. Jonek-Kowalska, I. Koszty produkcji w polskim górnictwie węgla kamiennego (Production costs in the Polish hard coal mining). In *Analiza I Ocena Kosztów W Górnictwie Węgla Kamiennego W Polsce W Aspekcie Poprawy Efektywności Wydobycia*; Turek, M., Ed.; Difin: Warszawa, Poland, 2013; pp. 45–56. ISBN 978-83-7641-825-4.
94. Turek, M.; Jonek-Kowalska, I.; Ganszczyk, Z. *Determinanty Innowacyjności W Przedsiębiorstwach Górniczych (Determinants of Innovation in Mining Enterprises)*; Politechnika Śląska: Gliwice, Poland, 2016. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BSL3-0024-0084 (accessed on 25 April 2022).
95. Jonek-Kowalska, I. Challenges for long-term industry restructuring in the Upper Silesian Coal Basin: What has Polish coal mining achieved and failed from a twenty-year perspective? *Resour. Policy* **2015**, *44*, 135–149. [CrossRef]
96. Rybak, A. The strategy of flexible mining in conditions of seasonal demand for hard coal (Strategia elastycznego wydobycia w warunkach sezonowości popytu na węgiel kamienny). *Wiadomości Górnicze* **2014**, *65*, 227–233.
97. Wendt, R. *Change Management in a Polish Company (Zarzadzanie Zmianą W Polskiej Firmie)*; Dom Wydawniczy Zachorek: Warsaw, Poland, 2010. Available online: https://wendt.pl/images/files/Zarzadzanie_zmiana_bezplatny_fragment.pdf (accessed on 25 April 2022).

98. *Analiza I Ocena Kosztów W Górnictwie Węgla Kamiennego W Polsce W Aspekcie Poprawy Efektywności Wydobycia (Analysis and Evaluation of Costs in the Hard Coal Mining Industry in Poland in Terms of Improving Mining Efficiency)*; Turek, M. (Ed.) Difin: Warszawa, Poland, 2013; ISBN 978-83-7641-825-4.
99. Sojda, A. Analiza statystyczna wskaźników finansowych dla przedsiębiorstw górniczych (Statistical analysis of financial indicators for mining enterprises). *Organ. I Zarządzanie. Zesz. Nauk. Politech. Śląskiej* **2014**, *68*, 255–264. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-235fe354-121b-4c8d-9abe-54ab7c70b65a (accessed on 25 April 2022).
100. Turowski, K. Unowocześnienie struktury gospodarczej jako czynnik wzrostu produktywności w polskiej gospodarce (Modernization of the economic structure as a factor of productivity growth in the Polish economy). In *Problemy Gospodarowania W Dobie Globalizacji*; Kunasz, M., Ed.; Print Group, Daniel Krzanowski: Szczecin, Poland, 2006; pp. 145–157. ISBN 8360065942.
101. Cellura, M.; Longo, S.; Mistretta, M. Application of the Structural Decomposition Analysis to assess the indirect energy consumption and air emission changes related to Italian households consumption. *Renew. Sustain. Energy Rev.* **2012**, *16*, 1135–1145. [CrossRef]
102. Barba, I.; Iraizoz, B. Effect of the Great Crisis on Sectoral Female Employment in Europe: A Structural Decomposition Analysis. *Economies* **2020**, *8*, 64. [CrossRef]
103. Barcik, R.; Dziwiński, P. Społecznie odpowiedzialna restrukturyzacja zatrudnienia. *Pr. Nauk. Uniw. Ekon. We Wrocławiu* **2016**, *419*, 21–32. [CrossRef]
104. Pierścionek, Z. *Strategie Rozwoju Firmy (Company Development Strategies)*; Wydawnictwo Naukowe PWN: Warszawa, Poland, 1996; ISBN 8301119802.
105. Cascio, W.F. Strategies for responsible restructuring. *Acad. Manag. Perspect.* **2002**, *16*, 80–91. [CrossRef]
106. Chomątowski, S. Warunki a czynniki rozwoju przedsiębiorstwa. Próba identyfikacji i klasyfikacji (Conditions and factors of enterprise development. An attempt to identify and classify). In *Restrukturyzacja W Procesie Przekształceń I Rozwoju Przedsiębiorstw*; Borowiecki, R., Ed.; Towarzystwo Naukowe Organizacji i Kierownictwa: Kraków, Poland, 1996; pp. 174–175. Available online: http://www.nukat.edu.pl/nukat/icov/WALAZ/zz2007825000.pdf (accessed on 25 April 2022).
107. Gabrusewicz, W. Rozwój przedsiębiorstw przemysłowych i jego ocena w gospodarce rynkowej (Development of industrial enterprises and its evaluation in the market economy). *Zesz. Nauk. Akad. Ekon. W Pozn.* **1992**, *120*, 197. Available online: https://www.wbc.poznan.pl/dlibra/publication/97731/edition/109494/content (accessed on 25 April 2022).
108. Fijorek, K.; Kaczmarek, J.; Kolegowicz, K.; Krzemiński, P. Ocena zagrożenia przedsiębiorstw upadłością—Koncepcja systemowa ISR (Evaluation of enterprise bankruptcy risk—A systemic concept of ISR). *Przegląd Organ.* **2015**, *4*, 18–25. [CrossRef]
109. Antonowicz, P. *Metody Oceny I Kondycji Ekonomiczno-Finansowej Przedsiębiorstw (Methods of Evaluating the Economic and Financial Condition of Enterprises)*; ODiDK: Gdańsk, Poland, 2007; pp. 31–42.
110. Juszczyk, S. Prognozowanie upadłości przedsiębiorstw (Forecasting enterprise bankruptcy). *Ekonomista* **2010**, *5*, 701–728. Available online: http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000168325184 (accessed on 21 January 2022).
111. Prusak, B. *Nowoczesne Metody Prognozowania Zagrożenia Finansowego Przedsiębiorstw (Modern Methods of Forecasting Enterprise Financial Threats)*; Difin: Warszawa, Poland, 2005; pp. 129–172.
112. Jajuga, K. Statystyczne modele wczesnego ostrzegania—Metody Formalne (Statistical models of early warning—Formal Methods). *Barom. Reg.* **2006**, *6*, 52–55. Available online: http://br.wszia.edu.pl/zeszyty/pdfs/br06_07jajuga.pdf (accessed on 25 April 2022).
113. Gavurova, B.; Packova, M.; Misankova, M.; Smrcka, L. Predictive potential and risks of selected bankruptcy prediction models in the Slovak business environment. *J. Bus. Econ. Manag.* **2017**, *18*, 1156–1173. [CrossRef]
114. Hosmer, D.W.; Lemeshow, S. *Applied Logistic Regression*; Wiley: New York, NY, USA, 1989; pp. 145–162.
115. Fijorek, K.; Fijorek, D. Dobór zmiennych objaśniających metodą najlepszego podzbioru do modelu regresji logistycznej Firtha (Selection of Explanatory Variables Using the Best Subset Method for Firth's Logistic Regression Model. *Metod. Inform. Stosow.* **2011**, *2*, 15–24. Available online: http://www.pan.wi.zut.edu.pl/mispdf/MIS-2011-2.pdf (accessed on 11 January 2022).
116. Long, S.J. *Regression Models for Categorical and Limited Dependent Variables*; Thousand Oaks, SAGE Publications: London, UK, 1997; pp. 56–68.
117. Hafiz, A.A.; Lukumon, O.O.; Hakeem, A.O.; Vikas, K.; Saheed, O.A.; Olugbenga, O.A.; Muhammad, B. Systematic review of bankruptcy prediction models: Towards a framework for tool selection. *Expert Syst. Appl.* **2018**, *94*, 164–184. [CrossRef]
118. Fijorek, K.; Denkowska, S.; Kaczmarek, J.; Náñez Alonso, S.L.; Sokołowski, A. Financial threat profiles of industrial enterprises in Poland. *Oeconomia Copernic.* **2021**, *12*, 463–498. [CrossRef]
119. Heinze, G.; Schemper, M. A solution to the problem of separation in logistic regression. *Stat. Med.* **2002**, *21*, 2409–2419. [CrossRef] [PubMed]
120. Firth, D. Bias reduction of maximum likelihood estimates. *Biometrika* **1993**, *80*, 27–38. [CrossRef]
121. Fijorek, K.; Sokołowski, A. Separation-Resistant and Bias-Reduced Logistic Regression: STATISTICA macro. *J. Stat. Softw.* **2012**, *47*, 1–12. [CrossRef]
122. Hadasik, D. Upadłość przedsiębiorstw w Polsce i metody jej prognozowania (Bankruptcy of enterprises in Poland and the methods of its forecasting). *Zesz. Nauk. Akad. Ekon. W Pozn.* **1998**, *153*, 1–198. Available online: www.wbc.poznan.pl:115723 (accessed on 9 January 2022).

123. Zelek, A. Wczesna identyfikacja kryzysu ucieczką od bankructwa (Early identification of a crisis as an escape from bankruptcy). *Przegląd Organ.* **2002**, *2*, 32–36. Available online: http://www.przegladorganizacji.pl/plik/375/po200202pdf (accessed on 14 January 2022). [CrossRef]
124. Fijorek, K.; Kaczmarek, J.; Kolegowicz, K.; Krzemiński, P. Bankruptcy Risk Assessment—A Microeconomic Perspective. In *The Rapid Response Instrument to Bankruptcy Risk in the Non-Financial Sector. Design and Implementation*; Boguszewski, P.A., Ed.; Polish Agency for Enterprise Development: Warsaw, Poland, 2014; pp. 117–131.
125. Piłatowska, M. *Repetytorium Ze Statystyki (Repertory of Statistics)*; Wydawnictwo Naukowe PWN: Warszawa, Poland, 2006.
126. Higgins, R.C.; Koski, J.L.; Mitton, T. *Analysis for Financial Management*, 12th ed.; McGraw-Hill Education: New York, NY, USA, 2019; pp. 35–89.
127. Block, S.; Hirt, G.; Danielsen, B. *Foundations of Financial Management*, 17th ed.; McGraw-Hill Education: New York, NY, USA, 2019; pp. 250–348.
128. Dudycz, T.; Wrzosek, S. *Analiza Finansowa. Problemy Metodyczne W Ujęciu Praktycznym (Financial Analysis. Methodological Problems in a Practical Approach)*; Wydawnictwo Akademii Ekonomicznej we Wrocławiu: Wrocław, Poland, 2000; pp. 124–168.
129. Chomątowski, S. (Ed.) *Dynamika I Kierunki Zmian Wielkości I Struktury Sektora Przedsiębiorstw W Polsce W Latach 1990–2005*; Fundacja Uniwersytetu Ekonomicznego w Krakowie: Kraków, Poland, 2009; p. 39.
130. Kukuła, K. Propozycja w zakresie pewnych miar dynamiki struktur (A proposal for certain measures of the dynamics of structures). *Przegląd Stat.* **1975**, *3*, 453–461.
131. Archibugi, D.; Pianta, M. Measuring technological change through patents and innovation surveys. *Technovation* **1996**, *9*, 451–468. [CrossRef]
132. Castellacci, F. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Res. Policy* **2008**, *37*, 978–994. Available online: https://www.files.ethz.ch/isn/32006/719_TechnologicalParadigms.pdf (accessed on 25 April 2022). [CrossRef]
133. Chomątowski, S.; Sokołowski, A. Taksonomia struktur (Taxonomy of structures). *Przegląd Stat.* **1978**, *2*, 217–226.
134. Kamiński, J. *Siła Rynkowa W Krajowym Sektorze Wytwarzania Energii Elektrycznej—Zagadnienia Wybrane (Market Power in the Domestic Electricity Generation Sector—Selected Issues)*; Wydawnictwo IGSMiE PAN: Kraków, Poland, 2012.
135. Szpor, A. Coal Transition in Poland. An Historical Case Study for the Project Coal Transitions: Research and Dialogue on the Future of Coal. *IDDRI Clim. Strat.* **2017**. Available online: https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/201706-iddri-climatestrategies-reportcoal_pl.pdf (accessed on 11 January 2022).
136. Karbownik, A.; Wodarski, K.; Turek, M. Wpływ procesów restrukturyzacyjnych w latach 1989–2000 na kształtowanie się wielkości parametrów struktury i modelu kopalń węgla kamiennego (The impact of restructuring processes in 1989–2000 on the shaping of the parameters of the structure and model of hard coal mines). In *Restrukturyzacja Górnictwa a Struktura Kopalń Węgla Kamiennego*; Główny Instytut Górnictwa: Katowice, Poland, 2002; p. 11.
137. Rybak, A.; Rybak, A. Possible strategies for hard coal mining in Poland as a result of production function analysis. *Resour. Policy* **2016**, *50*, 27–33. [CrossRef]
138. Blaschke, W.; Gawlik, L.; Lorenz, U. Perspektywy górnictwa węgla kamiennego po przystąpieniu Polski do Unii Europejskiej w świetle realizowanych programów restrukturyzacyjnych (Perspectives of hard coal mining after Poland's accession to the European Union in the light of the implemented restructuring programs). In *Proceedings of the XIV Konferencja Z Cyklu Aktualia I Perspektywy Gospodarki Surowcami Mineralnymi W Zakopanem, Sympozja I Konferencje Nr 63*; Wyd. Instytutu GSMiE PAN: Kraków, Poland, 2004; pp. 15–27.
139. Stalewski, T.; Szpak, A. *Likwidowanie Kopalń Węgla Kamiennego W Małym Mieście Górniczym (Closure of Hard Coal Mines in a Small Mining Town). Studia Regionalne i Lokalne nr 4*; Uniwersytet Warszawski: Warszawa, Poland, 2000.
140. Szczepański, M.S. Górnicy Nie Przepuścili Odpraw. Często Brakowało im Jednak Qiedzy (The Miners Did Not Miss the Severance Pay. However, They Often Lacked Knowledge), *Dziennik Zachodni*, 12 January 2015. Available online: https://dziennikzachodni.pl/prof-szczepanski-gornicy-nie-przepuscili-odpraw-czesto-brakowalo-im-jednak-wiedzy/ar/c3-3711606 (accessed on 11 January 2022).
141. Fornalczyk, A.; Choroszczak, L.; Mikulec, M. *Restrukturyzacja Górnictwa Węgla Kamiennego (Restructuring of Hard Coal Mining)*; Poltext: Warszawa, Poland, 2008; pp. 34–52.
142. Sejm Rzeczpospolitej Polskiej, Ustawa Z Dnia 26.11.1998 r. o Dostosowaniu Górnictwa Węgla Kamiennego Do Funkcjonowania W Warunkach Gospodarki Rynkowej Oraz Szczególnych Uprawnieniach I Zadaniach Gmin Górniczych, Wraz Z Późniejszymi Zmianami (Dz.U.1998, nr 162, Poz.1112). Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU19981621112 (accessed on 22 February 2022).
143. Sejm Rzeczpospolitej Polskiej, Ustawa Dnia 28.11.2003 r. o Restrukturyzacji Górnictwa Węgla Kamiennego W Latach 2003–2006 (Dz. U. nr 120, Poz.2037). Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20032102037 (accessed on 22 February 2022).
144. Paszcza, H.; Madejski, A. Górnictwo węgla kamiennego w Polsce w 2003 roku (Hard Coal Industry in Poland in 2005), Wiadomości Górnicze 2004, 6, 249. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BGPK-1398-5383 (accessed on 22 February 2022).
145. Bednarski, L.; Borowiecki, R.; Duraj, J.; Kurtys, E.; Waśniewski, T.; Wersty, B. *Analiza Ekonomiczna W Przedsiębiorstwie (Economic Analysis in the Enterprise)*; Wydawnictwo Akademii Ekonomicznej we Wrocławiu: Wrocław, Poland, 1995.

146. *Restructuring and Privatizing the Coal Industries in Central and Eastern Europe and the CIS*; World Energy Council: London, UK, 2000; pp. 1–199. Available online: https://www.worldenergy.org/assets/downloads/PUB_Restructuring_and_privatizing_coal_in_CIES_2004_WEC.pdf (accessed on 28 January 2022).
147. Dubiński, J.; Turek, M. Wybrane aspekty zmian restrukturyzacyjnych w polskim górnictwie węgla kamiennego w latach 1990–2008 (Selected aspects of restructuring changes in Polish hard coal mining in 1990–2008). *Res. Rep. Min. Environ.* **2009**, *2*, 5–19. Available online: https://kwartalnik.gig.eu/sites/default/files/articles/prace-naukowe-gig/2009_2_1.pdf (accessed on 24 January 2022).
148. Jonek-Kowalska, I.; Turek, M. Dependence of Total Production Costs on Production and Infrastructure Parameters in the Polish Hard Coal Mining Industry. *Energies* **2017**, *10*, 1480. [CrossRef]
149. Marek, J. Uwarunkowania i przebieg procesu likwidacji kopalń węgla kamiennego (Determinants and the process of hard coal mines liquidation). *Studia Ekon. Akad. Ekon. W Katowicach* **2006**, *37*, 269–283. Available online: https://www.ue.katowice.pl/fileadmin/user_upload/wydawnictwo/SE_Archiwalne/SE_37/18.pdf (accessed on 28 January 2022).
150. Rutledge, D. Estimating long-term world coal production with logit and probit transforms. *Int. J. Coal Geol.* **2011**, *85*, 23–33. [CrossRef]
151. Tkocz, M. Effects of hard coal mining restructuring in Poland. *Stud. Ind. Geogr. Comm. Pol. Geogr. Soc.* **2006**, *9*, 28–39. [CrossRef]
152. Smoliło, J.; Chmiela, A.; Gajdzik, M.; Menéndez, J.; Loredo, J.; Turek, M.; Bernardo-Sánchez, A. A New Method to Analyze the Mine Liquidation Costs in Poland. *Mining* **2021**, *1*, 351–363. [CrossRef]
153. Fuksa, D. Innovative Method for Calculating the Break-Even for Multi-Assortment Production. *Energies* **2021**, *14*, 4213. [CrossRef]
154. Kaczmarek, J. The effectiveness of working capital management strategies in manufacturing enterprises. *Sci. Pap. Sil. Univ. Technol. Organ. Manag.* **2019**, *136*, 191–208. [CrossRef]
155. *Ukryty Rachunek Za Węgiel (Hidden Coal Account)*; WiseEuropa: Warszawa, Poland, 2017; pp. 1–44. Available online: https://wise-europa.eu/2017/09/19/ukryty-rachunek-wegiel-premiera-raportu/ (accessed on 18 January 2022).
156. Rybak, A.; Rybak, A. Analysis of the Main Coal Mining Restructuring Policy Objectives in the Light of Polish Mining Companies' Ability to Change. *Energies* **2020**, *13*, 3281. [CrossRef]
157. Kaczmarek, J. The Balance of Outlays and Effects of Restructuring Hard Coal Mining Companies in Terms of Energy Policy of Poland PEP 2040. *Energies* **2022**, *15*, 1853. [CrossRef]
158. Baran, M.; Kuźniarska, A.; Makieła, Z.J.; Sławik, A.; Stuss, M. Does ESG Reporting Relate to Corporate Financial Performance in the Context of the Energy Sector Transformation? Evidence from Poland. *Energies* **2022**, *15*, 477. [CrossRef]
159. Galos, K.; Lewicka, E.; Burkowicz, A.; Guzik, K.; Kot-Niewiadomska, A.; Kamyk, J.; Szlugaj, J. Approach to identification and classification of the key, strategic and critical minerals important for the mineral security of Poland. *Resour. Policy* **2020**, *70*, 101900. [CrossRef]
160. Kotelska, J. Przesłanki procesu restrukturyzacji górnictwa węgla kamiennego w Polsce (Premises of the restructuring process of the hard coal mining industry in Poland). *ZN WSH Zarządzanie* **2018**, *1*, 207–229.
161. Mokrzycki, E.; Ney, R.; Siemek, J. Światowe zasoby surowców energetycznych. Wnioski dla Polski (Global reserves of energy fossil resources—Conclusions for Poland). *Rynek Energii* **2008**, *6*, 2–13. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BPL2-0011-0044 (accessed on 22 February 2022).
162. Kaliski, M.; Sikora, A.; Szurlej, A. Węgiel kamienny w polityce energetycznej Polski (Hard coal in Poland's energy policy). *Polityka Energetyczna-Energy Policy J.* **2014**, *17*, 7–18. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-0d18bd03-a9ef-437f-875d-7dec826e0f52/c/kaliski_in_wegiel_kamienny_17_3.pdf.pdf (accessed on 22 February 2022).
163. Oksińska, B.; Furman, T. Plan rządu dla górnictwa sypie się. Nie ma planu B (The government's plan for mining is falling apart. There is no plan B). *Rzeczpospolita. Ekon. I Rynek* **2005**, *15*, 115.
164. Szlązak, J. *Restrukturyzacja Górnictwa Węgla Kamiennego W Polsce W Latach 1990–2002. Analiza Skuteczności Realizowanych Programów (Restructuring of Hard Coal Mining in Poland in the Years 1990–2002. Analysis of the Effectiveness of Implemented Programs)*; Biblioteka Szkoły Eksploatacji Podziemnej: Kraków, Poland, 2004.
165. Restrukturyzacja. In *Fakty I Opinie (Restructuring. Facts and Opinions)*; Zarząd Główny SITG: Katowice, Poland, 2015.
166. Makieła, Z. Wyniki realizacji programów restrukturyzacji górnictwa węgla kamiennego po 1989 r. (Results of implementation of hard coal mining restructuring programs after 1989). *Pr. Kom. Geogr. Przemysłu Pol. Tow. Geogr.* **2002**, *4*, 57–65. Available online: http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171298913 (accessed on 25 April 2022).
167. Grmela, A.; Harat, A.; Adamczyk, Z. The process of mines liquidation as an environmental, economic and legal problem. *Ecol. Eng. Environ. Technol.* **2017**, *18*, 39–45. [CrossRef]
168. Gumiński, A. Efektywne wykorzystanie zasobów ludzkich jako kluczowy warunek funkcjonowania przedsiębiorstwa górniczego w perspektywie długoterminowej (Effective use of human resources as a key condition for the functioning of a mining company in the long term). *Organ. I Zarządzanie. Zesz. Nauk. Politech. Śląskiej* **2016**, *89*, 163–176. Available online: https://bibliotekanauki.pl/api/full-texts/2020/12/11/2eb3cc3e-64bf-47c4-8bd2-12f12bfccfbe.pdf (accessed on 25 April 2022).
169. Bluszcz, A. Proces przemian struktury zatrudnienia w górnictwie węgla kamiennego (The process of changes in the employment structure in the hard coal mining industry). *Studia Ekonomiczne. Uniw. Ekon. W Katowicach* **2014**, *196*, 103–113. Available online: http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171356073 (accessed on 25 April 2022).

170. Gumiński, A. Analiza możliwości zwiększenia efektywności wykorzystania środków produkcji w ścianach wydobywczych kopalni węgla kamiennego (Analysis of the possibilities of increasing the efficiency of the use of production means in the mining walls of a hard coal mine). *Organ. I Zarządzanie. Zesz. Nauk. Politech. Śląskiej* **2015**, *78*, 167–177. Available online: http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171402853 (accessed on 25 April 2022).
171. Grzybek, J. Restrukturyzacja zatrudnienia w górnictwie węgla kamiennego—Nakłady budżetowe, efekty podjętych działań. (Employment restructuring in the hard coal mining industry—Budget expenditures, effects of actions taken). *Przegląd Górniczy* **2012**, *68*, 63–67. Available online: http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-b1c9f470-d936-49b1-b162-78d9cbb3ae55?q=0739a17e-cf12-49e3-84b7-4fd19fd2d4b6$2&qt=IN_PAGE (accessed on 25 April 2022).
172. Dołęga, W. Operation security of national distribution grids. *Przegląd Elektrotechniczny* **2020**, *1*, 23–26. [CrossRef]
173. Turek, M.; Jonek-Kowalska, I. Rozwój polskiego górnictwa węglowego w świetle prognozowanych potrzeb energetycznych (Development of the Polish coal mining in the light of forecasted energy needs). *Zesz. Naukowe. Organ. I Zarządzanie/Politech. Śląska* **2015**, *83*, 691–701. Available online: http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171408367?printView=true (accessed on 25 April 2022).
174. Kamyk, J.; Kot-Niewiadomska, A.; Galos, K. The criticality of crude oil for energy security: A case of Poland. *Energy* **2021**, *220*, 119707. [CrossRef]
175. Stala-Szlugaj, K.; Grudziński, Z. Energy efficiency and steam coal transport over long distances. *ES3 Web Conf.* **2016**, *10*, 00089. [CrossRef]
176. Frankowski, J.; Mazurkiewicz, J.; Sokołowski, J.; Lewandowski, P. Employment in Hard Coal Mining in the Upper Silesian Coal Basin. Zatrudnienie W Górnictwie Węgla Kamiennego W Zagłębiu Górnośląskim. IBS Research Report, Warsaw, Poland, January 2020. Available online: https://ibs.org.pl/app/uploads/2020/09/IBS_Research_Report_01_2020.pdf (accessed on 22 February 2022).
177. Dróżdż, W. The distribution system operator in the era of innovative energy challenges. *Zesz. Nauk. Inst. Gospod. Surowcami Miner. I Energią Pol. Akad. Nauk.* **2018**, *102*, 291–300. Available online: https://min-pan.krakow.pl/wydawnictwo/wp-content/uploads/sites/4/2018/03/20-zn-19-drozdz.pdf (accessed on 22 February 2022).
178. Rusin, A.; Wojaczek, A.; Nawrat, K. Change of the energy system structure and possibilities of energy production by national power units. *Rynek Energii* **2020**, *2*, 3–7. Available online: http://rynek-energii.pl/pl/RE147 (accessed on 22 February 2022).
179. Malec, M. The prospects for decarbonisation in the context of reported resources and energy policy goals: The case of Poland. *Energy Policy* **2022**, *161*, 112763. [CrossRef]
180. Kaliski, M.; Gawlik, L.; Szurlej, A.; Sikora, A.; Kamiński, J. Hard coal in the fuel-mix of Poland: The long perspective. *Arch. Min. Sci.* **2016**, *61*, 335–350. [CrossRef]
181. Bórawski, P.; Bełdycka-Bórawska, A.; Szymańska, E.J.; Jankowski, K.J.; Dubis, B.; Dunn, J.W. Development of renewable energy sources market and biofuels in the European Union. *J. Clean. Prod.* **2019**, *228*, 467–484. [CrossRef]
182. Papież, M.; Śmiech, S.; Frodyma, K. Determinants of renewable energy development in the EU countries. A 20-year perspective. *Renew. Sustain. Energy Rev.* **2018**, *91*, 918–934. [CrossRef]
183. Bonnet, C.; Hache, E.; Seck, G.S.; Simoën, M.; Carcanague, S. Who's winning the low-carbon innovation race? An assessment of countries' leadership in renewable energy technologies. *Int. Econ.* **2019**, *160*, 31–42. [CrossRef]
184. Bel, G.; Joseph, S. Policy stringency under the European Union Emission trading system and its impact on technological change in the energy sector. *Energy Policy* **2018**, *117*, 434–444. [CrossRef]
185. Wierling, A.; Schwanitz, V.J.; Zeiß, J.P.; Bout, C.; Candelise, C.; Gilcrease, W.; Gregg, J.S. Statistical Evidence on the Role of Energy Cooperatives for the Energy Transition in European Countries. *Sustainability* **2018**, *10*, 3339. [CrossRef]
186. Grudziński, Z. Konkurencyjność paliw w wytwarzaniu energii elektrycznej (Competitiveness of fuels in electricity generation). *Energy Policy J.* **2013**, *6*, 87–105. Available online: https://se.min-pan.krakow.pl/publikacje/13_06zg_pe_z.pdf (accessed on 25 April 2022).
187. European Parliament and the Council, Regulation (EU) 2019/943 of the European Parliament and of the Council. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0943 (accessed on 22 February 2022).
188. Appunn, K. Setting the Power Price: The Merit Rrder Effect. Available online: https://www.cleanenergywire.org/factsheets/setting-power-price-merit-order-effect (accessed on 22 February 2022).
189. Loumakis, S.; Giannini, E.; Maroulis, Z. Merit Order Effect Modeling: The Case of the Hellenic Electricity Market. *Energies* **2019**, *12*, 3869. [CrossRef]
190. Korkmaz, O.; Önöz, B. Modelling the Potential Impacts of Nuclear Energy and Renewables in the Turkish Energy System. *Energies* **2022**, *15*, 1392. [CrossRef]
191. What's Next after Coal? RES Potential in Poland. Raport. Instrat.pl. Available online: https://instrat.pl/wp-content/uploads/2021/06/Instrat-What-next-after-coal-v.1.2.pdf (accessed on 3 May 2022).
192. Brodny, J.; Tutak, M.; Saki, S.A. Forecasting the Structure of Energy Production from Renewable Energy Sources and Biofuels in Poland. *Energies* **2020**, *13*, 2539. [CrossRef]
193. Przybylska-Cząstkiewicz, M. The legal conditions for the development of Renewable Energy in Poland after 2015. *Energy Policy J.* **2017**, *20*, 115–116. Available online: https://epj.min-pan.krakow.pl/The-legal-conditions-for-the-development-of-Renewable-Energy-nin-Poland-after-2015,96161,0,2.html (accessed on 3 May 2022).

194. Gawlikowska-Fyk, A. Po 2025 r. Węgiel Będzie Wychodził Z Polskiego Systemu Energetycznego Falami (After 2025, Coal Will Come Out of the Polish Energy System in Waves). Available online: https://www.forum-energii.eu/pl/blog/luka-weglowa-2025 (accessed on 22 February 2022).
195. Zamasz, K. *Efektywność Ekonomiczna Przedsiębiorstwa Energetycznego W Warunkach Wprowadzenia Rynku Mocy (Economic Efficiency of an Energy Company in the Conditions of Introducing the Capacity Market)*; Wydawnictwo Naukowe PWN: Warszawa, Poland, 2015; ISBN 9788301183783.