

Article

The Balance of Outlays and Effects of Restructuring Hard Coal Mining Companies in Terms of Energy Policy of Poland PEP 2040

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Abstract: The article aimed to present the balance of outlays and the effects of restructuring Polish hard coal mining companies in the face of directions of the Energy Policy of Poland PEP 2040. The research problem is defined by the following question: have the goals of restructuring coal mining companies been achieved (and to what extent), and has the restructuring-related expenditure been economically rational? An answer to this question is based on the verification of five research hypotheses, in particular, have the incurred costs of restructuring contributed to changes to the energy mix (its desired time and degree), reducing related expenditure? The scope of research comprises all companies engaged in the extraction of solid mineral energy resources (the entire industry). An assessment of the restructuring process was conducted from two perspectives related to its time and scope. The first perspective was the restructuring programme as a sub-process of the economic transformation (1990–2020), and economic forecasts until the planned coal phase-out (2021–2049). The second perspective was an analysis of the mechanism that determines companies' performance after carrying out typical and direct restructuring activities (2007–2021). Two multivariate measures were developed for methodological purposes, and the analysis also made use of a logit prediction model and several financial analysis ratios. The analysis led to the general conclusion that the restructuring of hard coal mining companies was not effective—it did not ensure their independent and effective functioning. In particular, the analysis led to the following conclusions: (1) the restructuring process had different levels of intensity, which allowed for its periodization; (2) the main and increasingly important factor of changes was human labour productivity (as opposed to objectified labour—machines and equipment); (3) the identified mechanism of creating results pointed to the areas of inappropriate management; (4) the previous restructuring costs did not contribute to changing the energy mix, and they are likely to rise until coal phase-out.



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1. Introduction

Restructuring is a microeconomic category, and it relates to enterprises and management. However, it can be viewed from a broader perspective of structural changes, and in the case of Poland, from the perspective of the economic transformation. Restructuring processes aim to increase the effectiveness of companies' activities and their development. In a broader sense, various and interrelated processes are designed to achieve a state of equilibrium between a company and its environment. These processes are controllable and are reflected in the specific activities undertaken under a given strategy. Therefore, restructuring does not occur of its own accord—restructuring is a process that is managed. Therefore, it is necessary to measure its effects and costs. This allows the assessment of the achieved goals and applied methods. The theoretical framework of measurement is broader than its possible practical application. Moreover, it mainly refers to a financial approach, i.e., specific results (which are strongly aggregated), without pointing to the original causes embedded in a company's economic activities.

The presented research study aims to analyse the balance of the outlays and effects of restructuring Polish hard coal mining companies. Where necessary, the article refers to lignite mining. This study comprises all enterprises belonging to the division of public statistics (Polish Classification of Activities (PKD 5)), i.e., solid mineral energy resource mining enterprises. The research problem is formulated as the following question: have the goals of restructuring coal mining companies been achieved (and to what extent), and has the restructuring-related expenditure been economically rational?

One of the major objectives of the model of Poland's radical economic transformation (the early 1990s) was the increased effectiveness of corporate activities as a result of restructuring [1]. It was a serious challenge for the coal mining industry—both for particular companies and economic policies [2]. In 1990–2020, the government developed 15 restructuring programmes. Their original objective was to discharge debt and protect entities against business failures. In the longer run, they aimed to achieve profitability and financial independence, increased productivity and reductions in employment. It became increasingly difficult to adjust coal output to reduced demand [3]. As a result of the accession to the European Union (2004) and the first energy and climate package “20-20-20” (2008) [4], the situation was strongly affected by changes in the energy mix [5]. Nevertheless, the subsequent energy policy programmes regarded coal as a strategic foundation of energy security [6]. However, the period of relative stability was followed by a downturn in the coal mining industry in 2014–2016, which was even more strongly felt in 2020–2021.

Subsidies for coal mining in 1990–2020 amounted to bn PLN 263.7 (9.3% of GDP in 2020). How did the economy benefit? Were the outlays balanced by benefits? What was the impact of the restructuring of coal mining on the energy transformation? These are the main questions posed in the article. Answers to these questions are based on extensive analyses. Unfortunately, general conclusions are negative from two perspectives: the restructuring process itself as well as the energy transformation [7].

First, neither labour productivity nor asset productivity recorded any visible increase. Their level after 31 years was the same as in the early 1990s. The asset and capital structure remained clearly inefficient, posing a threat to financial security. Investment outlays were insufficient, and fixed asset management was ineffective. A pathological mechanism was revealed of violating cost discipline and cost classification.

Second, great efforts of the restructuring process and the effects achieved by the coal mining industry in 2006 turned out to be totally futile after 2011. Instead of supporting the energy transformation, coal mining became a burden. Energy, social and environmental policies reached a stalemate [8]. Energy based on coal (68%), including hard coal (45%), was blocked in changes in energy sources [9]. Currently, the energy transformation is the only solution [10]. However, its costs will be much higher than a decade ago. Moreover, the prolonged energy transformation is likely to result in the necessity to maintain unprofitable coal mining until 2049 (approx. bn PLN 320.8, i.e., 11.3% of GDP in 2020).

The article presents the effects of restructuring coal mining companies from the perspective of the time and scope of the process. With regard to time, the analysis covered the period starting at the beginning of the economic transformation (1990–2020). With regard to the other perspective, the paper analysed the mechanism determining coal mining companies' financial results after 2006—the year of finalising the programme of typical, direct restructuring activities (2007–2021). For the purpose of the discussion of results, the assessment of the restructuring programme presents outlooks for the planned coal phase-out (2021–2049) [11].

Two authors' original multi-feature measures were developed for the needs of the analysis. The first measure is composed of four partial measures: productivity of labour and material costs, asset productivity, capital structure, fixed asset recovery and an additional eight factors. The second measure is the surface of a decagon whose legs represent the dynamics of changes in the standardised values of major financial ratios. Additionally, the analysis made use of the authors' original logit model, which measures the financial security degree, and a series of specific financial analysis measures.

In addition to a comparative analysis, this study made use of a cause–effect analysis based on a deductive deterministic approach—the logarithmic method. Additionally, the study explored relevant correlations and basic descriptive statistics (see the methodological part of the article).

From a methodological perspective, a value-added characteristic of the research study of restructuring coal mining companies is authors' original designed multivariate measures. The main measure provides a multi-dimensional assessment of restructuring and fulfils the characteristics of an economic model. It is a universal model suitable for use in international comparisons. This is important due to the restructuring processes being carried out in the coal mining industry in other countries, not just European ones. Moreover, this model is supplied with standardized information from public statistics with wide access. Its application is broader than just the coal mining industry and can be successfully used by individual enterprises (microeconomic level), various industries (mesoeconomic level) and in the framework of economic policies (macroeconomic level).

From an empirical, cognitive and practical perspective, the value of this study is due to the following factors: (1) a quantitative evaluation of the costs and effects of restructuring, based on economic measures; (2) an overall analysis of the economic aspects of activities and the related costs and effects, based on a multi-dimensional approach; (3) a long-term analysis covering the entire period of changes, as well as presenting projected changes.

The achievement of the research goal, the analysis of the research problem and the verification of hypotheses are supported by an appropriate structure of the article. A general introduction to the assessment of the restructuring process is followed by a literature review related to a triad of key concepts: transformation, structural changes and restructuring. The next part characterises restructuring activities undertaken by coal mining companies, with special attention given to their integration with government programmes. The next part of the article presents the main research methods and specially designed measures. This is followed by the presentation and discussion of results in the context of the research goal. The discussion is a basis for verifying the research hypotheses. The article ends with conclusions related to the future of coal mining companies in the context of the costs and effects of restructuring programmes. The conclusions are presented in a broader context of the mining and energy industries.

1.1. Polish Economy Transformation

The turn of the 1980s and the 1990s marked the beginning of the systemic transformation in Poland, representing a broad and multi-aspect (holistic) picture of changes in an economic system [12] (p. 295) and phenomena occurring in an economy, such as deregulation, deflation, demonopolisation, denationalization, the creation of new market institutions and restructuring [13,14].

A systemic transformation is characterised by the simultaneous occurrence of radical changes as part of a number of other parallel transformations, and such a process implemented intentionally and quickly was an experiment on a global scale [15] (p. 137) [16]. An economic transformation (as the core of a systemic transformation) should be treated as a category of theories of economic systems and economic policies [17] (pp. 27–31). Despite attempts, in this first approach, an economic transformation cannot be fully explained in a traditional theoretical approach, which focuses on an analysis of the states of equilibrium [18]. Only partial approaches are used, mainly based on the theory of ordoliberalism [19] (pp. 25–30), developed by W. Eucken. Therefore, in the absence of a well-developed, separate theory of transformation, the closest concepts are those developed by O. Blanchard [20] (pp. 45–50), G. Roland [21] (pp. 54–56) and T. Mickiewicz [22] (pp. 138–141). They have much in common, but they do not create an overall picture and, in particular, do not offer clear recommendations to take specific action [23] (pp. 1–27). It should be noted that numerous transformation models developed in practice cannot be identified with theories [24] (p. 50) because models represent simplified realities for the needs of analyses and economic policies [25] (p. 20).

Poland's membership in OECD and its accession to the European Union are the milestones of the process of change, also marking the end of the period of transition [26] (p. 162) [27] (p. 84) [28]. The distinctive feature of the end of this process is the creation of an economic system in which an economic policy becomes an exogenous, factor which only regulates the dynamics of the process [29]. Unlike transition, transformation as a process of constant change still continues, and its first phase has come to an end. Currently, its goals, structure of processes and tools are different and are designed to keep up with the process of developing a post-industrial economy [30] (p. 109) in which the basic factors of production are knowledge and innovation. Generally, an assessment of Poland's transition (or the level of the intensity of the first phase of the transformation process) is positive. The obtained results bring Poland closer to the average performance of highly advanced countries [31]—particularly in terms of price liberalization, exchange rates, foreign trade and “small scale” privatization (1998–2000), but to a lesser degree in areas such as competition policies, management and corporate restructuring reforms (2006–2008).

In conclusion, most authors believe that transformation has a positive impact on economic development [32]. Explicitly positive assessments are given to a macroeconomic stabilising factor [33] (pp. 8–9), despite the natural period of recession at the initial stage of the process [34]. This is also true of the impact of market reforms and liberalization [35], particularly in the radical model [36]. Additionally, positive assessment is given to institutional changes [37], with special significance attributed to continuous improvements in the quality of management, increased efficiency and respect for human freedoms (i.e., property rights) [38]. On the other hand, much controversy is caused by “large-scale privatization” [39], dependent on the way in which this process is implemented [40]. Simultaneously, the correlation between the initial conditions of the transformation process and economic growth is commonly regarded as negative, and its dynamics is believed to decrease [41].

1.2. Structural Changes

Transformation goals describe and affect the process as well as the effectiveness of particular entities and of the entire economy. The author believes that processes supporting the achievement of the specific goals of an economic transformation are as follows: structural changes, increased competitiveness, restructuring, improved financial security (financial standing) and value creation.

The concept of structure in economics was introduced by E. Wagemann [42]. It represents a relationship between the elements of the system and its entirety, as well as mutual relations between the system's particular elements. A structure is temporary in character, and it is transformed over the course of time, which leads to creating a new convergence of circumstances (at a given place and time) [43]. The factors that cause structural changes and their correlation with growth were identified by S. Kuznets [44] (p. 15). Structural changes result from disclosed economic mega-trends [45] (pp. 120–142) as universal phenomena but are diversified in terms of their scope and pace. The key change factors include technical advancement, innovation and its diffusion, the crisis of traditional energy sources, increased competition and internationalization processes (globalization and regionalization), higher social expectations and the development of post-industrial society, and the crisis of state regulation.

Structural changes can be autonomous (caused by internal changes in a structure), or they can be induced as in the case of an economic transformation. They are related to structural policies, whose rationale and role have always caused much controversy [46] (pp. 45–54). Despite their destructive impact on market mechanisms [47], they allow for a reduction in and equitable distribution of the social costs of structural changes [48–50].

1.3. The Nature of Restructuring

In this context, structural changes should lead to the following effects at a microlevel: companies' increased competitiveness and strengthened pro-export orientation, increased

effectiveness, accelerated growth, modernization and support in overcoming development barriers. The article does not identify restructuring with structural changes in an economy. Restructuring, being an integral part of structural changes (including a transformation process), is one of the platforms of changes which occur in the entire economic structures—enterprises. A restructuring process from the perspective of an economy is generally perceived as the process of eliminating ineffective enterprises [51] (p. 83), and from the point of view of a subjective economic structure, it can also be referred to as macrorestructuring.

Companies' operations are determined by their potential and development opportunities but, to a greater degree, by their evolving environment. The occurring changes distort companies' internal and external equilibrium [52] (p. 114), and their survival and expansion are conditioned by adjustment measures (restructuring), which are frequently very intense and rapid [53]. Recovering the state of equilibrium with the environment is effected through a specific strategy [54] (p. 266), which sets directions for a company's development, and restructuring is one of such strategies [55]. However, contemporary companies' strategies, on an increasing scale, depart from development continuity concepts [56] (pp. 394–396) [57] (pp. 18–21), embarking on new expansion paths and initiating processes that can be referred to as strategic turnaround. However, successful restructuring processes and achieving desirable effects are dependent not only on adopted strategies and measures, but also on applying appropriate tools and methods [58] adjusted to the areas [59] that undergo restructuring [60].

A set of universal reasons for restructuring [61], reflected in an organization's internal and external environment, is well defined [62] (pp. 1083–1110). The objective of a restructuring process is viewed from the perspective of companies' increased competitiveness [63], performance and increased value added [64] (pp. 50–62) [65] (p. 89)—a universal measure of effective functioning [66]. Presently, created value is given special attention, and restructuring is frequently seen as a strategy for increasing the value of particular companies and the entire corporate sector [67]. In this context, the proposed measures of restructuring effectiveness focus on increased corporate value [68] (p. 304).

1.4. The Course of Restructuring the Coal Mining Industry in Poland

The presented background of an economic transformation and its key process—corporate restructuring, is a basis for undertaking a research study of the course and effects of coal mining—a significant component of Poland's economy [69] (pp. 35–49). Until the end of World War II, hard coal was the main factor of economic growth, supporting industrialization processes through meeting an increasing demand for electricity and heat power [70]. Additionally, hard coal represented a significant share of exports, ensuring the inflow of hard currencies. From the end of the war to the year 1979, the extraction of coal increased from 55 m tonnes to a record 200 m tonnes (1979), decreasing steadily after the beginning of the transformation in 1989, reaching the level of 54 m tonnes in 2020. The early 1970s marked the mass-scale use of lignite—for a number of years, its extraction has remained stable at the level of 51 m tonnes. This stability results from the functioning of mines and power stations as one entity—in the absence of the lignite market, the levels of extraction are exclusively determined by the demand of power stations whose operations are stable, supplying one-quarter of electricity in Poland.

A broad-scale and intense economic transformation that commenced in the early 1990s [71] posed ambitious challenges for the economy and its entities (apart from the initial macroeconomic stabilization):

- Dominant role of the market mechanism of resource allocation, and attributing an exogenous function to economic policies;
- Building long-lasting and high competitiveness;
- Increased effectiveness of managing creative resources as a result of their restructuring.

The achievement of these goals by the coal mining industry was one of the major challenges both for companies and structural economic policies [72] (pp. 20–82). The mining industry was subjected to the transformation process when coal prices were regulated

by the government, the industry was subsidised by the central budget, the supply of coal considerably exceeded the demand and the number of employees was at a high level of 415 thousand [73]. A number of government restructuring programmes were developed [74] (pp. 14–86), which aimed to achieve economic effectiveness and gain the ability to compete in an open market [75]. These general goals [76] were identified as a set of actions aiming to reduce costs and increase labour productivity [77,78]:

- Separation of non-production activities from coal mines and outsourcing of selected support processes;
- Reduction in employment—the main cost-generating factor;
- Adjustment of output to domestic demand and profitable export;
- Reduction in production capacity and liquidation of selected coal mines.

A large number of 15 major restructuring programmes [79] (pp. 1–72), developed and implemented by the government, their goals and types of activities allow for the identification of the particular stage of the restructuring process (for more details, see [80]):

- 1990–1992—market coal prices, liquidation of central subsidies and coal mines' financial independence [81,82];
- 1993–1995—consolidation of coal mines into mining companies and liquidation of selected coal mines [83–85];
- 1996–1997—technical restructuring and suspension of the liquidation programme [86];
- 1998–2002—coal mining companies' market orientation, lowered debt levels, reduction in extraction volumes and employment and liquidation of coal mines [87,88];
- 2003–2006—consolidation of coal mining companies into coal mining holding companies, debt reduction and public aid and achievement of profitability [89–91].

The year 2006 is a turning point of the restructuring process [92]. The programmes of the three previous years aimed to achieve the effectiveness of the coal mining industry [93] (pp. 1–48). Importantly, after this year, the government stopped using typical, direct restructuring measures [94]. In 2007, the government set directions for developing the coal mining industry—a basis for developing coal mining strategies by enterprises [95]. This indicates a change in the approach to structural change programming [96].

The directions of development also included new elements concerning the identification and measurement of the costs of the negative impact of mining on the environment and human health [97,98]. Moreover, there were strongly emphasized problems of reclamation [99], recognized in other countries, as well as changes in the technology of mines' functioning in the direction of energy transformation [100]. Another novelty was pointing out the direction of coal mining enterprises as socially responsible [101]. In the assessment of the enterprises' results, the necessary emphasis was placed on the activities in compliance with the contemporary requirements of the ESG policy, especially in relation to listed companies [102].

In 2016, the government developed a programme for restructuring coal mining companies, which aimed to establish a company responsible for liquidating coal mines [103]. In 2018 and 2019, the government developed a strategy which assumed coal phase-out by 2049 [104], supported by the 2021 social contract [105].

Since 1990, the lignite industry has not implemented any restructuring programmes. Some improvement processes mainly aimed to introduce organizational and ownership changes. Mines are regarded as parts (branches) of power plants and suppliers of raw materials. However, power plants' installed capacity exceeds the coal extraction capacity, which is not increased due to the lack of licences. A major threat is posed by ecological damage and substantial outlays for the extraction of new deposits. The first strategy developed by the government in 2018 set directions for the stable operations of mine–power station complexes until 2030, and their liquidation until 2040/2045, without the extraction of new deposits [106].

2. Research Methodology

The literature review points to a significant knowledge gap, particularly in the area of empirical research of the overall and multi-dimensional assessment of the determinants, effects and costs of restructuring processes in coal mining companies. This gap is caused by a number of limitations resulting from access to figures, as well as a large number of analysed elements and their interdependencies, thus necessitating the research study undertaken in this paper.

Generally, the identified knowledge gaps are as follows: a theoretical gap—insufficient knowledge about analysing the restructuring process from the perspective of its financial aspects (results) and, simultaneously, from the perspective of the economics of activities (causes), which would allow for the identification the mechanisms of achieving these results; a methodological gap—the lack of an integrated model for measuring the trends, impact and structure of restructuring in a cause–effect approach; an empirical gap—the lack of research studies based on the entire population of coal mining companies and for the whole time horizon, i.e., from the beginning of the transformation of the Polish economy (1990) to coal phase-out (2049) (a broader literature review and presentation of knowledge gaps can be found in [107] (pp. 19–39, 59–80, 103–126).

An answer to the question (research problem) “Have the goals of restructuring coal mining companies been achieved (and to what extent), and has the restructuring-related expenditure been economically rational?” is based on the verification of the main hypothesis:

The properly implemented restructuring of coal mining companies resulted in their independent (self-financing) and efficient functioning.

The main hypothesis is supported by partial hypotheses resulting from the specific goals and “atomization” of the research problem (the research framework is shown in Figure 1):

- H1. Restructuring is not a uniform process in terms of its intensity in time and achieved results, which allows for its periodization and the determination of its effectiveness;
- H2. The main driver of changes was the replacement of human labour by objectified labour (machines and equipment), leading to the increased productivity of labour and a more efficient use of assets under the conditions of a stable capital structure;
- H3. Effective management and economic relationships resulting from restructuring ensured companies’ stability and long-term operations;
- H4. The incurred costs of restructuring contributed to changes to the energy mix (its desired time and degree), reducing the related expenditure.

In the assessment of the restructuring of the hard coal mining industry, one more aspect should be pointed out. It is not the fact that it took place only in Poland in the absence of other experiences. On the contrary, it was possible to take advantage of many activities, specific benchmarks that have been, and still are, provided by the restructuring of hard coal mining even only in Europe [108], in countries such as Great Britain [109,110], France, the Netherlands, Belgium or Germany [111,112]. This aspect, unfortunately, further strengthens the negative assessment of the restructuring carried out in Poland, as well as its further course towards the energy transition [113,114], and it may represent a field of further research.

The article presents the effects of the restructuring of coal mining companies from the perspective of time and scope. With regard to the time horizon, the analysis covers the period marked by the beginning of the transformation process (1990–2020). The analysis makes use of two specially constructed synthetic measures for assessing the restructuring process and companies’ financial standing. With respect to the scope of the process, the analysis focuses on the mechanism that determines coal mining companies’ financial results in 2007–2021 (first half year), i.e., after 2006, when the process of typical and direct restructuring activities came to an end. For this purpose, the analysis makes use of a series of financial analysis measures.

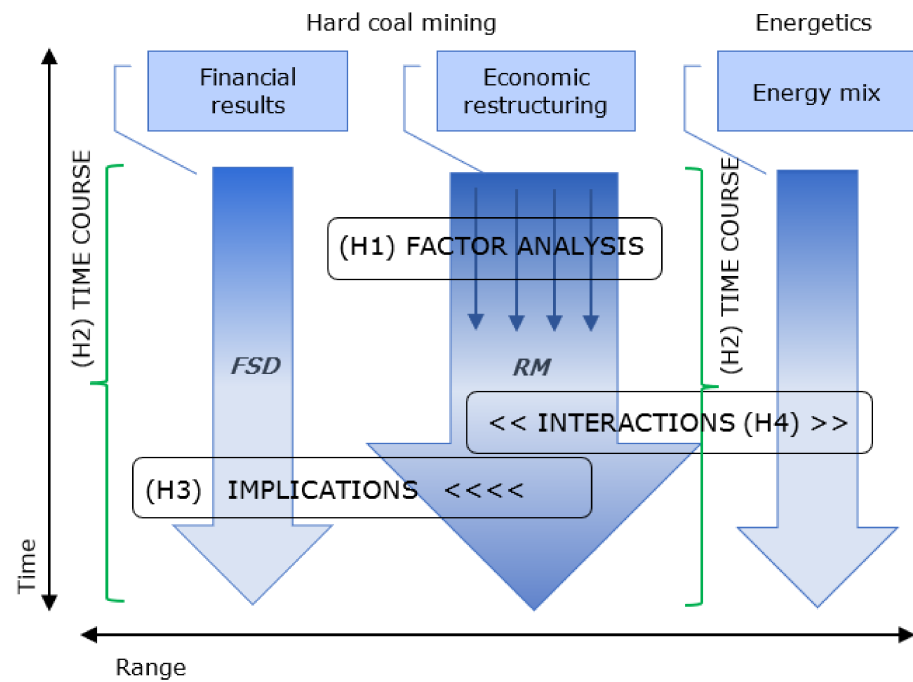


Figure 1. The research framework and process relationships in terms of partial hypotheses. Source: author’s research. Note: *RM*—multivariate restructuring measure; *FSD*—financial security degree. H1–H4—partial hypotheses.

The assessments of restructuring processes are mainly based on financial results and value measures. However, this statement is a simplification. Financial results are secondary, reflecting the monetary (financial) aspects of the efficiency and effectiveness of performance—economic results, which are primary factors. For the purpose of this analysis, the authors’ original multivariate restructuring measure (*RM*) was constructed on the basis of four partial measures (Figure 2):

- Labour and tangible costs productivity;
- Asset productivity;
- Asset–capital structure;
- Fixed asset renewal.

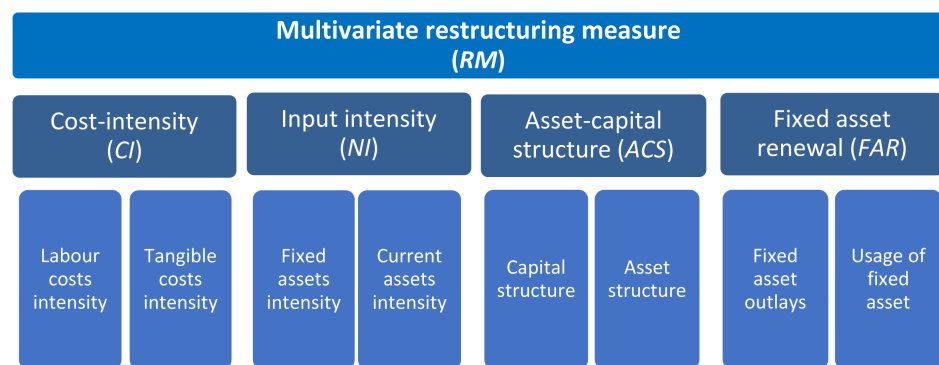


Figure 2. Structure of multivariate restructuring measure *RM*. Source: author’s research.

The calculation of the synthetic restructuring measure (*RM*) is based on relevant statistical procedures (standardization, transformation of destimulants into stimulants, elimination of negative values—deduction of a scalar, determination of the distance from anti-pattern (d_{i0})—the coordinate system origin), which is demonstrated by the following formula:

$$d_{i0}(RM) = \sqrt{\sum_{j=1}^K (x_{ij} - x_{0j})^2}; x_{ij} = \begin{cases} destym(CI) \rightarrow stym(LTP) \\ destym(NI) \rightarrow stym(AP) \\ stym(ACS) \\ stym(FAR) \end{cases} \quad (1)$$

where

CI: cost intensity;

NI: input intensity;

LTP: labour and tangible cost productivity;

AP: asset productivity;

ACS: asset–capital structure;

FAR: fixed asset renewal;

$x_0 = (0, \dots, 0)_K$, K number of multivariate measure components ($j = 1, \dots, K$).

Each partial measure is explained by two factors, which creates a multidimensional relationship structure, giving a wide range of restructuring evaluations (4 partial measures and 8 factors). Its clarification is presented as follows.

The division of labour and tangible costs productivity (*LTP*) into two components: *LA*—labour costs (remuneration, social insurance and other benefits), and *TC*—tangible costs (costs of materials and energy, and depreciation), which require the reversal of relations, i.e., an analysis of costs intensity (*CI*) as a sum of labour cost intensity ($\frac{LA}{RS}$) and tangible cost intensity ($\frac{TC}{RS}$). This allows for the assessment of the process of replacing living labour with objectified labour as an indication of technical advancement. In the context of assessing the structure of costs, it is also possible to assess the degree of the use of outsourced services—the effect of creating links between entities (outsourcing).

$$LTP = \frac{RS}{LC + TC}; LTP = \frac{1}{CI}; CI = \frac{LC}{RS} + \frac{TC}{RS} \quad (2)$$

Changes in asset productivity (*AP*), reflecting the effectiveness of its use, are divided into factors related to fixed assets (*FAs*) and current assets (*CAs*) in such a way that the inverse of the sum of their capital intensity (*NI*) is equal to asset productivity (revenues from sales (*RSs*) to total assets (*TAs*)). This allows for the evaluation of the impact of two different types of assets (in terms of their function) and capital intensity.

$$AP = \frac{RS}{TA}; AP = \frac{1}{NI}; NI = \frac{FA}{RS} + \frac{CA}{RS} \quad (3)$$

The asset–capital structure (*ACS*) is determined by the relation between measures of assessing appropriate proportions between the use of capital (fixed assets (*FAs*) and current assets (*CAs*)) and the sources of financing (equity (*EQ*) and debt capital (*DT*)). Changes in *ACS* values allow for evaluating the degree of compliance with the balance sheet rules of thumb and general trends in changes to financial conditions (improvement/deterioration).

$$ACS = \frac{EQ}{DT} \div \frac{FA}{CA} \quad (4)$$

The process of fixed asset renewal (related to tangible fixed assets) requires investment outlays, and is accompanied by the wear and tear of fixed assets. The analysis separates the fixed asset outlay ratio ($\frac{IN}{FA}$) and usage of fixed asset ratio ($\frac{US}{FA}$) (usage (*US*) is expressed by depreciation (*DE*)) from the fixed asset renewal ratio (*FAR*). This allows the impact of the two factors on the process of fixed asset renewal to be shown.

$$FAR = \frac{IN}{DE} = \frac{IN}{FA} \div \frac{DE}{FA} \quad (5)$$

The measurement of financial security degree (*FSD*) was carried out using an original logit model estimated by the authors. *FSD* is the opposite of financial distress of going concern and bankruptcy. This change aims to define *FSD* as a stimulant for the needs of multivariate analyses.

According to the adopted methodology, model *FSD* assumes the following form [115]:

$$FSD = \left(1 - \frac{1}{1 + \exp\left[-\left(-0.70 - 0.42 \frac{W_1 - 1.89}{1.09} - 0.93 \frac{W_2 - 0.39}{0.31} + 0.65 \frac{W_3 - 0.47}{0.27} - 0.73 \frac{W_4 - 2.94}{13.46}\right)\right]} \right) \cdot 100\% \quad (6)$$

where W_1 —asset productivity ratio; W_2 —self-financing ratio; W_3 —short-term liability ratio; W_4 —operating return on asset ratio.

This measure assumes values of 0 and 100%, with higher values indicating the higher probability of maintaining financial security in a one-year time horizon. The model characterizes the following: sensitivity: 82.4%; specificity: 82.1%; *AUC*: 0.894 (Area Under ROC Curve (Receiver Operating Characteristic)).

The cause analysis is based on a deterministic approach and the logarithm method. Its use allows the transformation of the string of the product of explanatory variable dynamics (D_{EV}) into the string of the sum, and then the logarithm of dependent variable dynamics (D_{DV}) is referred to as unity. As a result, the structural ratios are determined, which describe the impact of the independent variables (R_{EV}) on the dependent variable (R_{DV}):

$$\begin{aligned} D_{DV} &= D_{EV1} \cdot D_{EV2} \cdot \dots \cdot D_{EVn}; \log D_{DV} = \log(D_{EV1} \cdot D_{EV2} \cdot \dots \cdot D_{EVn}) \\ R_{EV1} &= \frac{\log D_{EV1}}{\log D_{DV}}; R_{EV2} = \frac{\log D_{EV2}}{\log D_{DV}}; \dots; R_{EVn} = \frac{\log D_{EVn}}{\log D_{DV}} \\ R_{DV} &= R_{EV1} + R_{EV2} + \dots + R_{EVn} \end{aligned} \quad (7)$$

The analysis of the interdependencies of time series assumes a critical significance level $\alpha = 0.05$ to test the probability *p*-value. A *p*-value lower than the critical significance level justifies an interim procedure based on the assumption that the null hypothesis concerning the lack of correlation is rejected (the degree of correlation as a numerical value is presented in the results of analyses only if *p*-value < α). The adopted correlation measure is Pearson's *r* (the degrees of correlation: <0.1 low; 0.1–0.3 weak; 0.3–0.5 moderate; 0.5–0.7 high; 0.7–0.9 very high; >0.9 nearly full), and the measure of variation is standard deviation (*SD*) and coefficient of variation (*CV*). The average rate of change (*ARC*) is calculated as follows:

$$ARC = \left(\sqrt[n-1]{\frac{x_n}{x_1}} - 1 \right) \cdot 100\% \quad (8)$$

The assessment of the analysed companies' potential and financial results is based on well-known and standardised measures. They are widely discussed in the literature on the subject, so they are not described in detail in the article [116] (pp. 35–89) [117] (pp. 250–348) [118] (pp. 135–276) [119].

The authors' original synthetic measure (*AOD*) was constructed for the needs of multivariate financial analysis. Its value corresponds to the surface of a decagon whose legs represent the dynamics of changes in key financial indicators—stimulants (general financial standing indicator, self-financing ratio, short-term receivables cycle, short-term liabilities cycle, quick liquidity ratio, solvency ratio, operating return on sales, operating return on assets and asset productivity). An increase in the value of *AOD* is interpreted as a general improvement in financial standing (and vice versa).

According to PKD—Polish Classification of Activities based on Statistical Classification of Economic Activities in the European Community NACE Rev. 2, PKD 5 comprises solid mineral energy resources mining enterprises, classified as group 05.1—mining of hard coal, and 05.2—mining of lignite. The share of the former group dominates in terms of the number of employees (95.9%), total assets (96.6%), revenue from sales (96.7%) and net financial result (99.5%). This indicates that the potential of PKD 5 companies is determined by hard coal mining companies, which results from the fact that lignite mining companies

operate as the subsidiaries (parts/branches) of energy companies (power plants). The only independent company is Kopalnia Sieniawa Sp. z o.o. (a lignite mining, limited liability company). Its output is relatively small and mainly designed for heating purposes, so it does not have any impact on the results of the entire mining industry.

The analysis comprises all companies belonging to PKD 5 with more than 10 employees and which are obliged to submit statistical reports. Most of these entities are large multi-plant companies (mining groups and holding companies operating a number of mines), representing a group of entities covered by public statistics (entities up to 9 employees are treated as representative samples). Such samples are referred to in special-purpose analyses.

3. Results

3.1. Labour Costs and Tangible Costs

Labour cost and tangible cost productivity (*LTP*) was characterised by longer periods of stability, reaching peak values in 2003 and 2016 ($ARC = -0.2\%$). *LTP* was moderately correlated with changes related to business activities (revenue from sales) ($r = 0.48$).

The average share of labour costs was high (40.9%), and cost intensity rose ($ARC = 0.5\%$). On the other hand, tangible costs ($AV = 24.9\%$) decreased ($ARC = -0.2\%$), and changes in cost intensity were similar to changes in labour costs. The changeability of cost intensity related to tangible costs was higher ($CV = 13.6\%$), as compared with labour costs ($CV = 10.8\%$).

The area between labour costs and tangible costs was mainly filled by the costs of outsourcing (average share: 18.6%; $ARC = 2.3\%$). This share rose until 1999, then dropped sharply, and was relatively stable as of 2003.

As compared with average values for production companies, coal mining industries recorded lower than average productivity levels (*LTP*, by an average of 8.8%). However, considerable differences occurred in the area of cost-generating factors. As for labour costs, the difference was 3.2 times higher (+2195%), and in the case of tangible costs, nearly 50% lower (−47.0%). It should be noted that the share of outsourcing was 52.4% higher, as compared with the average level for production companies (Figure 3).

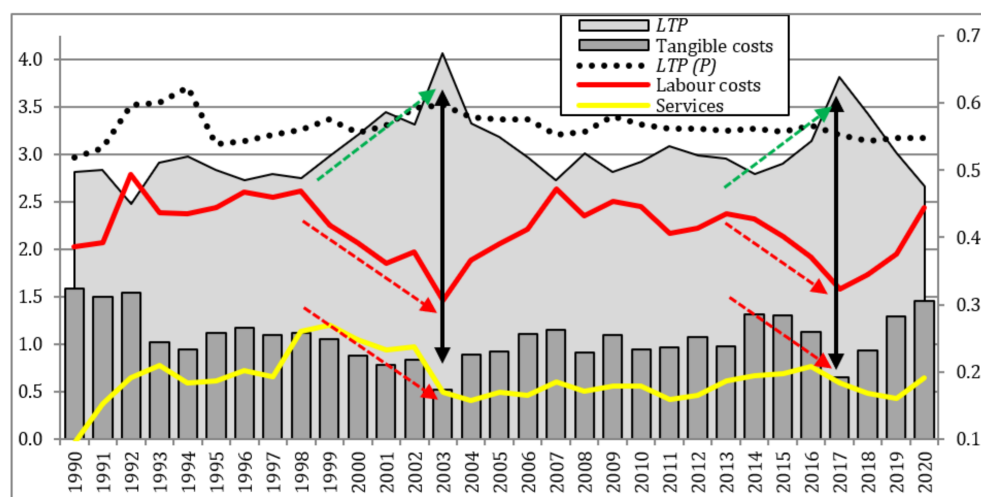


Figure 3. Productivity of labour and tangible costs (*LTP*), and components of cost intensity in coal mining companies in 1990–2020. Note: *LTP*—standardised values, left axis. *LTP(P)*—productivity of labour and tangible costs for production enterprises. Source: author’s research based on GUS in Warsaw (Statistical Head Office in Warsaw, Poland)—databases of limited access. Available online: <https://stat.gov.pl/en/databases/> (accessed on 4 December 2021); Pont Info Warsaw—Gospodarka SŚDP—commercial databases. Available online: <http://baza.pontinfo.com.pl/index.php> (accessed on 2 December 2021; Coface For Trade, Warsaw—commercial databases. Available online: <https://www.coface.pl/Analizy-ekonomiczne> (accessed on 4 December 2021).

3.2. Partial Cost Intensity Components vs. Asset Productivity

Total asset productivity AP rose steadily until 1997, following the transformation recession (+107.0%). It dropped steadily for a period of 23 subsequent years ($ARC = -1.8\%$), being reduced by nearly 50% (-49.0%). Its level in 2020 was equal to that in 1992. Generally, AP was not correlated (in inverse proportion) with activity-related changes (revenue from sales) ($r = -0.10$). As compared with average values for production companies, AP for coal mining companies was 23.4% lower.

With regard to cost intensity related to fixed assets (NI_{FAs}) and current assets (NI_{CA}), this year was a turning point. Up to this year, both cost intensity categories decreased, but in later years, NI_{FA} increased steadily ($ARC = +2.6\%$), while NI_{CA} remained relatively stable ($ARC = -0.4\%$, $CV = 12.6\%$). As compared with production companies' average values, NI_{FA} was more than 1.5 times higher (+53.8%), while NI_{CA} was more than 4 times lower (-26.8%).

3.3. Asset–Capital Structure

The average degree of asset immobilization (FA/CA) was very high ($AV = 3.52$), as compared with average values for production companies ($AV = 1.63$). Therefore, the value of fixed assets was more than 3.5 times as high as that of current assets. An increasing trend occurred ($ARC = 3.1\%$), but in the first place, a high level of changeability ($CV = 25.9\%$) and upper (2007 and 2015) and lower (2003, 2011 and 2018) record levels. This indicated the sequences of increases and decreases as of 2003.

Equity to debt (EQ/DT) was even less stable in this period ($CV = 82.0\%$). This resulted from changes to negative values in 1999–2002 (due to negative values of equity). However, the achieved average value was low both in absolute ($AV = 0.40$) and relative terms in relation to average production enterprises ($AV = 1.08$).

As a result of these changes, the asset–capital structure (ACS) was characterised by considerable changeability ($CV = 96.6\%$), and cyclical deviations were the opposite of the degree of asset immobilization (FA/CA). Its level was critically low ($AV = 0.11$), and it never exceeded the level of unity in the analysed period of 31 years (failure to comply with balance sheet rules of thumb). Its greatest decreases coincided with increases in FA/CA and decreases in EQ/DT . The degree of correlation of ACS with the level of business activities (revenue from sales) was high ($r = 0.67$).

3.4. Renewal of Fixed Production Resources

The process of the renewal of fixed assets is characterised by a changing degree of intensity. In this context, three periods could be identified: 1990–1994, 2003–2011 (the highest intensity) and 2016–2018. FAR ($CV = 26.4\%$) was highly changeable, while the general trend decreased ($ARC = -0.7\%$), and the average level was lower than in the production sector (-21.9%). A rapid decrease marked the period of 2012–2015 (-65.8%). This was followed by a slow recovery process, and the recorded levels in recent years of the period were similar to those in the late 1990s. FAR was not correlated with changes in revenue from sales ($r = -0.05$).

As regards FAR factors, fixed asset outlays were highly changeable ($CV = 24.0\%$), but they tended to increase ($ARC = 1.4\%$). Unfortunately, the process of wear and tear of fixed assets accelerated ($ARC = 2.1\%$), as compared with industry average levels (+27.4%). Peak values were recorded in 2014–2020, which—accompanied by a decrease in fixed asset outlays—resulted in the greatest deterioration in FAR values.

The results presented so far are the basis for the negative verification of the partial hypothesis (H1), because the main and increasingly important change driver was labour productivity; the process of replacing it by objectified labour (machines and equipment) was not identified; intense technical and technological advancement did not occur; asset productivity tended to decrease in longer periods of time, accompanied by difficulties in the renewal of production resources and the dramatically unfavourable asset–capital structure.

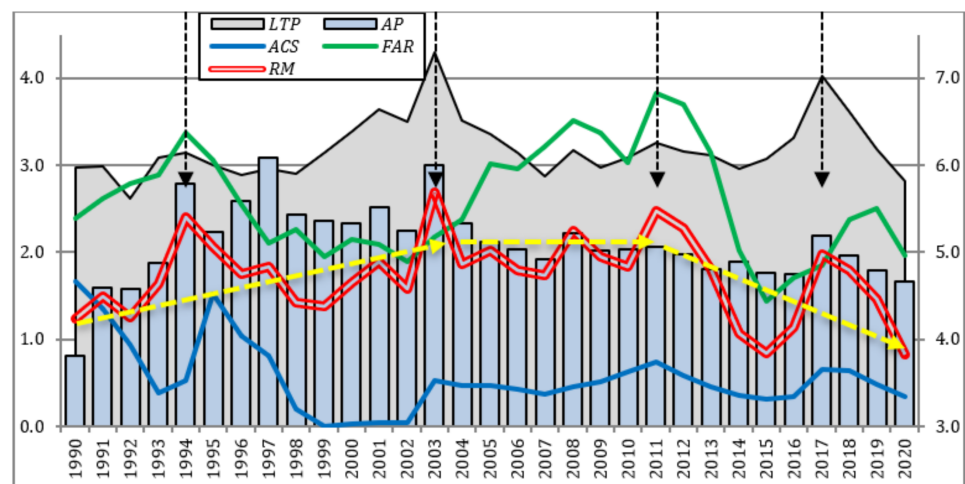
3.5. The Measure of Restructuring and Its Factors

The analysis of the synthetic restructuring measure (*RM*) allowed for the identification of three periods of changes: 1990–2004—an increasing trend ($ARC = 2.1\%$) with higher changeability ($CV = 8.6\%$); 2005–2011—stabilization ($ARC = -0.2\%$) and moderate changeability ($CV = 6.2\%$); and 2012–2020—a decreasing trend ($ARC = -3.5\%$) and high changeability ($CV = 11.2\%$). The first period recorded two peaks (1994 and 2003), and the two lowest values (1990 and 1999), drawing a borderline between increases and decreases in *RM*. In the second period, such phases were not distinct, unlike in the third period—the pairs of peaks occurred in 2012 and 2015, and in 2017 and 2020, with a higher amplitude between them and shorter phases, as compared with the first period.

Out of 31 analysed years, only five years recorded a simultaneous increase in all *RM* factors, and six years were characterised by a simultaneous decrease. For this reason, these years were characterised by the highest and lowest *RM* values, respectively.

The analysis of partial measures indicated that the year 1998 marked the beginning of a long-term decreasing trend for *AP* values and low levels of *ACS*. Apart from two peaks, *LTP* remained relatively stable. The greatest deviations were recorded for *FAR* values.

The results of a cause–effect analysis pointed to a modest share of *LTP* (45.8%), *FAR* (28.6%), *AP* (18.9%) and *ACS* (0.7%) in the *RM* value. In this last case, this resulted from a serious departure from the asset–capital structure (balance sheet rules of thumb). The share of *RM* factors changed over the course of time, shifting towards a larger share of *LTP* and *AP* and a lower share of *ACS* and *FAR*. As compared with average industry levels, a larger share was recorded for *LTP* (+19.0%), and a lower share for *FAR* (−10.6%) and *AP* (−1.6%), and particularly *ACS* (−90.9%), having a major negative impact on coal mining companies (Figure 4).



(a)

LTP	+	-	+	+	-	-	+	-	+	+	-	+	-	-	-	-	+	+	-	-	-	+	+	-	-	-	-	-	LTP
AP	+	-	+	+	-	+	+	-	-	-	+	-	+	-	-	-	+	-	+	-	-	+	-	-	+	-	-	-	AP
ACS	-	-	-	+	+	-	-	-	+	+	-	+	-	+	+	+	+	-	-	-	-	+	+	-	-	-	-	-	ACS
FAR	+	+	+	+	-	-	-	+	-	+	-	+	+	+	-	+	+	-	-	-	-	-	+	+	+	+	+	-	FAR
RM	+	-	+	+	-	-	+	-	+	+	-	+	-	+	-	-	+	-	-	-	-	+	+	-	-	-	-	RM	

(b)

Figure 4. Restructuring evaluation results: (a) restructuring measure (*RM*) and its components for coal mining companies in 1990–2020; (b) direction of change in *RM* and its components for coal mining companies in 1990–2020. Note: standardised values, stimulants. *RM*—right axis. Direction of change: (+) increase; (−) decrease. Source: as in Figure 2.

RM values were moderately correlated with the degree of financial security (*FSD*), which reflects companies' financial standing ($r = 0.46$). The analysis of the interdependencies of these measures confirmed the previously identified periods: 1990–2004, 2005–2011 and 2012–2020. The first period was characterised by similar *RM* and *FSD* values in coal mining companies and average values in the production sector—*FSD* (*P*), both in increasing and decreasing phases. In the second period, both measures tended to stabilise (*FSD*—*FSD* (*P*) $r = 0.83$ until 2011). The third period recorded considerable fluctuations in *RM* and *FSD* in coal mining companies and further stabilization in production companies—*FSD* (*P*).

The first period also recorded considerable losses (negative *ROS*), decreased value added due to the decreased value-added margin (*VAM*), and a decreasing trend in the share of exports (*EXP*). Similar problems occurred in the third period, and at the end of the period, *RM*, *FSD*, *VAM*, *ROS* and *EXP* assumed values recorded in the early 1990s (Figure 5).

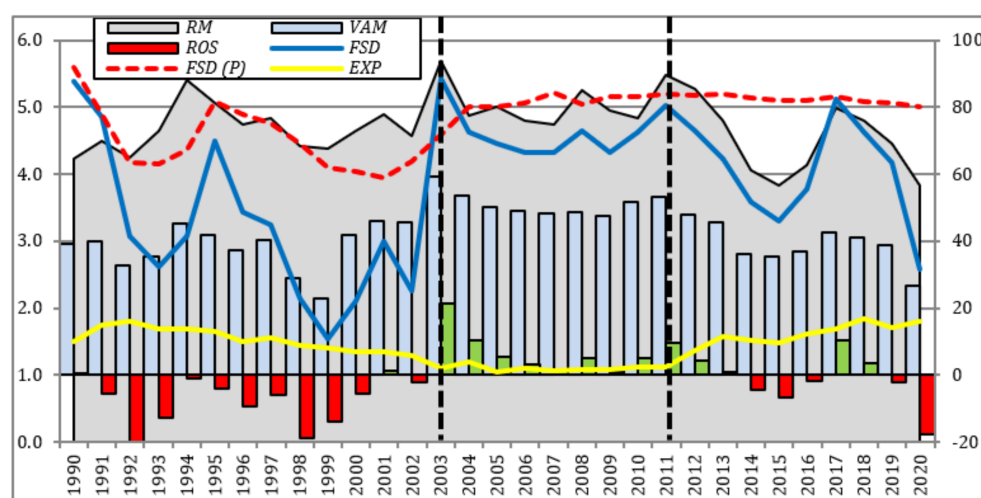


Figure 5. Restructuring measure (*RM*), *ROS*, export (*EXP*), *VAM* and financial security degree (*FSD*) for coal mining companies in 1990–2020. Note: *RM*—standardised values, left axis. *FSD* (*P*)—financial security degree for production enterprises. Other categories—right axis (%). Source: as in Figure 2.

The conclusions formulated so far are the basis for the verification of the partial hypothesis (H2). The restructuring was not a uniform process in terms of its intensity in the course of time and its effects, which allowed it to be divided into three periods (1990–2004, 2005–2011 and 2012–2020). Therefore, the hypothesis was positively verified.

3.6. Financial Results and Their Determinants after 2006

In 2006, the government abandoned the use of typical direct restructuring methods. As already mentioned, at a certain point, coal mining companies embarked on a path of stabilization and positive financial results. However, this period was relatively short and followed by two major downturns. The question is: what were the reasons for this and the related mechanisms?

The peak value of total and fixed assets was recorded in 2013. An increase in current assets resulted from increased revenues from sales, while short-term receivables cycle remained stable and inventories cycle increased slightly. An increase in fixed assets resulted from investment outlays. The outlay/depreciation ratio was favourable (on average, 1.52). Some negative trends prevailed after 2013: short-term liabilities cycle increased by 65.0%, accompanied by a slight increase in inventory; the receivables cycle remained relatively stable, but fixed assets started to decapitalise (outlays/depreciation—an average value of 0.87).

The cost structure was dominated by fixed costs ($AV = 77.2\%$), mainly including labour costs (33.5%), outsourcing (18.0%) and depreciation (10.2%). A large part of the use of materials (10.0%) and energy (5.5%) was represented by fixed costs. The number of employees decreased to varying degrees but only until 2016 ($ARC = -2.1\%$). This led to an increase in general productivity (revenue from sales/employees), but this ratio decreased after 2016. At the end of this period, technical productivity (having a major impact on performance—output/miners) reached a similar level to that recorded at the beginning of the period ($ARC = 0.2\%$). Moreover, labour productivity (revenue from sales/labour costs) remained stable, and a rapid increase in 2017 was followed by a sharp fall ($ARC = 0.01\%$). Technical productivity exceeded the level of a strong correlation with labour productivity ($r = 0.58$) and a very strong correlation with labour productivity ($r = 0.77$) (Figure 6).

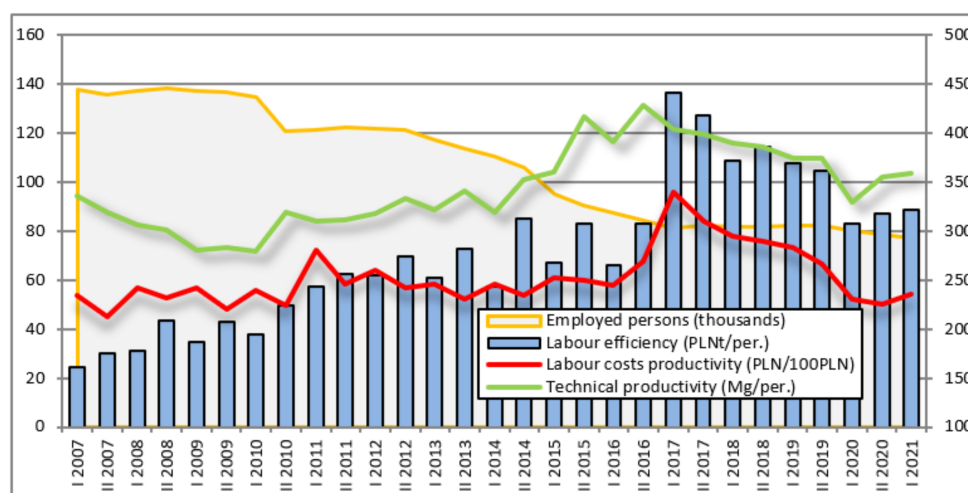


Figure 6. Employees, labour efficiency, labour costs productivity and technical productivity in coal mining companies in 2007–2019 (half-year data). Note: employees—left axis (thousands). Source: as in Figure 2.

The assessment of (ACS) the asset–capital structure was negative. First, the balance sheet rules of thumb were not adhered to when ACS values were well below a unity ($AV = 0.3$; min.: 0.06; max.: 0.6). Second, ACS tended to decrease ($ARC = -5.8\%$). Third, the maximum FA/CA values coincided twice (2015 and 2021) with the minimum EQ/DT values (capital structure). These two moments were critical, and the resulting situation was a threat to going concern.

Moreover, the low level of liquidity continued to decrease (analysed from a statistical perspective—current liquidity ratio (CL): $AV = 0.85$; min.: 0.43; quick liquidity ratio (QL): $AV = 0.61$; min.: 0.29), and a dynamic perspective—(CE) cash efficiency: $AV = 9.6\%$; min.: -12.7% ; ($CFCR$) cash flow coverage ratio: $AV = 14.0\%$; min.: -12.7%). Ultimately, the creation of value added in the two periods decreased dramatically (-54.4% and -60.5% , respectively, in relation to max. value); return on sales (ROS) had negative values (-12.4% and -18.6% , respectively); there was a continued decrease in return on equity (ROE : -29.4% and -66.1% , respectively); and equity decreased to merely bn PLN 4.8 at the end of the period (Figure 7).

The assessment of trends and the degree of changes to 10 key financial ratios using the AOD measure supplemented and synthesised the presented findings. A decrease in AOD (-30.6%), as compared with the beginning of the period, marked the first stage of the financial downturn of 2015, and a decrease of -56.1% , the second downturn in 2021. In comparison, this was reflected in the logit model of financial security degree (FSD), with AOD reports preceding FSD by six months to one year (Figure 8).

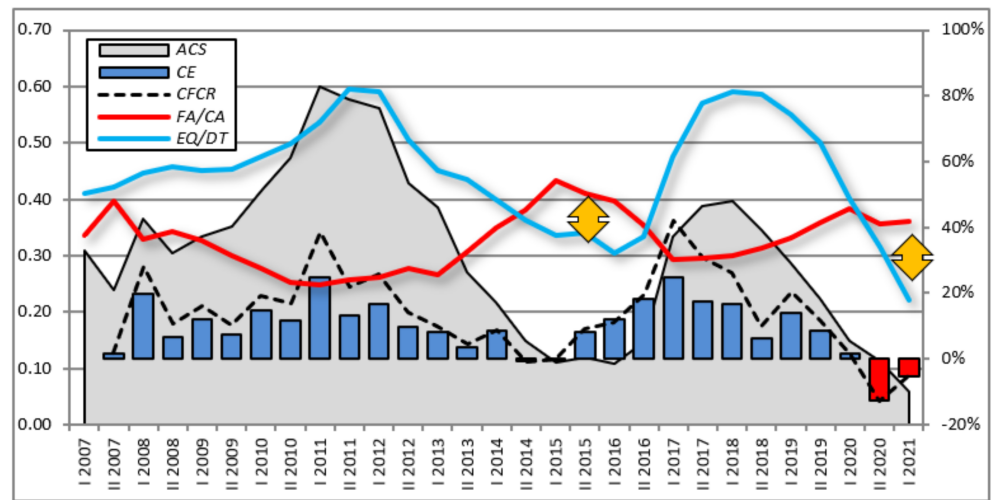


Figure 7. Asset-capital structure (ACS) and its determinants, and cash efficiency (CE) and cash flow coverage ratio (CF) in coal mining companies in 2007–2019 (half-year data). Note: ACS—dimensionless values, left axis. Source: as in Figure 2.

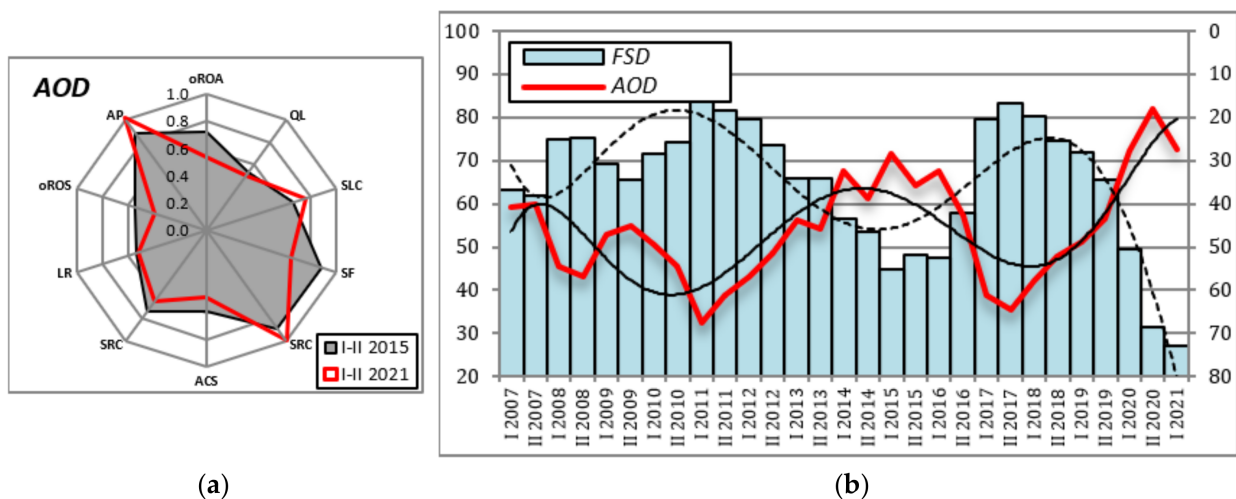


Figure 8. Relationships of multivariate measures: (a) AOD and its components in coal mining companies in 2007–2019 (half-year data); (b) AOD and financial security degree (FSD) in coal mining companies in 2007–2019 (half-year data). Note: AOD—standardised values. FSD—dimensionless values, left axis. Source: as in Figure 2.

In this context, it is necessary to explain the reasons for the financial distress experienced by coal mining companies in the two identified periods—endogenous and exogenous factors. With regard to exogenous factors, the impact of business cycles (GDP growth) did not seem to be correlated with the extraction output (a steady decline, $ARC = -1.8\%$, in total -40.3%) or (SMR) sales margin rate (referred to in mining as accumulation). This represents the difference between the actual revenue from the sales and production costs of sold coal. Changes in the status of inventories were taken into account on the cost side at the stage of a shift from costs by nature to production costs of sold coal [120]. In turn, an analysis of coal prices (which do not affect extraction volumes) pointed to the double occurrence of a spectacular situation: higher prices were accompanied by a decrease in SMR , as well as operating return on sales ($oROS$). The first of these situations (the first six months of 2011–the last six months of 2012) was preceded by a serious downturn, resulting in major losses in 2014–2016, while the second event (the last six months of 2017–the last six months of 2018) was preceded by the period of losses in 2020–2021. An in-depth analysis

of the two situations pointed to a lowered ratio of the advance notice of cost dynamics (Cd) in relation to sales dynamics (Sd) (Figure 9). In part, this can be attributed to the fact that higher prices loosened discipline in controlling the cost of goods sold. However, the main factor was the inclusion of investment and capital expenditure ($CAPEX$) into operating expenditure ($OPEX$). The above reasons are endogenous factors. Their negative impact was enhanced by an exogenous factor—the lower market prices of coal, resulting in major losses in 2014–2016. In the case of the second situation, an increase in prices (by 55.2%, as compared with 2014–2016) was a positive factor in the beginning, having a neutral impact in the later years (price increase in 2007–2021). It should be noted that export (an exogenous factor) did not affect the results. Its share in revenue from sales increased considerably from 1.5% to 20.9%, but its correlation with total revenue was moderate ($r = 0.38$) but weak and the opposite of the sales margin rate (SMR) ($r = -0.24$).

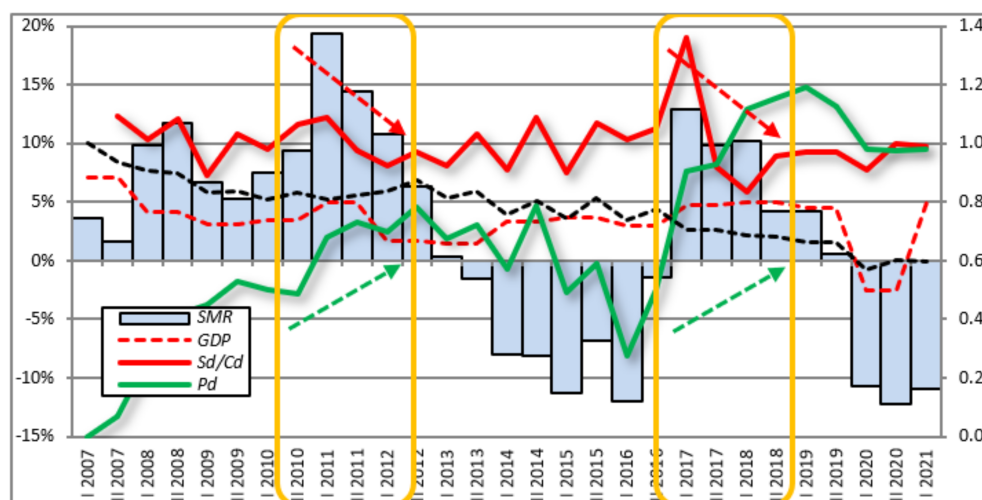


Figure 9. Sales margin rate (SMR), coal price dynamics (Pd), output dynamics (Qd), dynamics of revenue from sales to costs (Sd/Cd) in coal mining companies in 2007–2019 (data for six months). Note: SMR , GDP —left axis. Source: as in Figure 2.

The conclusions formulated so far are the basis for the verification of the partial hypothesis ($H3$). The identified mechanism, which determined the financial results of coal mining after the abandoning of typical, direct restructuring measures in 2006, revealed ineffective management and inappropriate economic relations, which did not facilitate the stable and long-term functioning of companies. Therefore, the hypothesis as negatively verified.

4. Discussion

The analysis of the course and effects of the restructuring process using a dedicated model (multivariate restructuring measure (RM)), and the inclusion of the entire period of the economic transformation (1990–2020) and the entire population of coal mining companies, is a pioneer project. Therefore, reference to the results of other studies is not fully reliable and can be treated as having a fragmentary and self-selecting nature. The validity of the proposed model and the obtained results can be verified over the course of time and subjected to comparative analyses.

The discussion of the obtained results is inductive in character—it presents the primary factors that influence the effects of the restructuring process, and it is concluded by the balance of the effects and restructuring of the mining industry.

The final effect of the restructuring process can be described by four processes: productivity of labour costs and tangible costs, asset productivity, asset–capital structure and renewal of fixed asset resources. Therefore, the following can be stated:

1. Relatively low-cost intensity related to tangible costs, accompanied by the lack of limitations of the contribution of labour to the obtained results, justifies the statement that technological advancement processes are not characterised by high intensity (the replacement of human labour by objectified labour). Moreover, despite two distinct periods of short-term decreases in the share of labour costs, this share in the last analysed years was similar to that at the beginning of the process [121]. The originally intense outsourcing activities tended to decline (coal mining companies became less inclined to cooperate with other entities) [122]. Generally, the evaluation of changes in the productivity of labour costs and tangible costs was negative—the period of 31 years as not marked by visible progress in this area—and the current level of productivity was comparable with that recorded in the early 1990s.
2. Current asset productivity remained unchanged after 1997, which contradicts the universal and expected trend of increasing the efficiency of current asset management [123]. Fixed asset productivity is of key significance to coal mining—a capital intensive industry. Unfortunately, productivity levels tended to decrease steadily after initial increases (until 1997), which should be regarded as a negative phenomenon in the context of the general advancement of techniques and technologies of coal extraction. Generally, the assessment of changes in asset productivity and its potential to generate financial effects (revenue from sales) was negative, and negative trends prevailed, particularly after 2011.
3. The stability of activities is created by appropriate relations between the sources and the period of the availability of capital and the investment of capital in fixed and current assets [124]. This indicates the need to adhere to the balance sheet rules of thumb. Unfortunately, coal mining companies failed to act in accordance with this rule throughout the period of the 31 analysed years (operating well below recommended standards). Moreover, this trend was accompanied by increasing levels of asset immobilization and decreasing levels of self-financing. This violates the fundamental principles of economics and effective performance [125]. The combined impact of these factors indicates a serious threat to going concern and a bankruptcy predictor [126]. Therefore, the assessment of changes in the asset–capital structure was highly negative.
4. The process of investing in fixed assets, considering its high instability, did not balance their wear and tear and, consequently, decapitalization [127] (pp. 127–138). It had a negative impact on asset productivity, hindering technical and technological advancement, particularly after a sharp decline in investment after 2012. Proper relationships between fixed asset investment and the wear and tear process were maintained only in the period of 2003–2012 [128]. At that time, investment outlays increased while the latter process was at a stable level. Apart from this period, fixed asset management was not properly focused and ineffective.

A successful restructuring process was conditioned by a consistent and positive impact of four key processes. This requirement was met in only 5 out of the 31 analysed years. Simultaneously, one-sided activities and a decreasing trend prevailed during a period of 6 years, driving coal mining companies to a crisis. Their functioning and economic condition relied heavily (45.8%) on the productivity of labour and tangible costs, and the impact of these factors increased by up to 54.1%. This constituted a negative assessment, which was also confirmed by a low level of technical productivity [129,130] due to the lack of investment in new technologies (technical productivity levels were very diversified: mines in Silesia—560–760 tonnes/person, 90.1% of total output; mines in the region of Lublin—1956 tonnes/person, 9.9% of total output).

An in-depth analysis of the 2007–2021 period explained the mechanism that caused losses in mining companies. Higher coal prices encouraged cost control loosening and the treatment of a large part of CAPEX as OPEX. Cost dynamics exceeded revenue from sales, which, accompanied by a period of lower prices, led to two critical deficits and losses. The mechanism of setting coal prices, subsidies and contracts with powerful energy concerns

led to the situation in which coal extraction costs were determined by increases in coal prices [131]. When prices decreased, it was not possible to avoid this downward spiral, which resulted in huge losses and increased levels of indebtedness. An increase in coal exports (a maximum level of 11.0 m tonnes in 2020, including 6.3 m of coke), accompanied by a decreasing domestic demand and its import due to energy concerns and by heat-generating companies (a maximum of 19.3 m tonnes of energy coal in 2018, and 12.8 m tonnes in 2020), was by no means beneficial for mining companies [132]. It only led to the government's regulation enforcing power plants to purchase energy coal exclusively from domestic companies.

The three distinct periods of the intensity and effects of the restructuring process justified the government's decision to abandon typical, direct restructuring measures after 2006 [133] (pp. 1–199). It can be assumed that coal mining companies were well prepared to adopt market-oriented policies and that they were consolidated, their debts were reduced, their financial results were satisfactory, and they were ready to develop strategic action plans under government programmes for the industry [134] (pp. 92–107). However, the degradation process of the industry, which started in 2012, brought about disastrous effects in 2014–2016. The organizational and ownership changes initiated by the government (2015–2017) [135], which aimed to establish Polska Grupa Górnicza SA (a “super coal holding company”) and the liquidation of selected mining companies and mines (contributed as assets to Spółka Restrukturyzacji Kopalń S.A. (Coal Mine Restructuring Company)), resulted in short-time and doubtful effects, ultimately leading to a more serious crisis in 2020–2021. The values of restructuring measures, financial security, value added ratios and profitability of sales were similar to those recorded in the 1990s. The efforts of 31 years of restructuring, which aimed to ensure the uninterrupted functioning of the industry until a shift towards alternative sources of heat and electricity (other than fossil fuels), turned out to be futile.

The assessment of the restructuring of the coal mining industry, in addition to the verification of its effects [136], also focused on the aspect of costs [137]. Direct budgetary subsidies in 1990–2020 amounted to bn PLN 143.1. They peaked in 1990–2001 (bn PLN 34.0) and 2007–2015 (bn PLN 65.7), with the largest one-time subsidy in 2003 (bn PLN 18.9) [138] (pp. 1–44). However, the subsidies were not the only sources of financing [139] (pp. 1–81). Funds were granted by the Ministry of Economy, the Ministry of Finance, internal revenue and customs services, environmental protection institutions and local governments, and, to a large extent, as method of covering a social insurance deficit (co-financing miner's pensions and disability pensions—bn PLN 99.2). Subsidies in 1990–2020 reached a total of bn PLN 210.5, which accounted for 7.4% of GDP (2020) [140] (pp. 1–44). The average annual subsidies reached the level of bn PLN 6.8, with the average annual subsidies of bn PLN 7.2 after 2010, and a record high amount of bn PLN 10.1 in 2015 [141] (pp. 1–114).

The process of subsidising coal mining has not come to an end—according to the current restructuring programme, coal phase-out is planned to be implemented as late as in 2049 [142]. Direct subsidies until 2030 are expected to reach the level of bn PLN 28.8, while the full coverage of expenses amounts to at least bn PLN 72.3. According to a conservative estimate, subsidies are likely to amount to bn PLN 209.6 until 2049 (7.4% of GDP).

The industry's economic burden as a result of the economy and society (1990–2020) should also include net accumulated losses (bn PLN 24.1), negative equity (bn PLN 22.9) and value added loss (bn PLN 55.8), totalling bn PLN 102.8. Additional costs include nearly bn PLN 10 resulting from energy concern outlays and expenditure related to coal mining (direct support for their own mines and, indirect aid, through approval given to higher coal prices and subsidising the mining of coal).

The year 2049 as Poland's coal phase-out is a goal that might not be achieved [143–145] (pp. 1–141). First, a number of the previously implemented restructuring programmes have not met their targets in terms of the actual coal output. Second, even if demand [146] decreases in opposition to the previous trends, “zero output” will occur in 2038. Addi-

tionally, it should be considered that the annual output of below 30 m tonnes (2028) is highly unprofitable.

Output volumes are also determined by geological conditions [147] (pp. 1–60) and, in particular, by the demand of power stations (approx. 78%—energy coal), which face a major challenge, posed not only by the agreements of the Kyoto Protocols, but primarily by a new energy mix [148,149], the EU climate and energy package “20-20-20” [150], Energy Policy of Poland (PEP 2040) [151] and UE “Fit for 55” [152,153].

Moreover, the rolling costs incurred by society in connection with the coal mining industry [154] (pp. 108–121) should include the costs of coal-generated electricity (a decreasing trend—45.0% in 2020). They include the following: coal subsidies, free-of-charge EU-ETS allowances, the stranded cost of KDT’s dissolution (long-term contracts for the sales of electricity), the mechanism of rewarding for power reserves (ORM—operational power reserve; IRZ—emergency power reserve “winter”), subsidies for co-incineration (“green certificates”) and EU subsidies. In 1990–2020, the financial burden was estimated at bn PLN 263.7 (9.3% of GDP), while in 2021–2049, it is expected to reach the level of at least bn PLN 320.8 (11.3% of GDP). This exceeds the costs incurred in 1990–2020 by nearly 25% (Figure 10).

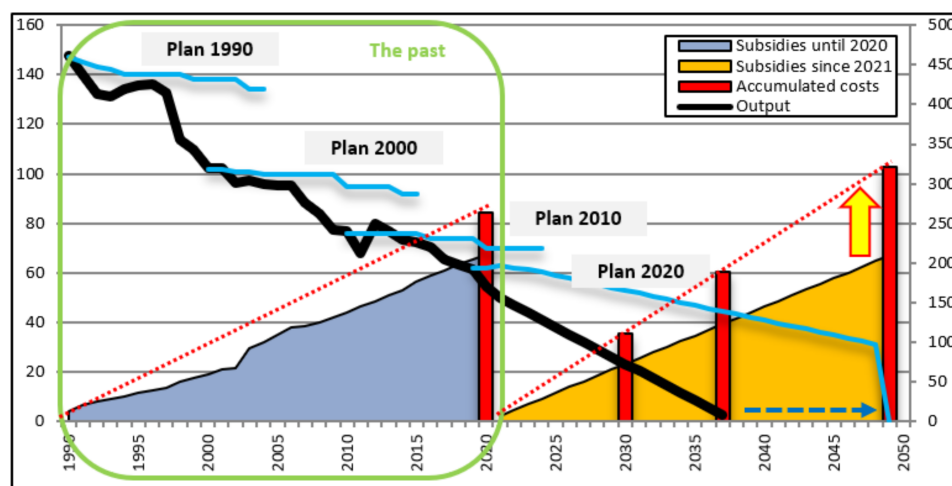


Figure 10. Coal output, subsidies and accumulated costs resulting from restructuring and planned coal phase-out in 1990–2020 and 2021–2049. Note: output—millions of tonnes, left axis; subsidies and costs—PLN billions, right axis. Source: as in Figure 2.

The social financial burden resulting from the functioning of coal mining [155] should also include the costs and losses resulting from emissions, influencing human health [156] and the environment [157,158], which are not covered by the mining and energy industries, estimated at bn PLN 15–46 annually (coal mines: 695 thousand tonnes of methane, i.e., 56.7 m tonnes of CO₂; power stations and heat-generating plants (hard coal and lignite): 112.5 m tonnes of CO₂—65.3% of CO₂ EU-ETS accumulated emissions, as well as more than 84.3 m tonnes of NO_x, 87.6 m tonnes of SO₂, 4.6 m tonnes of fly ash, 3.2 thousand tonnes of lead and 3.4 thousand tonnes of mercury).

Undoubtedly, the position of coal as the strategic basis for Poland’s energy security was solid for decades. This position was also strongly reinforced by the strategies resulting from energy policies. These policies forecasted that the demand for coal in the energy sector would remain stable or even increase. Moreover, most of these forecasts were based directly on the guidelines of the previously implemented coal mining reforms. Unfortunately, these programs did not assume any major reduction in coal output. The first time, the energy policy until 2020 (PEP 2020) assumed a reduction in hard coal consumption of nearly 30% (about 2006). Such a significant reduction in the consumption of coal in the energy sector should, therefore, result in a reduction in its output, and thus give a strong incentive for

the restructuring of the coal mining industry. In practice, coal consumption remained unchanged, and the coal mining industry entered a period of deep losses and required high subsidies. The coal mining industry was put under strong claim pressure and demands to maintain the volume of output. Thus, all plans in the energy industry came to nothing. Certainly, this is the reason for the conclusion that the possibility of changing the national energy policy depends on the effectiveness of the restructuring of the coal mining industry.

The above discussion means that the coal mining restructuring outlays in the form of direct budgetary subsidies and indirect expenditure did not contribute to changing the energy mix in terms of the time framework, its degree and undertaken commitments, which resulted in the further and quicker increase in the accumulated costs incurred by society. Therefore, the partial hypothesis (H4) was negatively verified.

In summary, the obtained results, their discussion and the evaluation of the restructuring of hard coal mining enterprises were the basis for the verification of the formulated partial research hypotheses. Hypothesis H2 was positively verified, and hypotheses H1, H3 and H4 were denied. The findings on the verification of the partial hypotheses justify the general statement that the restructuring of coal mining companies was ineffective, mismanaged and did not ensure their independent and efficient performance. This implies that the main research hypothesis was negatively verified.

The previous discussion can lead us to question whether there are other possible scenarios than the closure of mines until 2049. Obviously, it can be assumed that coal phase-out will take place immediately. The costs of severance payments and increased social insurance contributions (old age and disability pensions, etc.) would not exceed bn PLN 120.5. This is much less than the planned subsidies until coal phase-out in 2049 (bn PLN 320.8). However, apart from the 77.1 thousand employees in coal mining, nearly 400 thousand people have jobs related to this industry. An immediate closure of mines indicates a huge crisis in the region of Silesia. Moreover, mines cannot stop their operations overnight, which implies substantial outlays for recultivation projects. The most difficult problem is the fact that the electricity generated by coal cannot be quickly substituted by other energy sources. Simultaneously, apart from social agreements, miners are not willing to give up their jobs in return for high severance payments. They prefer to benefit from early retirement packages. Again, miners demand higher wages, which increases industry losses and government subsidies. It seems that finding a satisfactory solution is nearly impossible. However, what was a challenge and a threat, i.e., the energy transformation, becomes an opportunity for a quicker and less expensive solution. There is a growing pressure resulting from higher prices of energy generated by conventional sources. In 1990–2020, the share of coal in electricity generation decreased by 28 percentage points (29.1%), but in absolute terms, it represented only 9%. This indicates that changes in the energy mix resulted from meeting the increasing demand for energy (16%) by the use of other than coal energy sources (an 8.5-fold increase, including a 15-fold increase in the use of RES—renewable energy sources), mainly wind turbines (an average annual increase of 50% in 2001–2020) and photovoltaic systems (an average annual increase of 182% in 2011–2020). This process is supported by a breakthrough technology of small modular reactors (SMRs) to be used by large industrial companies to avoid reliance on expensive coal-generated energy and the uncertainty of the use of Earth gas. This indicates the necessity of revising the current plans of the further restructuring of coal mining and the schedule of energy transformation, which will facilitate easier access to less expensive, more reliable and clean energy, leading to a growth spurt instead of slow and less effective changes. Consequently, the Polish economy will become much more competitive.

5. Conclusions

The obvious effect of the transformation of the Polish mining industry in 1990–2020 was a decrease in the number of coal mines (from 70 and 3 under construction to 21—so called multi-entity mines), a decrease in coal output (from 147.5 m tonnes to 54.4 m tonnes, i.e., by 63.1%) and the reduced number of employees (from 393.9 thousand to 78.5 thou-

sand, i.e., by 80.1%). The original objective, however, was to carry out a breakthrough restructuring process, ensuring profitability in a free market economy and in the situation of decreasing demand for coal resulting from a changing energy mix. The results of the research study of the 1990–2020 period using a multivariate restructuring measure (*RM*) allowed for the division of the restructuring process into three distinct periods. Unfortunately, the last period resulted in the partial measures of the effects of restructuring, dropping to the level of the early 1990s. Considerable efforts and the peak effects achieved in 2006 were wasted after 2011. Along with the energy sector, which is dependent on coal, coal mining reached a social, environmental and technical stalemate. Investment in mining operations and increased productivity, considering the time of liquidation, was pointless. The delayed and prolonged liquidation process will require further subsidies and increase the total social costs—by 25% more than the financial burden of the last 31 years.

Adapting coal mining to market realities by means of restructuring measures turned out to be a very difficult task due to several key reasons. The achievement of goals set by the government in the subsequent programmes, which aimed to increase economic effectiveness, was postponed until later periods. Finally, in 2006, typical, direct restructuring measures were no longer used, which was reflected in a certain level of stability and profitability. However, this period was followed by a serious downturn, and the completely abortive organizational changes introduced in 2015–2017 and increased subsidies in various forms did not prevent the inevitable crisis.

The accumulation of problems became apparent: first, the failure to implement programmes aiming to reduce the share of fossil fuels in energy (not only electricity) generation. These programmes were based on the 2008 EU energy and climate package (“20-20-20”). However, government and, consequently, business decisions (some mines are part of energy concerns) led to the opposite effect: new investment projects increased energy generation based on coal (current requirements are set out in PEP 2040 and “Fit for 55”).

The second problem was a social aspect—the process of employment reductions stopped in 2015, and approval was given to financing increased labour costs under the conditions of decreases in productivity and technical efficiency. The third problem is the energy balance, which, as of 2015, has pointed to the increasing dominance of electricity consumption over its output, with the current deficit reaching the level of 6.5%. Hard coal, despite its decreasing share, generates 45.0% of electricity (lignite—24.5%), and in relation to the installed capacity, 50.4%. Moreover, hard coal accounts for 71% of heat output and 61% of combined heat and power generation, which represents nearly 60% of primary energy (lignite—17.5%).

The 2018 coal mining programme (PGWK) was the first one after nearly 30 years of the restructuring process to anticipate not only a gradual reduction in coal output but also its phase-out. The programme was updated in 2022 as a result of the verification of forecasts (a downward adjustment) and the postulated compliance with PEP 2040 goals (developed in 2021). PEP 2040 assumes a reduction in the share of coal (hard coal and lignite) in electricity generation from 68% in 2020 to 56% in 2030, and to 28% in 2040. It implies a reduction in the use of hard coal in electricity generation from 36.2 Mg in 2020 to 26.4 Mg in 2030, and to 19.1 Mg in 2040 (−47.2%). It is the base scenario, while a scenario which takes into account further increases in the prices of EU-ETS emission allowances anticipates a reduction in the share of coal to 11% in 2040, accompanied by a reduction in the use of hard coal to 11.1 Mg in 2040 (−69.3%). In addition to a reduction in the use of hard coal in energy generation, PEP 2040 assumes a reduced demand of industrial plants, the heating industry and small consumers mainly as a result of the increasing share of renewable energy sources (RES) (an average annual increase of 22% in 2015–2020). Ultimately, the equivalent of the PEP 2040 base variant in PGWK assumes the coal output at the level of 52.9 Mg in 2030, and 40.9 Mg in 2040. It can be concluded that the PGWK plan is not realistic, which is confirmed by the PEP 2040 variant with increased EU-ETS prices and long-term coal output projections (coal phase-out at the end of 2038, not in 2049). The process can be accelerated by an increasing share of RES and easier access to small modular reactors (SMR). Third, the programme of

government subsidies for coal mining has been submitted to the European Commission (EC). Considering the energy transformation schedule and a decreasing demand for coal, the EC is not likely to give its consent beyond the year 2035. This may result not from the Commission's unfavourable attitude but the lack of rational arguments on the part of the Polish government. PGWK is not compatible with PEP 2040—PEP 2040 goals will be achieved, but coal phase-out will take place sooner than anticipated by PGWK.

The energy sector faces the following challenge: a reliable alternative source of energy (mainly nuclear power stations) will be available in 15–20 years, and the necessary outlays in this area are estimated at more than bn PLN 500. These are among the reasons for delays in coal phase-out programmes until 2049, which also implies subsidising at the level of at least bn PLN 321. This coincides with the end of the period of stable energy generation based on lignite after 2030, and the end of the functioning of coal-energy groups by 2040/2045. The prolonged mining of hard coal and lignite necessitates the investments of approximately bn PLN 100 until 2030 (new deposits and coal mine modernization—bn PLN 40; new lignite deposits—bn PLN 10; and power stations—bn PLN 50).

Each study has certain limitations, and the intention is to reduce them at the stage of design, construction of methods and research procedure. First, it should be pointed out that there is no problem of generalization of identified regularities for the conducted research. This is due to the fact that the research was carried out on all coal mining enterprises operating in Poland and included in public statistics (no problem of representative sample). In addition, the research covered a full time horizon, from the beginning of economic transformation in Poland and the beginning of the restructuring of coal mining enterprises, through today, to the end of planned coal mining. The limitation for study research is the method used. The literature review provided a conclusion that restructuring has multiple dimensions and levels. There are many postulated approaches to measuring the effects of restructuring, but mostly as many single measures. Moreover, most often, only financial results and value measures are used, which is a simplification. The core is the measurement of economic results, especially productivity and effectiveness. This purpose is fulfilled by the author's original multi-factor measure of restructuring (it combines eight factors and four partial measures). Of course, a different method may produce different results, but it can be hypothesized that the general parameters and trends would not differ significantly.

The presented results of the research study assess the restructuring of the coal mining industry from a quantitative perspective, based on unbiased economic measurements; second, they represent a comprehensive picture based on a multi-dimensional approach; third, they refer to a long-term analysis, comprising the entire period of changes and the entire period of forecasts until the coal phase-out programme. The existing relations between the mining of coal and energy generation set directions for further research. Future analyses include an overall assessment of the restructuring of electricity and heat-generating companies (power stations and heat-generating plants: "district heating plants"), allowing for a combined evaluation of the entire fuel–energy sector.

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