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Review

Review of Research on the Impact of Changes Resulting from the Hard Coal Mining Sector in Poland on the GDP Value

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Abstract: Energy transition is one of the main objectives of the European Union. Significant changes will mainly affect countries in which significant modifications will have to be made to their energy sources. The process will involve high investment in infrastructure and additional costs of the transformation, such as reduced production (which may affect the GDP value) in the economic sectors involved in the process. The aim of this article is to provide the energy transition community, namely the national economy in general and those involved in planning for structural change in particular, with the key lessons and challenges in researching the impact of production changes in the mining sector. This article also shows the relevance of the mining sector in the economy. Within this area, particular attention is given to the following issues: the impact of economic sectors on the country's GDP (gross domestic product); the identification of key sectors of the economy using the input–output method; the contribution of coal mining and the mining industry to Poland's GDP; an analysis of changes in the structure of Poland's economy using the input–output method; and the use of the input–output method in the context of changing/reducing the supply of economic sectors.

Keywords: hard coal mining; GDP; input–output method; share of mining in GDP; mining in national economy

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1. Introduction

According to the International Energy Agency (IEA), the total coal reserves were around 880 billion metric tons (Mg) in 2020 globally, with the largest coal reserves located in China, Russia, the US, India, and Australia. Coal reserves are known coal resources that can be mined using current technologies and distributed in global fuel markets at market prices. Coal stands as one of the most critical energy sources globally, and it is predominantly used for electricity and heat generation. However, its combustion emits substantial amounts of carbon dioxide (per GJ), contributing to climate change and global warming [1]. Many countries worldwide are increasingly emphasising the development of renewable energy sources while aiming to reduce coal usage [2,3].

The specifics of underground mining companies primarily lie in the fact that companies transform useful minerals extracted from deposits to a usable form for direct placement in the market [4]. In general, mineral deposits are owned by the government state, and the legal framework governing their exploitation is determined by mining law and geological dependencies. Enterprises and mining plants are subject to the mentioned laws and several mining regulatory acts. Compliance with these laws implies extensive obligations for mining companies, which are greater than those in other sectors of the economy.

The coal mining sector has been the cornerstone of Poland's raw material economy and has remained one of most important industrial sectors for a long time. Poland has been consistently ranked among the top European Union (EU) countries in coal production for several years [5,6]. Poland has also been an important exporter of coal in the European market for years [7,8].

In that context, it is also crucial to analyse coal's role in the industrial revolution, as argued in references [3,8–11].

The significance and contribution of the coal mining industry in shaping the country's economy largely depend on the specific macroeconomic indicators that are directly associated with it. These primarily encompass domestic investment, foreign investment, export, net foreign trade, government revenue, gross domestic product (GDP), employment, and wage levels [12].

Consequently, the magnitude of the economic contribution of mining hinges on various factors, such as the value of production and the payments to productive factors (including subsidiaries indirectly engaged in production). Factors contributing to inputs encompass payments for goods and services supplied to the mining sector, worker salaries, interest payments on loans, and dividends that mining companies must remit (to either domestic or foreign shareholders, each carrying its own significance). This remittance can be seen as a reward for the risks associated with investing in the long-term assets of the mining industry.

2. An Analysis of the Current State of the European Mining Industry

In recent years, the European Commission has implemented several climate laws and regulations that require translation into specific targets for individual EU member states. The documents introduced by the European Union outline targets for reducing air pollution, particularly focusing on carbon dioxide emissions. In the case of Poland, the coal mining industry stands out as the primary contributor to this pollution.

The targets outlined in the climate and energy package for 2030 aim to reduce greenhouse gas emissions by at least 40% compared to the 1990 levels, with a broader plan to achieve an 80–95% reduction by 2050. However, the European Union's communication, titled 'A more ambitious climate target for Europe by 2030—Investing in a climate-neutral future for the benefit of citizens' [13], anticipates a substantial increase in these limitations. The revised targets aim for a minimum of 55% in greenhouse gas emission reductions across the EU economy by 2030 compared to the 1990 levels.

Considering the above, it can be concluded that the future of coal mining heavily depends on internationally adopted environmental regulations that directly and indirectly affect the sector, particularly policies aimed at decarbonising the economy. By assessing the long-term impact on the sector, specific regulations which also impact Poland's largest consumer—the power sector—are anticipated to wield the most significant influences on coal mining:

- Directive 2003/87/EC of the European Parliament and of the Council is establishing a scheme for greenhouse gas emission allowance trading—(so-called ETS Directive) and Directive 2009/29/EC of the European Parliament and of the Council is streamlining and extending the Community emissions trading scheme [13].
- Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions (the so-called IED) [14], which replaced, inter alia, Directive 2008/1/EC of the European Parliament and of the Council concerning integrated pollution prevention and control (the so-called IPPC Directive) [15], and Directive 2001/80/EC of the European Parliament and of the Council focus on the limitation of emissions of certain pollutants into the air from large combustion plants (the so-called LCP Directive) [16].
- Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 focuses on the promotion of the use of energy from renewable sources [17] (the so-called RES Directive), amending and repealing Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources [18].
- Directive 2006/32/EC of the European Parliament and of the Council focuses on energy end-use efficiency and energy services [19].
- Directive 2014/94/EU of the European Parliament and of the Council focuses on the development of alternative fuel infrastructures [20].

Understanding and complying with EU legislation is crucial for businesses and industries operating within its member states. It often necessitates adaptation, investment in new technologies, and occasionally restructuring to meet the standards set by these regulations. Furthermore, the interpretation and implementation of these laws within individual countries can have distinctive effects on their economies and industries. The influence of EU legislation on the national economy and its various sectors is extensively explored in the works of [19,21].

At the EU level, a set of regulations known as the European Green Deal has been adopted. Within the framework of the European Green Deal, EU member states have committed themselves to achieving climate neutrality by 2050, aligning with their obligations under the Paris Agreement. This comprehensive package comprises policy initiatives aimed at guiding the EU toward an ecological transformation, ultimately leading to climate neutrality by 2050. Launched by the Commission in December 2019, this initiative encompasses a range of measures, including the 'Fit for 55' package, the European Climate Law, and the EU Climate Change Adaptation Strategy [22].

The provisions outlined in the aforementioned directives are consistently transposed into national legislation. The state wields influence over the development and formation of the national economy, primarily through the government's economic, industrial, and raw material policies. While economic policy can be defined in various ways [21,23], in this context, it refers to the intentional actions and decisions made by government institutions—both at the national and local levels. These actions are purposeful, aiming to align with established goals and principles, with the intention of actively influencing real economic processes and outcomes [24,25]. According to Dorożyński and Świerkocki [26], industrial policy encompasses any type of policy that influences the shaping of a country's economic structure.

Among the most significant legislative enactments by the Parliament of the Republic of Poland concerning the country's economy is the Energy Policy of Poland [27,28]. The Energy Policy of Poland until 2040, referred to as PEP2040, stands as one of the pivotal legislative frameworks in the country, delineating the path for Poland's energy transition. This document provides strategic insights into the selection of technologies aimed at establishing a low-carbon energy system. PEP2040 serves as a crucial contribution to implementing the Paris Agreement, ratified in December 2015 during the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21). Its focus lies in achieving a fair and solidarity-based transition.

Moreover, it constitutes a national commitment to realising the European Union's climate and energy policies. This document recognises the magnitude of challenges in aligning the national economy with the EU's regulatory environment, encompassing the 2030 climate and energy targets, the European Green Deal, the COVID-19 pandemic recovery plan, and the pursuit of climate neutrality. PEP2040 aims to ensure energy security while enhancing the economy's competitiveness, promoting energy efficiency, reducing the energy sector's environmental impact, and optimising the utilisation of domestic energy resources. The performance indicators used to measure the achievement of these objectives can be found in [29].

The introduction of the PEP2040 document has sparked numerous protests from social groups, with a surge in public opposition, especially from representatives of coal mining trade unions opposing the closure of mining operations in the country. It is essential to consider this issue from a global perspective. Notably, one of the primary reasons for the closure of domestic mines is the need to align with EU policy, and consequently, with Poland's Energy Policy.

It should be emphasised that supporting and subsidising the mining industry and unprofitable mines is not in accordance with EU nor national laws. Consequently, the profitability of extraction continues to decline, and the debts of mines keep growing [30]. As a result of the growing negative sentiment, the national authorities entered into talks with representatives of the coal mining industry, resulting in the signing of the Social

Agreement on the Transformation of the Coal Mining Sector and Selected Transformation Processes of the Silesian Voivodeship in May 2021 [31]. The agreement includes mutually agreed provisions on the financing mechanism for companies in the hard coal mining sector, wage indexation, rules for the construction and implementation of so-called clean coal installations, the establishment of a special Silesia Transformation Fund, employment guarantees, and a social benefits package for employees of decommissioned production units. In accordance with the bilaterally signed document and in collaboration with trade unions representing the interests of miners, the Polish authorities have set a date for the end of hard coal production in individual mines in Poland. Ultimately, the cessation of mining operations was established for the end of 2049. According to the preliminary schedule of transformation of the hard coal mining sector attached to this agreement, the mine closure plan is shown below (Figure 1).

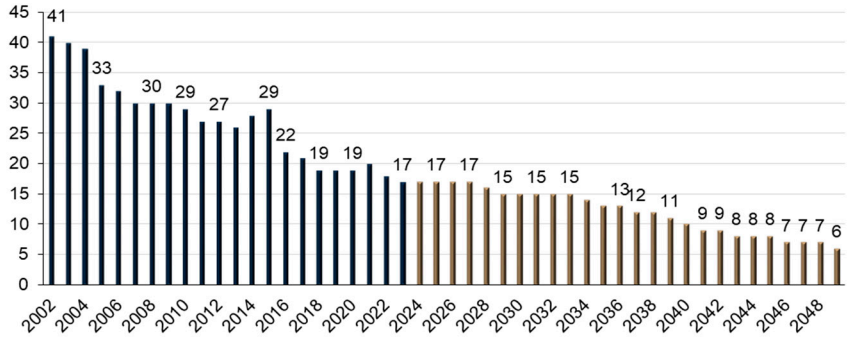

Figure 1. The number of mines in line with the forecast for the transformation schedule of the coal mining sector in Poland. Source: The authors' own elaboration based on [32].

It is notable that delays in mine closures persist due to the continuously evolving geopolitical situation, primarily influenced by the conflict in Ukraine, a neighbouring country to Poland. The subject of coal mining decommissioning and remediation options has been extensively discussed by numerous scholars, as noted in references [24,28]. Over the years, the Polish government has initiated several actions to restructure the country's mining sector. Scholarly literature also delves into the ramifications of these restructuring efforts on the condition of the sector and its mines [32–38].

The coal mining industry involves various companies that provide essential services and products that are crucial for its operations, commonly referred to as mining-related companies. These entities include manufacturers of mining machinery and equipment, as well as research and development institutions specialising in mining-related fields [35]. In addition to supplying materials, these companies engage in research and analyses, actively supporting advancements in mining operations. Therefore, it is evident that the mining sector not only extracts resources but also serves as a supplier to other segments of the economy. Consequently, the decision to either maintain or discontinue domestic coal mining holds substantial significance for the functioning of the Polish economy.

The Polish mining sector faces numerous challenges due to its continuously shifting operating conditions. Given the current circumstances, the sector's future closely hinges on international-level solutions, particularly in environmental regulations that directly and indirectly influence the industry. This notably encompasses policies aimed at decarbonising the economy.

Aligned with the European Union's directives on the transformation of the energy sector, member states, including Poland, are undertaking various measures to achieve climate neutrality by 2050. National policies have set a trajectory to decrease reliance on fossil fuels, including hard coal and lignite. For Poland, maintaining its position as a primary producer of critical raw materials, such as coking coal and copper, within the European Union is crucial. The EU Parliament is consistently developing a comprehensive policy through a framework termed the European Critical Raw Materials Act [36].

The reduction in coal mining or the transition away from coal is not only evident in Poland, but also in other European countries. Figure 1 shows that many countries reached their peaks in mining years before Poland. Belgium, for instance, ceased mining its own reserves in 1992 and has not had active coal mines since then. The cessation of coal mining in Belgium in 1992 has led to a transformation of former mining facilities into brownfields with new public utility functions [37]. Interestingly, the decline in or abandonment of mining in countries like the UK, France, and Belgium (as depicted in Figures 2 and 3) did not result in GDP declines.

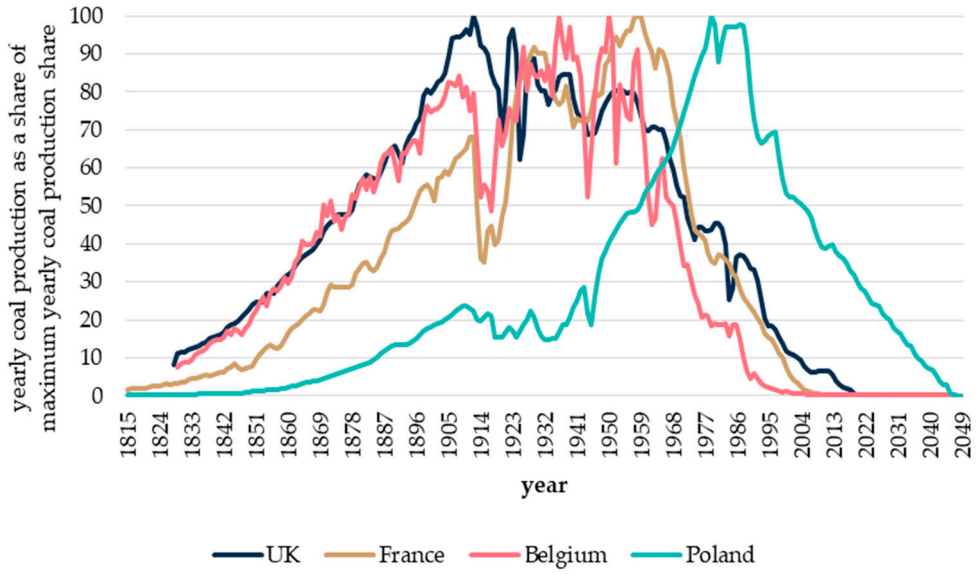

Figure 2. Peaks of coal mining in member states, %. Source: Graph was compiled on the basis of "wysokie napięcie" 2023.

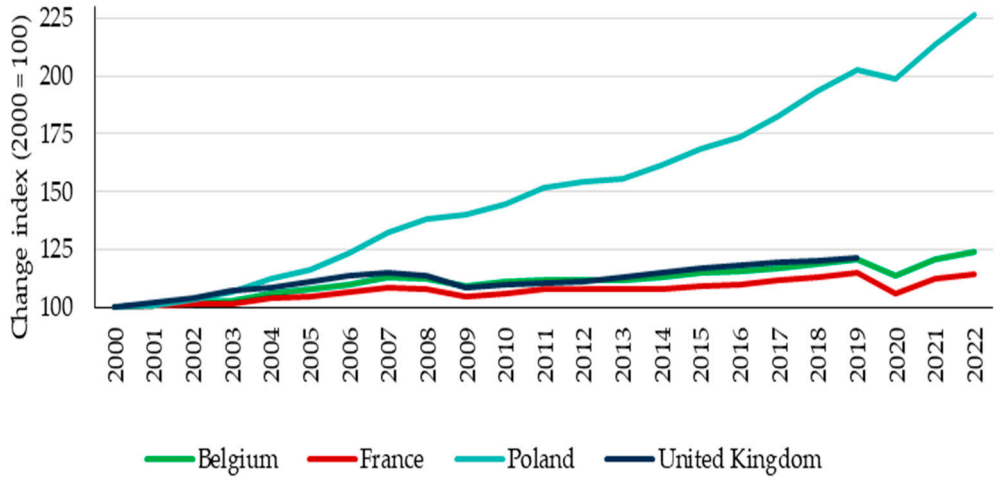

Figure 3. Change in GDP in countries, %. Source: Authors' own elaboration based on https://www.statista.com, accessed on 1 December 2023.

However, when examining the situation in Poland, it is crucial to acknowledge its unique circumstances due to the scale and significance of the mining sector in its economy. Coal mining stands as one of the pivotal economic sectors in Poland, employing a considerable workforce. Moreover, the country's electricity production has long been reliant on this raw material. Consequently, transitioning away from coal becomes an intricate and complex process, necessitating comprehensive plans for a sustainable transformation of the sector and the creation of new employment opportunities for those engaged in mining.

The implementation of a sustainable energy transition strategy becomes paramount for Poland to avert sudden or enduring impacts on the economy. One potential reason for negative economic effects could be the shift to imported raw materials, which may compromise energy security and redirect resources away from the Polish economy to other countries.

The purpose of this article is to provide a detailed analysis of the literature on the impact of changes resulting from energy transformation on the hard coal mining sector in Poland with a particular emphasis on its effect on the GDP value.

3. Materials and Methods

3.1. The State of Research in Analysing the Impact of Coal Mining on GDP Formation Using the Input–Output Method

The aim of this chapter is to present the current state of knowledge on the impact of coal mining on GDP formation through the input–output method and related studies. Mathematical modelling often serves to study economic sector impacts on a country's overall economy; this chapter will also highlight current research in this area.

Šmid [38] defines an economic sector as the sum of enterprises producing goods or offering similar services. Runge A. and Runge J. [39] developed a classification outlining three primary sectors of the economy:

The first (agricultural) sector includes agriculture, forestry, hunting, fishing, and extractive industries.

The second (industrial) sector comprises manufacturing, mining, and construction.

The third (service) sector encompasses services broadly, divided into tangible services (related to products, object repairs, and physical object generation) and intangible services (not resulting in direct physical products, including activities such as education, healthcare, finance, and cultural services).

The analysis of the literature encompassed papers published in peer-reviewed journals and monographs spanning from 1956 to 2023. Selection criteria included relevance to the research topic, methodological quality, result relevance, and alignment with the analysis objectives. The process involved eliminating duplicates, assessing abstracts and content, and considering relevance to the research context, leading to the classification of the analysed articles into five primary research streams (as shown in Figure 4). Both international and national journal publications were examined.

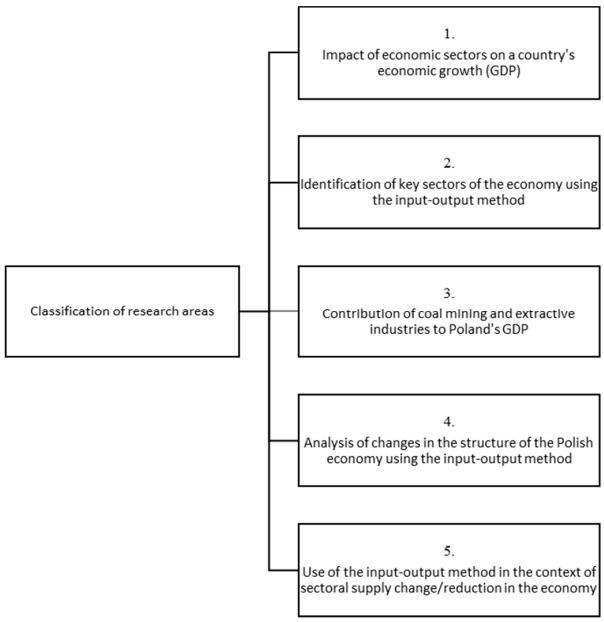

Figure 4. Classification of research areas. Source: Authors' own elaboration.

In Poland, each sector aligns its activities according to the Polish Classification of Activities (PKD), comprising 21 sectors, with each one encompassing activities, groups, classes, and subclasses with specific scopes and natures [32,37]. Each economic sector significantly contributes to GDP creation, thereby impacting the country's overall GDP. The influence of individual economic sectors on the nation's economy is extensively discussed in the global literature.

Within the specific areas identified in the literature, a keyword search was carried out as follows:

- Impact of economic sectors on a country's economic growth (GDP)—keywords used included economic sector, GDP, economic growth, impact of sectors on GDP, impact analysis, macroeconomics, changes in GDP by sector, and growth rate associated with sectors;
- Identification of key sectors of the economy using the input–output method—keywords used included input–output method for sector identification, sector identification, key sectors, branch analysis, cross-sectoral linkage analysis, key industries of the economy, and assessment of strategic economic sectors;
- Contribution of coal mining and extractive industries to Poland's GDP—keywords used included coal mining, analysis of the contribution of sectors, role of extractive sectors, extractive industries in GDP, impact of mining on Poland's GDP, contribution of extractive sectors to GDP, contribution of extractive sectors to Poland's GDP, importance of coal mining to Poland's economy, analysis of the contribution of extractive sectors to GDP, and structure of Poland's economy and contribution of mining to GDP;
- Analysis of changes in the structure of the Polish economy using the input–output method—keywords used included structure of the economy, Poland, analysis of changes, input–output method, evolution of the structure of the economy, sectoral changes in Poland, and intersectoral analysis of the Polish economy;
- Use of the input–output method in the context of sectoral supply change/reduction in the economy—keywords used included input–output method, sectoral supply reduction, sectoral supply change in the economy, cross-sectoral flows, analysis of the impact of supply change, effects of supply change on the structure of the economy, cross-sectoral balance, effects of sectoral supply reduction on other sectors of the economy, assessment of changes in the supply of sectors of the economy, and dynamics of supply change versus economic structure.

3.2. Summary

A review of studies in the literature that are relevant to the scope of the intended research yielded the following conclusions.

The work identified 110 scientific articles published in peer-reviewed scientific journals in the following research areas:

- Impact of economic sectors on a country's economic growth (GDP)—45 articles;
- Identification of key sectors of the economy using the input–output method—25 articles;
- Contribution of coal mining and extractive industries to Poland's GDP—25 articles;
- Analysis of changes in the structure of the Polish economy using the input–output method—6 articles;
- Use of the input–output method in the context of sectoral supply change/reduction in the economy—10 articles.

4. Results of Review Analyses

4.1. The Impact of Economic Sectors on the Country's Economic Growth (GDP)

Empirical research in the literature has shown that the extractive sector has been seen as one of the key factors in the economic growth and development of many countries, such as China, which is the largest producer and consumer of coal in the world; Saudi Arabia, which is one of the largest oil producers in the world; and Australia, which has natural resources such as iron ore, coal, gold, and other mineral resources [38,40–45]. Raw

material resources provide low-cost access to important inputs in the production process, which can lead to increased employment and higher incomes [46], as demonstrated by Waters et al. [47] and Allcott and Keniston [45] on the example of oil and natural gas production in the United States. Furthermore, the importance of the geographical proximity of coal as a factor underlying the economic development of Europe during the Industrial Revolution was demonstrated by Fernihough and O'Rourke [48], who concluded that the availability of coal resources drove about 60% of the population growth of European cities between 1750 and 1900. The authors Fernihough and O'Rourke [9] indicated that access to coal became an important driver of regional economic development in the 19th century, showing a clear link between proximity to coal and urban growth after 1750.

In the analysis of the Polish-language literature, the authors examined various economic sectors within the context of Poland and the European Union. The agriculture sector, in particular, has been extensively discussed in several papers. Kondratowicz-Pozorska [49] delves into the impact of agriculture on economic growth, considering economic, social, and environmental dimensions.

According to the author, during the 2012–2014 period in highly developed countries, the share of agriculture in GDP creation was approximately 3%. The author highlights that, in Europe, there are several countries, including Germany, Switzerland, and the United Kingdom, where the share of agriculture in GDP fell below 1%, while in developing countries, it reached up to 50%. Sierra Leone is cited as an example.

The author underscores the importance of agriculture, but the work lacks calculations confirming the share of agriculture in GDP. Furthermore, there are no calculations provided for Poland in this context.

The income-generating role of agriculture in the countries of the European Union was also taken up in the work by Baer-Nawrocka and Kiryluk-Dryjska [50]. The internal determinants of the development of Polish agriculture are presented by Ziętara [51], where he points to the size of the share in Poland's GDP but also in other economies citing the Statistical Yearbook of the Republic of Poland for the 1996–2007 period [52]. The author describes agriculture as one of the important branches of the national economy; the share of agriculture together with hunting in the GDP in Poland was 3.7% in 2006, while in 1990, this share was 7.2%. In this publication, there is information stating that in highly developed countries, such as the United States, the share of agriculture in the GDP is below 1%. The topic of agriculture and its share in the GDP is also dealt with by other authors, such as Jarosz-Angowska [53], who indicates that the share of value added that is generated in agriculture in the gross domestic product of the European Union decreased from 2.3% to 1.5%, which is a decrease of 0.8 percentage points, between 2000 and 2012. The author also mentions that in the Eurozone, the rate of decline was similar, with the share falling from 2.4% to 1.7%, while in the United States, the share remained unchanged at 1.2%, and in China, it decreased from 15.1% to 10.1%. The largest rate of decline was observed in India, a developing country, at 5.5%. The author shows changes in the share of agriculture in the economy of the European Union against the background of the United States, Japan, Brazil, China, and India between 2000 and 2012. Similarly, in the work by Chudzik [54], the author, assessing the share of the agricultural sector in global production, indicates a clear decrease in its share of global production in the national economy and a decline from 8.7% in 1995 to 4.2% in 2006. Another example can also be the share of tourism in the GDP indicated in the article [55], which, based on data from the World Travel & Tourism Council [56], reports that the value of the GDP generated by the Polish tourism industry in 2015 was PLN 30.14 billion. In contrast, the entire tourism economy generated as much as PLN 77.91 billion in 2015. The author points out that between 2005 and 2015, the size of the share of tourism in the national GDP did not always show an upward trend, while the largest increase was recorded in 2007—an increase of 12.99%. He also continues by stating that the following year, on the other hand, saw the most significant declines in the period under study—by 7.36% and 5.28%, respectively. Since 2011, the GDP generated by tourism in Poland was successively increasing, while in 2014, there was again a decrease. Similar

considerations are made by Marciniuk-Kluska [57]. The contribution of construction to the GDP is indicated by Barburski [58], who, referring to the statistical yearbooks of the Central Statistical Office (GUS), shows the share of construction in Poland's GDP in the 1992–1997 period, and Łachańska [59], who, also citing data published by the Central Statistical Office in Poland, indicates that the share of construction in the GDP in the mid-1990s was around 6%, and between 2000 and 2004, it decreased from 6.9% to 4.9%, while in 2008, it was 6.7%. Chrzanowska and Zielińska-Sitkiewicz [60] report that, in Poland, the share of construction in the GDP is around 8%. All of the above publications quantify the size of the construction industry's share of the country's GDP to show its contribution to Poland's economic growth.

An analysis of the causal relationships between oil and gas consumption and the value of the gross domestic product in Poland in the 2000–2009 period is presented by Lach [61]. The author concludes that changes in the level of oil and natural gas consumption had only temporary effects on the growth rate of the Polish economy in the analysed period. For this purpose, the author uses, among other things, the Granger causality test and bootstrap techniques. (A Granger causality tests is a statistical technique used to analyse causality between variables in a time series. This test assesses whether one time variable can predict or explain changes in another time variable [62]. This test is often used in economics to examine the relationship between various macroeconomic indicators, such as the GDP, inflation, unemployment, stock market conditions, transport, and energy, among others (the bootstrap method is a method for obtaining robust estimates of standard errors and confidence intervals for scores such as the mean, median, proportion, odds ratio, correlation coefficient, or regression coefficient [63].)

The literature also contains articles addressing the impact of energy consumption volumes on the national GDP. Yang [64] applied calculations for Taiwan's economy; the author additionally examined the causal relationship between the GDP and several energy carriers, including coal, oil, natural gas, and electricity, using the Granger technique. He found bidirectional causality between the total energy consumption and GDP values. Calculations for Taiwan's economy were also made by Hwang [62]. The study by Kraft and Kraft [65], which is the first study that looked at the correlation between economic growth and energy demand, used data on the US economy for the period of 1947–1974. The authors concluded that there was a relationship between the above two factors. They indicated that an increase in national income resulted in an increase in energy consumption. A study of Poland, on the other hand, addressing the impact of energy consumption volumes on the GDP, can be found in the publications Gurgul and Lach [66,67], which aimed to analyse the causal relationship between the total energy consumption in the Polish economy and the GDP value using the Granger causality test and bootstrap techniques. The results obtained by the authors led to the conclusion that energy consumption was related to the change in the GDP in Poland over the past decade. In addition, there was also a finding that there was a two-way long-run Granger causality relationship between employment and the GDP. There was also some evidence of a short-run effect of employment on the GDP. Furthermore, the authors state that energy consumption was an indirect causal factor for employment, as energy consumption directly caused a change in the value of the GDP.

A topic of significant popularity is the role and contribution of the tourism sector to the gross domestic product, which is presented here, among other articles, such as those by Ali [68], Cristian [69], Sofronov, [70] and Manzoor et al. [71], which cite WTTC 2018 [72], showing that in the South Asia region, the tourism sector's share of the GDP was 8.9% in 2017, with a projection of growth until 2028, in which it is forecasted to contribute 9.0% of the GDP. All of the above studies are based on publicly available data; no detailed calculations of the GDP share of an economic sector are conducted here.

An attempt was made by Masood et al. [73] to estimate the size of the agricultural sector's contribution to the GDP; they calculated the value of the agricultural sector's contribution to the GDP of Pakistan's economy for the period of 1975–2012. The least squares method was used to estimate the parameters of the model. (The least squares

method involves fitting a straight line to a point cloud in such a way that the sum of the squares of the differences between the actual and estimated values is as small as possible. In other words, it is used to make the determined straight line run as close as possible to each of the points on a scatter diagram [74].) For this purpose, the study considered several variables such as agriculture, industry, trade, and the GDP of Pakistan. The results of the study showed a positive and significant relationship between the GDP and agriculture in Pakistan. For the same case study, Nazish et al. [75] investigated whether there is a long-term relationship between the independent variables (which are agriculture, manufacturing, and services) and the dependent variable (which is Pakistan's GDP growth). They used secondary data and applied Johansen's multivariate cointegration technique. (The Johansen method is increasingly included in computer packages as a typical part of a time series analysis. However, it should not be applied mechanically. A very important step in the study of cointegration by the Johansen method is the proper specification of the vector-autoregressive model. The further part of the study, i.e., the examination of cointegration relationships, can be performed automatically, but the reliability of the results depends precisely on the preliminary step [76]). The results of the study suggest that all independent variables significantly affect Pakistan's annual GDP growth. In conclusion, the analyses conducted in the work indicate that the agriculture sector is one of the most important sectors of Pakistan's economy. Anthony [75] presented an analysis of the contribution of agriculture to Nigeria's GDP. Economic growth and the impact of specific sectors that most significantly shape the dynamics of change is an area of intense research. An example is the position taken by Pradhan et al. [76]; this article presents an empirical study of the relationship between financial sector development and economic growth in six South Asian countries over the 1972–1994 period: Bangladesh, India, Pakistan, Sri Lanka, Nepal, and Butan. The authors use various indicators of financial sector development, such as the size of financial intermediation, the depth of money and capital markets, the efficiency of resource allocation, and the stability of the financial system. They then test the direction of causality between these indicators and economic growth using the Granger test. The results from the causality analysis indicate that financial sector development causes economic growth. This article contributes to the literature on the role of the financial sector in economic growth. In a similar theme, these items persist in the studies by Rathinam et al. [77] and Singh et al. [78], which use the example of India, and the studies by Jalil and Ma [79] and Jalil et al. [80], which focus on Pakistan and China. The publications by Lavine [81] and Lawine and Law [82] use a range of literature examples to provide an analytical framework of the finance–growth nexus and then quantify the importance of the financial system in economic growth, similar to the calculations made by Christopoulos [83]. The model in the study by Berthelemy [84] also shows the importance of the banking sector, as is also mentioned by Beck et al. [85]. Sequentially, Xu [86] examines the impact of sustainable financial development on domestic investment and production in forty-one countries between 1960 and 1993. Greenwood and Smith [87] developed two models; the first looks at the role that financial markets—namely banks and stock exchanges—play in allocating funds to the most valuable uses in the economic system, and the second focuses on the role that markets play in supporting specialisation in economic activity.

The main objective in the publication by Aroca [88] was to measure the impact of the mining sector, mainly copper mining, on the Chile II region and to assess the conditions affecting the magnitude of this impact. Using an input–output matrix for the region, which the aforementioned author built independently, the impacts of copper mining on production, income, and employment in the region were calculated.

4.2. Identification of Key Sectors of Economy Using Input–Output Method

There are a number of studies in the literature analysing the identification of key sectors of the economy using the input–output method. The identification of key sectors is seen as a useful procedure for economic planning, especially in developing countries [89]. There are studies in the literature that focus on identifying relevant sectors, and the basis for

describing them has been set by earlier works, for example, the articles by Rasmussen [90], Hirschmann [91], and Chenery et al. [92]. The topic of how to approach the analysis of key sectors with reference to the most relevant sources in this topic is addressed in the publication by Gurgul and Lach [93]. In their article, Xesús Pereira et al. [94] propose an alternative to the Leontief method, which is used to identify key sectors based on the normalisation of the Leontief inverse; the authors use input–output tables from 2010 for Poland and Spain [95].

An example of the English-language literature on this topic is the article by Alcántara and Padilla [96], which analyses, from an input–output perspective, the key sectors that influence the volume of final energy consumption. Based on the assumptions and equations of the input–output method, the authors developed a methodology based on the impact of demand elasticity on the amount of final energy consumption. The publication by Alcántara and Padilla [96] proposes a method that is an extension to the method developed by Alcántara and Roca [97]. In the work of Alcántara and Roca [97], the 1995 input–output table estimated by Eurostat for Spain was used. The paper presents methods for estimating the energy demand and carbon dioxide emissions generated by different energy uses and for separating the different effects that explain changes in energy demand and carbon dioxide emissions. As reported by the authors, in contrast to previous analyses, they do not separate energy demand in terms of final consumption, but in terms of primary energy demand, and they do not treat the energy sector as an economic sector. The proposed method aims to find a vector that, for any quantitative unit of energy (such as electricity, petroleum products, and gas—expressed, for example, in kWh), gives the demand for different sources of primary energy. The paper uses this method to analyse the case of Spain from 1980 to 1990. The authors indicate that the key sectors in the Spanish case are transport, the chemical industry, and construction.

The role of transport, including rail, road, water, and air transport, in Korea's economy was explored using the input–output analysis method in the article by Lee et al. [98]. The transport industry has played an important role in Korea's economic development; according to the authors, transport accounted for about 3.0% of Korea's GDP. The article attempted to analyse the economic contribution of the use of the four modes of transport using an input–output analysis. The authors calculated the various economic effects of each mode of transport over the period of 2000–2010. These effects included output induction effects, supply shortage effects, price effects, backward linkage effects, and follow-on linkage effects. The authors found that road transport has the largest impact on the economy in terms of output, prices, and linkages, while rail transport has the smallest impact. To deal with the direct and indirect effects of supply constraints, a supply-based input–output model was developed. Based on the work by Davis and Salkin [99], the role of the agricultural and fisheries sector was indicated using the input–output method in the study by Lee and Yoo [100], who took into account both the supply and demand sides, but the impact on the economy was not shown through the GDP indicator and did not indicate the possibility of substitution. Additionally, the models shown are regional in nature.

Plaut [101] describes the relationship between the use of transport and communication services at the national level. The author points out that most transport and communication services are used by industry and not by households. This paper presents the results of a study on the relationship between the use of transport and communication services by industry in European Community countries. The author uses input–output tables for members of the European Community from 1980 to examine the correlations of transport and communication in different sectors of the economies of European Community countries on their basis. The relationship between transport and communication services was measured by estimating the correlation between the intensity of use of these two services in different industrial sectors in the economies of the European Community countries and the community as a whole. The Spearman correlation coefficients was chosen as the most appropriate measure. (The Spearman rank correlation coefficient is one of the non-parametric measures of the monotonic statistical relation-

ship between random variables. The coefficient is used to describe the strength of the correlation between two characteristics when they are measurable, when the study population is small in number, and when they are qualitative and can be ranked. This measure is also used to examine the relationship between quantitative characteristics when the number of observations is small. The Encyclopaedia of Management online access: https://mfiles.pl/pl/index.php/Wsp%C3%B3%C5%82czynnik_korelacji_rang_Spearmana, accessed on 19 December 2023).

The maritime industry contributes significantly to the Korean national economy, as highlighted in several studies, such as those by Kwak et al. [102] and Choi et al. [103], in which the I-O model was used to investigate the role of the maritime industry in the Korean national economy. The authors used input–output analysis to examine the role of the industry, with Kwak et al. focusing on the 1975–1998 period and Choi focusing on the 1995–2003 period. Kwak et al. [102] highlighted a two-sided view and an extension of the input–output model from both the demand and supply sides. The authors analysed the maritime sector by focusing on the linkages in inter-sectoral flows in successive years. The authors used data from input–output tables for the Korean economy prepared by the Bank of Korea. Kwak, Yoo, and Chang (2005) created a ranking of 32 sectors in the Korean economy in six input–output tables comparing the value of input–output year over year, drawing conclusions as to how the maritime industry ranked. Kwak et al. [102] did not take into account product substitution during the decommissioning of one economic sector. In addition, the authors did not address the impact of changes carried out within one sector on the GDP.

The input–output method was used in the analysis of the mining industry in the article by San Cristóbal and Biezma [104]. The authors calculated forward and backward linkage coefficients for Austria, Belgium, Denmark, Finland, Germany, Italy, the Netherlands, Spain, Sweden, and the UK. The article shows that three subsectors can be considered as key: coal and lignite mining and peat extraction in Germany; metal ore mining in Sweden; and mining and quarrying in Austria, Denmark, and Spain. As the authors conclude, these sectors are more driven by overall industrial growth than other sectors and have a greater impact on the national economy in terms of investment spending than other sectors. The forward and backward linkage values indicate that the mining and quarrying industry would show more stimulation from the output growth of the regional economy than other sectors. However, output growth in the mining and quarrying industry would not stimulate this regional economy more than growth in other sectors. Although the analysis concerned the European Union, the authors did not take into account the case study of Poland (despite the fact that Poland is the largest hard coal producer and the second largest lignite producer in the European Union [105]).

Authors Ivanova and Rolfe [106] and Lei et al. [105] concluded that coal mining can have a significant impact on the GDP, with the former highlighting the potential for economic impact at the local level and the latter emphasising industry's role in increasing fixed-asset investment and the GDP in China. Sitwell et al. [107] cautioned, however, that the impact of mining on the South African economy may not be as significant as previously thought, suggesting that the industry's potential to generate wealth and employment on a large scale may require further analysis. Al-Mulali et al. [108] further explored the relationship between coal consumption, CO_2 emissions, and GDP growth, finding a long-term relationship between the former and the latter, but no short-term or long-term causal relationship.

In another example analysed in the study by Sitwell et al. [107], input–output tables prepared by Statistics South Africa were used to analyse the impact of mining gold, platinum, titanium, chromium, manganese, vanadium, zirconium, phosphates, antimony, coal, and nickel on the economy and changes in the GDP of South Africa between 1971 and 1993. The authors combined all the tables into one, showing the magnitude of the flows they generate in intermediate flows and final demand. The authors concluded from their study that mining production and employment have not changed significantly over the years. They

presented the values of the dependence of one sector of the economy on another, showing the value of the technical coefficients for the Leontief matrix and preaching that there were few linkages between the mining industry and the other sectors of the economy in the case of South Africa. The results obtained in this study suggest that mining activities in South Africa will only increase their revenue and employment volumes in mining industries if commodity exports increase or if government policy documents are established, among other laws and regulations mandating increased cross-sectoral cooperation between the mining sector and other sectors within the South African economy.

There are also examples in the Polish-language literature of the application of input–output flows to identify the key sectors of the Polish economy. Olczyk [109] conducted an identification using input–output tables published by the Central Statistical Office in Poland for the years of 1995, 2000, and 2004. Olczyk cited two different methods she used to identify key sectors. The author used the Rasmussen approach [90], which made it possible to identify technical linkages between sectors. The sectors of electricity, gas, water production and distribution, transportation, and the chemical/pharmaceutical sector were selected as the top ranking sectors. The second method used was the Rasmussen weighted method, taking into account the role of sectors in value added creation and their share in final demand, in which the service sectors of construction and trade were identified as dominant in the ranking of the key sectors of the economy. The author stipulates that these results should be treated as preliminary, pointing out, at the same time, that in order to verify the theses presented in the paper, the latest techniques for identifying key sectors using the input–output method should be applied, among others, such as the extraction method (Dietzenbacher van der Linden's approach). (In the proposed extraction method, instead of extracting a single sector from a sectoral model, the effects of hypothetically extracting a region from a multi-region model are considered).

An analysis of the key sectors of the Polish economy on the basis of input–output tables prepared by the Central Statistical Office in the 1990–2000 period was carried out by Gurgul and Majdosz [110]. This research was used to conclude that the structure of the Polish economy is still characteristic of a centrally planned economy rather than a market economy. A modified approach to the analysis of key sectors, which extends the applicability of the traditional input–output methodology to the case of studying groups of countries based on the World Input-Output Database [111] covering the period of 1995–2011, is also proposed by Gurgul and Lach [112].

4.3. Contribution of Coal Mining and Extractive Industries to GDP

The issue of mining's contribution to the country's GDP has been addressed in several works listed below. As the topic of mining and quarrying is a broad one, the literature on this subject has been discussed from the general perspective—looking at the entire mining industry—to the specific perspective—focusing directly on coal mining. The topic of the importance of the mining industry in the energy structure of Poland was discussed in the articles by Gawlik and Mokrzycki [113] and Dubiński and Turek [114]. Most of the research conducted to date related to forecasting the role of coal and the size of its share in the national energy mix has focused on studies related to the use of coal in the energy balance structure source [114–116]. In the research on the mining sector, the topic of the environmental impact of coal in countries has been analysed in a number of examples in the literature—Poland is analysed by the authors of [116], the German case is described in [117], the case of the United States is described in [118], and the case of Australia is analysed by Valley et al. [119].

The impact of coal mining on GDP development in Poland is a complex issue. Al-mulali et al. [108] noted a long-term relationship between coal consumption and GDP growth, but they did not note a short-term causal relationship. Kopacz et al. [120] assessed the sustainability of the coal mining industry, noting limited improvements in the economic dimension. Jonek-Kowalska [121] focused on financial efficiency and labour productivity in Polish coal mines, providing insights into the management of the industry. The

research presented in the aforementioned items suggests that although hard coal mining has some impact on GDP development in Poland, this relationship is not straightforward and depends on various factors.

In reference [12], Ranosz numerically describes the role of the extractive industry, which is understood as the mineral production industry, in the economic development of individual countries. The author presents the percentage contribution to the GDP of twenty-one countries of the world in 2010. In his discussion, the author uses the Mining Contribution Index (MCI). The MCI is calculated based on the contribution of mining to the economy in a country. This index was developed as a measure of the extent of the mining industry's impact on the global economy. To determine the contribution of the mining industry to the economy using this index, the volume of mineral production for a given year, its change from previous years, and the volume of GDP of a country must be determined. The MCI is prepared as a part of the Role of Mining in National Economies report published by the International Council on Mining and Metals. According to the 2020 report, Poland ranked 32nd out of 183 countries in terms of the value of the MCI [122]. In the study, the author did not determine the share of coal mining in GDP, but determined the total mineral extraction industry in relation to various countries in the world.

Another example is the work by Kot-Niewiadomska [123], in which the author analyses the economies of the participating countries in terms of raw material resources as a part of an international project. In the countries listed, the size of the share of mining in the country's GDP is significant as follows: Australia—9% [124]; South Africa—8% [125]; and Canada—7% [126]. This study also mentions the US, where the share is low at 1.4% [127], and Japan, whose share ranges from 0.1 to 0.2% [128]. It should be noted that, as in the above-mentioned publications under the analysis of the third research strand, the share of mining covering all types of minerals was also taken into account here.

Only considering coal mining, items in the national literature include studies by Valley et al. [119] and Kopacz et al. [120], where the authors report that coal mining amounted to 61.86 million tonnes in 2019 in Poland and decreased to around 54.4 million tonnes in 2020 (a decrease of 11.7%). In contrast, the contribution of coal mining to the GDP is around 1%. This value is given explicitly by the authors in this publication. Thus, secondary data are also presented for the above publications.

In their publications, Jonek-Kowalska and ICMM [121,122] pointed out the relevance of the GDP as a measure of the size of the economy and indicated the share of fixed capital of industry and mining and coal mining in the fixed capital of the whole national economy in the 1995–2012 period. Under the term 'coal mining', the authors referred to hard coal and lignite mining. Observing the economic effects in the analysed period, measured by the volume of GDP generated, the authors indicated that the share of industry in Poland decreased from 25.06% in 1995 to 21.82% in 2012. On the other hand, the share of the mining and quarrying sector fell from 3.27% to 2.20% in this period. The authors based their analysis on national statistics reported in the Statistical Yearbooks of Poland. Thus, on the basis of secondary data, the authors not only determined the share of mining hard coal, but also of hard coal and lignite mining combined. The topic was also covered in his publications of Franik [129,130].

The main objective of the study by Gurgul and Lach [131] was to analyse the cause-and-effect relationship between quarterly domestic coal consumption (both hard coal and brown coal) in the Polish economy on the country's GDP. The authors also touched upon employment in the paper. Several econometric tools, such as the linear Granger causality test, and other tools such as the Toda-Yamamoto procedure, the Andrews and Buchinsky bootstrap algorithm, and the non-linear Granger causality test of Diks and Panchenko, were used to investigate the dynamic relationship between GDP, coal consumption (hard coal, lignite, and total coal), and employment in Poland. The calculations carried out for the period from Q1 2000 to Q4 2009 using the causality techniques confirmed the neutrality of hard coal consumption with respect to economic growth. On the other hand, the calculations for the lignite–GDP and total coal consumption–GDP pairs showed non-

linear causality from coal consumption to economic growth. This is clear evidence that lignite plays an important role in the economic growth of the Polish economy.

In the article by Aryee [132], the example of Ghana is given, and it defines mining as the activity of extracting any substance in solid or liquid form occurring naturally in or on the ground, on or under the seabed, or arising from or subject to a geological process, including construction and industrial minerals, but it does not include oil or water. This country is Africa's largest producer of gold and has abundant bauxite diamond and oil reserves [133]. The publication provides the results of an examination of the actual data of a sample of operating mining companies to determine how significant their contributions were and in which areas they made their contributions; secondly, a comparative review of the relative contribution of mining to some national economic indicators is conducted. According to the authors, the mining sector generates about 5.7% of Ghana's GDP. The analyses in this publication are based on the fees paid by mining companies in taxes and tributes to the national budget.

Jahanmiri et al. [134] adopted a heuristic approach to predict the contribution of the extractive sector to the growth of the gross domestic product index. For this purpose, information was collected from a database of 87 countries with mining activities, and the impacts of three parameters, namely the GDP value added, industrial production value per capita, and value added per capita, were examined using artificial intelligence. Selected techniques for applying artificial intelligence were used to estimate the contribution of coal mining to the GDP. A different proposition to the one that will be used in this paper was therefore applied. Based on OECD data, the authors indicated that the contribution of the mining sector to the GDP in Poland in 2017 was 0.7%.

Olalekan et al. [135] reported a case study of Nigeria. The contribution of mining to the GDP in Nigeria is 0.15 per cent. During the colonial period, coal and tin occupied high positions as sources of Nigeria's foreign exchange earnings, and after the country gained independence in 1960, other minerals such as limestone, gold, marble, clay, etc., were mined to a lesser extent, mainly for local consumption [136]. This country is an important case from the perspective of our country, as Poland is considering the possibility of importing raw coal from this country. The authors of the above-mentioned publication prepared an error correction model based on the assumptions that oil and gas, solid minerals, production, and agriculture determine economic development in Nigeria; proper exploitation and utilisation determine the outcome of extraction and production in all sectors; and there is no wastage of resources. The authors wrote an equation that shows the functional relationship between per capita income, value of oil and gas, value of solid minerals, value of production, and value of agriculture. Based on the trend analysis of the above-mentioned variables, the value of the impact on the GDP per capita was determined. The impacts of the components (value of oil and gas, value of solid minerals, value of production, and value of agriculture) on economic development (income per capita) in Nigeria were found to be 95.0% and 25.4% in both the long and short term, while the inaccurate components (error term) were found to be responsible for 4.9% and 74.5% of changes in economic development in Nigeria.

The mining industry, as defined by mineral mining in Tanzania, and its impact on the national GDP are described by Muganyizi [137]. Tanzania is rich in mineral resources with high economic potential. The mineral resources produced in the country include gold, diamond, coal, copper, silver, tanzanite, and other varieties of gemstones. The mining sector's contribution to the gross domestic product steadily increased from 1.4% in 1998 to 3% in 2008, but declined to 2.5% and 2.4% in 2009 and 2010, respectively. In terms of growth, the mining sector recorded double-digit growth rates for most of the period but experienced a significant decline between 2008 and 2010. Operationally, the gold sector continued to outperform the other sectors, although the revenue received by the government was below expectations, especially given the significant increase in gold production.

Turkey has a highly diversified mining industry, but it only accounts for 1.5% of the country's gross domestic product. In 2013, Turkey produced at least 53 different raw materials (including coal, ores, and industrial minerals) from 4500 deposits [138].

4.4. An Analysis of Changes in the Structure of the Polish Economy Using the Input–output Method

The fourth area analysed is the analysis of changes in the structure of the Polish economy using the input–output method.

In their publication, Czyżewski and Grzelak [139] present the ideas of the input–output model for macroeconomic assessments of the economy by taking into account the experience to date and formulating conclusions regarding possible future applications. A similar topic is examined by Kujaczyński [140], who presents the possibility of using input–output balances to assess changes in economic structures over long periods.

Input–output flows have been used to analyse changes in the structure of the Polish economy by Kudrycka and Górska [141]. The book presents the methodology and results of research on the impact of changes in the structure of the Polish economy on its growth and development in the years of 1975–1980. In this book, the authors compare matrices of direct input coefficients. Kudrycka and Górska draw attention to the problem of performing dynamic analyses and the resulting necessity of converting the input–output table into constant prices.

One of the sectors analysed using the input–output method in the work by Czyżewski and Mrówczyńska-Kamińska [142,143] is agriculture. This article deals with the structural changes of agribusiness in Poland in the context of integration with the European Union. The first part of the article examines the structure of supply to the agricultural sector and the structure of demand for agricultural products in the light of input–output tables for the years of 1995, 2000, and 2005. The analysis of the structure of material supply of agricultural production and demand for agricultural products was carried out using the input–output method. The authors analysed the structure of demand and supply; however, they did not use detailed calculations. They did not calculate the impact of sectoral changes in the agricultural sector on the country's GDP.

Staying on the topic of agriculture and the use of the input–output method, Mrówczyńska-Kamińska [144] presents the possibility of using input–output balances to determine branch interdependencies on the basis of selected indicators, i.e., the profitability, labour intensity, and profitability of the agri-food sector in the European Union countries in 1995, 2000, and 2007. The author calculates indicators of the profitability, labour intensity, and profitability of production in the food economy. The author indicates that input–output balances can be used to calculate input–output interdependencies, such as profitability, labour intensity, or profitability.

4.5. The Use of the Input–output Method in the Context of Changing/Reducing the Supply of Economic Sectors

The last topic to be analysed is the use of the input–output method in the context of changing/reducing the supply of economic sectors.

The input–output model, after a number of modifications, has also been used to model situations that require the determination of the sectorial output (supply) without determining final and intermediate demands. The issue of supply-side constraints caused by damage to production facilities has been addressed with a variant of the input–output model in the work of Davis and Salkin [99]. However, from later publications, we learn that the model by Davis and Salkin [99] was later modified by Steinback [145]. As reported by Leung and Pooley [146], Leontief's input–output model provides a basis for quantifying the backward multiplier effects of exogenous final demand shocks. In some situations, however, policy or uncontrollable factors induce exogenous changes in gross industrial production. Applying the Leontief method in such cases will lead to biased calculations of backward-looking economy-wide effects. To eliminate this bias, the author proposed a correction for the classical Leontief method based on output, which relates demand-driven Leontief

multipliers to exogenous production shocks. The output-based multipliers obtained in this study, however, only measure the short-run backward effects of predetermined changes in output. Forward linkages resulting from the interconnectedness of the exogenous sector(s) with the sectors to which they sell their products are not taken into account.

Reductions in the supply of economic sectors are also analysed in the context of reductions due to policy changes [147–149] or the depletion of raw materials, as is the case in the publication by Petkovich et al. [149]. Marcouiller et al. [150] also point to situations where the output increases due to regional changes in sectoral production or the reallocation of resource shifts between sectors of the economy, as in the case of the publication by Eiser and Roberts [151].

A supply-side approach in the case of rapid unexpected changes of a so-called shock in an input–output model was also used in the work by Ham et al. [152]. An inter-regional commodity flow model, including regional input–output relationships and corresponding transport network flows, was applied to assess the economic impact of an unexpected event such as an earthquake.

5. Conclusions

Major gaps were identified in the research area of the changes in the structure of the Polish economy using the input–output method, thus prompting the authors to undertake efforts to address these deficiencies. The authors embarked on work to address these deficiencies by exploring the research area of the impact of the coal mining sector in Poland using an input–output analysis.

Neither Polish literature nor the international literature in any of the currently available works use GDP share calculations that take into account all of the necessary components to calculate a specific GDP value. All of those mentioned use derived statistics or secondary data from published reports to compare the size of the GDP, to calculate the share of GDP, and to determine the importance of individual sectors to the GDP. However, these works lack detailed, stand-alone calculations of each of the components of the GDP, and there are no calculations for a separate branch of the economy such as thermal coal mining.

The input–output method has overwhelmingly been used to identify key sectors in economies using forward and backward linkages in time series, i.e., the impact of industries on each other in specific years. The input–output analysis offers the possibility of designating key sectors in the economy and is widely used in this respect. Different approaches and extensions of the Leontief method are used in the literature. Both the demand-side approach (the most popular) and models using the supply-side approach are used; however, no work to date has examined the supply of simultaneous change in input–output values.

There are currently no studies that address both the demand and supply sides of the Leontief model using the substitution of the economic sector in which we want to reduce supply by using the input–output method. In addition, there are no such studies of liquidation or substitution of the coal sector.

The input–output analysis work on supply-side changes focuses on the elimination of one raw material source or the elimination of an entire branch, none of which introduces the possibility of supply substitution and proposes a substitution methodology for equilibrium in the model.

Furthermore, there is no such analysis in Polish and foreign literature that gives a complete picture of the decommissioning of coal mining and its impact on the national GDP using the input–output method.

Despite the identification of articles that analyse the impact of the extractive sector on the national economy (on changes in GDP) using the input–output method, these are publications on forward/backward linkages, i.e., the identification of the impact of individual sectors in the flow matrix rather than an analysis of a specific branch prepared for the current year. It should be noted that the regional input–output matrices used by the authors in the publications cited above have been used often. In contrast, the extractive

sector in many of those indicated in this chapter is understood as the extraction of various types of raw materials. In addition, an input–output analysis often includes several to a dozen production branches.

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