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The Impact of Recent Crises on Kazakhstan's Mining Industry

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Abstract

The mining and quarrying industry is one of the main pillars of Kazakhstan's economy. According to the National Bank of Kazakhstan (2023), the industry accounts for about 15% of the country's GDP. Kazakhstan is source of 1.8% of the world's oil reserves. From FDI-perspective the EU is the largest investment partner. As a member of the Eurasian Economic Union dominated by the Russian Federation, Russia is also the major trading partner. On the other hand, the country has close ties with China as many transportation routes of the extractive East towards the consuming West pass-through Kazakhstan. In times of the COVID-19 crisis, the Russian-Ukrainian conflict and the intense focus on the dependence on natural resources and diversification of the supply portfolio, Kazakhstan has recently attracted increased international attention. The mining industry also faces the risk of additional sanctions from the EU and the USA. This article focuses on the impact of the recent crises on the mining industry of Kazakhstan. The source for the research on the mining industry is the country's foreign trade and foreign direct investment data. It also provides a forecast based on the country's strategy for the development of the mining industry in the coming years.

Keywords: *Kazakhstan, Mining, FDI, Sanctions.*
JEL Classification: E22, F51, L71, L72.

Introduction

Kazakhstan is among the world's leaders in terms of reserves of most types of mineral resources. The set of mineral resources that the country possesses is particularly rich, but also variable. In addition to rich and variable mineral resources, Kazakhstan occupies a geopolitical position favourable for the development of areas related to the exploration and trade of natural resources (Yasmin et al., 2020). Thus, exports of mineral products have long accounted for 80% of Kazakhstan's hard currency revenues (Bozhko, 2022). The metallurgical industry of the country is also significant, characterized by huge production capacities. The country ranks first in world reserves of zinc, tungsten and barite, second in silver, lead and chromates, and third in copper reserves (Petrosyan, 2023).

The Caspian region, of which Kazakhstan is a significant part, is a major hub for transregional projects due to its position at the junction of Europe and Asia (Hamidova, 2020). The energy-rich region, which plays a role as one of the hubs of transportation and communication links between Europe and Asia, is an important destination for investment from the world's leading economies, which further contributes to the development of Kazakhstan and, in particular, its mining and quarrying industry. The latter benefits significantly from this favourable position.

These factors have contributed to the rapid development of the mining and quarrying industry in the country and its transformation into one of the key pillars of Kazakhstan's economy. It is a key part of GDP, a major source of foreign investment in the country's economy, one of the most important aspects of the foreign trade, and a force to be reckoned with in the country's foreign relations. Thus, the mining and quarrying industry represents an important factor of strength for Kazakhstan. However, the changing international context has recently become a source of considerable challenges, first the COVID-19 pandemic that disrupted most segments of the industry, and then the conflict between Russia and Ukraine,

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and the ensuing set of sanctions. Secondary sanctions that could affect Kazakhstan's foreign trade are currently being discussed.

The purpose of this article is to assess the changes that have occurred in the Kazakhstan's mining industry in connection with these events. Although most of the consequences of these events are still difficult to evaluate, it is extremely important to study the state of Kazakhstan's mining and quarrying sector and the possibilities of its development in the new conditions.

Literature Review

A number of articles are dedicated to the study of the peculiarities of the mining sector and its role in the economy of Kazakhstan, as well as the current and potential state of the inflow of FDI in the country. Ashurov et al. (2020) conducted a study in the in the Central Asian Region, focusing on the determinants of Foreign Direct Investment in Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan. They emphasize the importance of FDI inflows for economic growth, in particular, for developing countries and state GDP growth, labor force, trade openness and optimized tax regulations as the most important factors in attracting FDI. Many authors point to the dependence of Kazakhstan's economy on the mining and quarrying industry as one of the risk factors and challenges for the country's future development. Yasmin et al. (2020) in their article on oil price and the relevance of economic diversification through reforms and policies in the Caspian Basin reflect on the significant dependence of the economies of the countries located in the Caspian Basin on natural resources in general. Bozhko (2022) focuses on how Kazakhstan's mining industry has responded to the challenges of 2022.

In particular, taking into account the problems associated with anti-Russian sanctions for metals and mining enterprises in Kazakhstan. The author emphasizes the vulnerability of the industry to fluctuations in the global economic and geopolitical situation and the need for Kazakhstan's mining enterprises to search for new markets to restore stability, as the country's economic situation is in direct dependence on the state of its mining industry. Isataeva et al. (2022) in their paper describe the transformation of the mining industry in Kazakhstan with a focus on international aspects. They also note the dominant importance of the mining industry for Kazakhstan, in particular in terms of attracting investment, emphasizing the need for greater optimization of state regulation of such an important industry and increased geological exploration to maintain its attractiveness for investors. Regarding the dynamics of FDI inflows from abroad, Mukasheva and Akhmedyanova (2023) describe the evolution of the bilateral partnership between the European Union and Kazakhstan. Having analyzed the PCA and EPCA, they note the evolution of cooperation between the EU and Kazakhstan towards more emphasis on trade, in particular, in the energy sector and human rights protection, and, accordingly, the development of one of Kazakhstan's key investment partners towards this particular industry. Also focusing of EU-Kazakhstan relations, Arupov and Otarbayeva (2020) identify the problems and prospects for investment cooperation between Kazakhstan and the European Union, emphasizing the dependence of investment inflows from the EU to Kazakhstan on price fluctuations in the energy sector.

Natural resources as a priority for EU investors, and exploring ways that Kazakhstan could use to optimize investment cooperation with the EU, in particular by directing EU FDI more towards manufacturing sector. Chinese investment into Kazakhstan is analyzed by Han Nai Chao and Adambekova (2023) in their article on Kazakhstan and China in the context of economic oil and gas cooperation. They emphasize the spillover effects of growing Chinese investment in Kazakhstan's oil and gas sector and, while noting the uneven development of Kazakhstan's economy with a focus on the oil and gas sector, note the positive impact of Chinese investment on the country's labour force, infrastructure, and social development.

Demeuov and Yesdauletova (2023) write about the current state and structure of foreign direct investment in the Republic of Kazakhstan. This is a study on the structure of FDI inflows to Kazakhstan, which also emphasizes the importance of FDI for developing countries, and, in the context of disruptions in FDI inflows in 2022, notes the problems associated with the high degree of orientation of FDI inflows to Kazakhstan towards commodity returns. Although diversification efforts have not yielded significant

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results, the current crisis could provide a strong impetus for development in this direction.

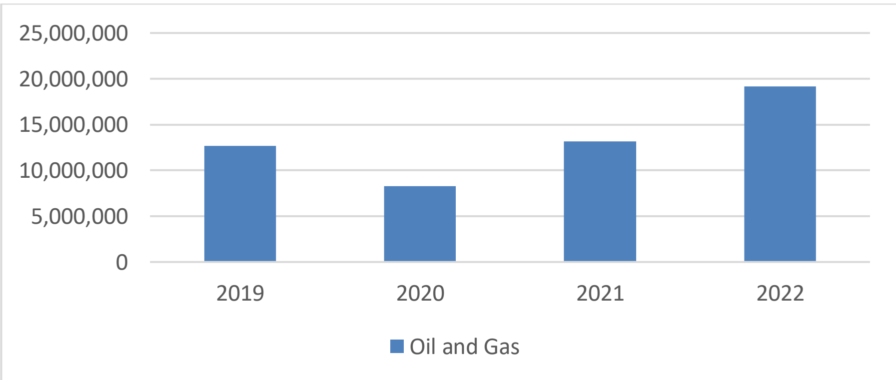
Key Characteristics of Mining and Quarrying Sector of Kazakhstan

Kazakhstan is rich in a variety of mineral resources, but the main ones, both in terms of production in monetary terms and export value, and reserves, is oil and gas. According to the National Statistical Service of Kazakhstan for 2022, oil and gas account for 71% of the country's total mining industry output (2023a, 2023b). They are followed by metal ore production, which accounted for 13% of mining and quarrying output, and the production of other ores (10%). By region, Figure 3 shows that the major part of mining and quarrying industry output is concentrated in the western part of Kazakhstan, mainly in Atyrau region (43% of total industry output in monetary terms), as well as in West Kazakhstan (14%), and in Mangystau (13%). This concentration is mainly due to the fact that most oil and gas reserves are located in the west of the country. As a result, more than half of the total volume of oil produced in Kazakhstan comes from the large western oilfields Tengiz, Karachaganak, Aktobe, Mangistau, and Uzen (Papyrakis & Parcero, 2022). Kashagan, Kalamkas and Zhetybai are also among the largest oil and gas fields in the country (Han et al., 2023).

Key Latest Dynamics in the Mining and Quarrying Industry

As for the dynamics of the Kazakhstan's mining and quarrying industry, the uncertainty left by the COVID-19 pandemic shock and the effects of the restrictive measures have been brought further by the new threat related to the 2022 conflict between Russia and Ukraine, and the ensuing international sanctions. However, despite these challenges, for now it can be stated that, although production of oil, gas, lead, and chrome ore showed a decrease in units 2022 compared to 2021, there has been no decrease in monetary terms. The development of production volumes was hindered by the challenging environment in 2022, but the monetary value of mineral production was maintained. This can be seen in Figure 1 and Figure 2.

Figure 1. Key Mining Products, Production in Money Terms, Oil And Gas, Tenge Million



Source: Author's calculation, based on Bureau of National Statistics, (2023a, 2023b)

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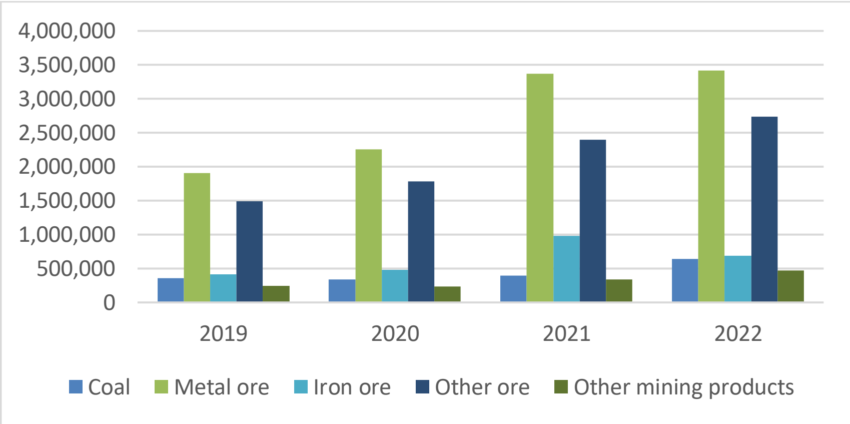
Figure 2. Key Mining Products, Production in Monetary Terms, Tenge Million



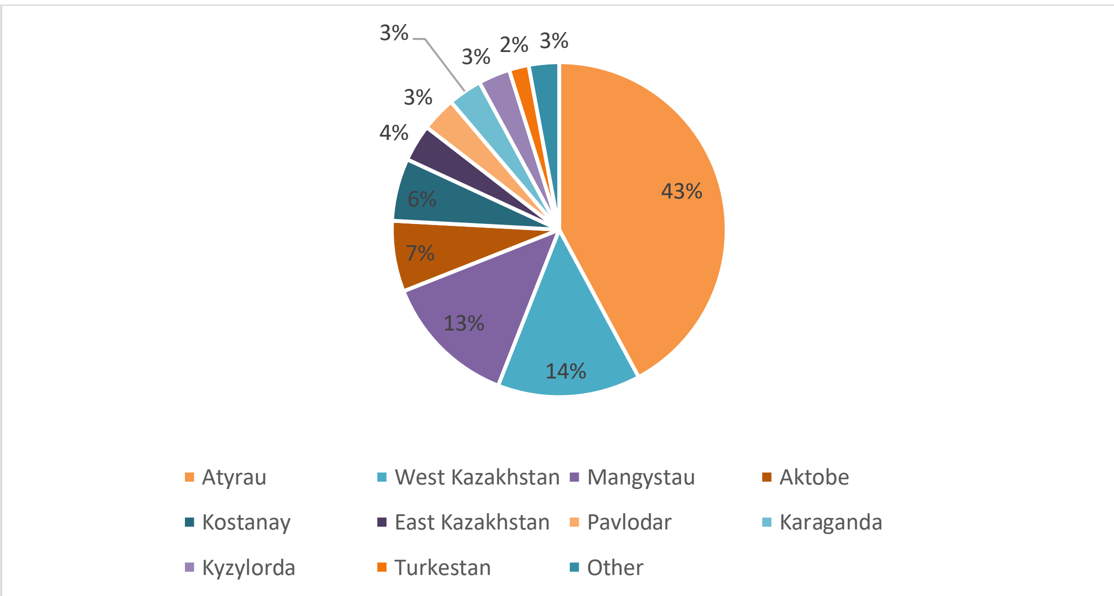
Source: Author's calculation, based on Bureau of National Statistics, (2023a, 2023b)

Trade volumes for most mining and quarrying products also continued to grow despite the challenging environment. Exports of fuels, non-metallic minerals, ferrous metals, copper, aluminum and zinc in monetary terms have maintained positive dynamics since 2020. Decreases can only be noted in exports of ores, in particular, iron ore due to problems in finding new markets alternative to Russia under sanctions (Bozhko, 2022), precious metals, and lead (Bureau of National Statistics, 2023c).

Kazakhstan's main export destinations have also remained largely unchanged: Russia ranked first, China second, followed by Italy, Turkey, South Korea and the Netherlands. Compared to 2021, the picture has not changed much: Russia and China still rank first and second, followed by Italy, the Netherlands, Turkey and Uzbekistan.

In 2022, Kazakhstan's mining and quarrying exports to Russia decreased. The largest decrease was in mineral products - by 28%, metal and metal products - 15%. However, this decrease was largely offset by an increase in exports to Italy, China, Netherlands, and Turkey.

Figure 3. Mining and Quarrying Output, Regional Participation, Ave. 2019-2021



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Source: Author's calculation, based on Bureau of National Statistics (2023e)

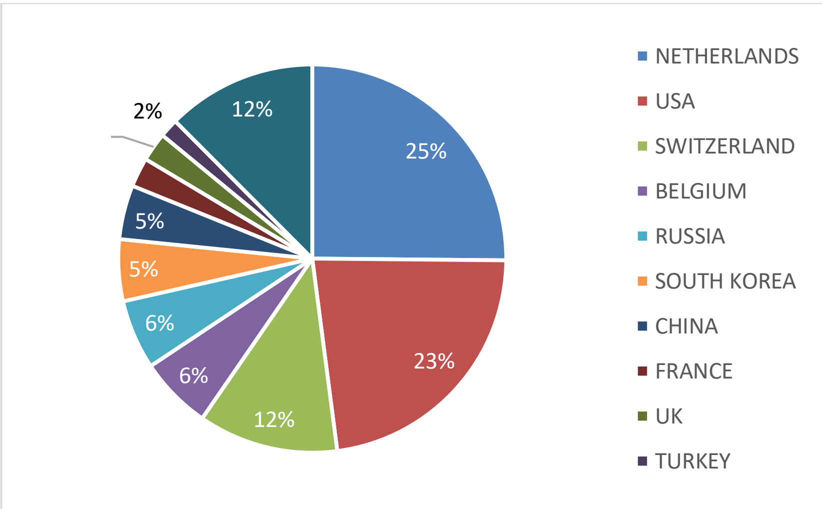
Foreign Direct Investments

The mining and quarrying industry is in many aspects one of the pillars of the economy of Kazakhstan. In terms of GDP produced, mining and quarrying accounted for approximately 14%-15% of the country's total GDP over the last five years, only decreasing to 12% in 2020 due to restrictions related to the COVID-19 pandemic (Bureau of National Statistics, 2023f).

In addition, mining and quarrying also attracts the largest amount of FDI entering the country. There has been a significant decline in its share of total FDI, from 56.12% in 2018 to 45.70% in 2022, but it still accounts for almost half of all investments entering the country (Arupov & Otarbayeva, 2020), (National Bank of Kazakhstan, 2023b). Foreign direct investment being one of the main ways of attracting capital (Ashurov et al., 2020) and technology diffusion, which is especially important for developing countries, such as Kazakhstan, lagging behind in ICT sector development and R&D volumes (Heim et al., 2023), requires special attention and a closer look at the trends and dynamics of their development in the country.

The structure of FDI directed to the mining and quarrying industry of Kazakhstan follows the rather unbalanced overall structure of the industry. Oil and gas extraction is by far the most attractive for foreign investors. Thus, in the first nine months of 2022, oil and gas industry accounted for 82% (USD 8.3 billion) of total FDI in Kazakhstan's mining and quarrying industry (Satubaldina, 2023). The coal and metals segment also shows some potential, but it lags behind the oil and gas industry. Regional distribution of FDI in mining and quarrying is also rather uneven: Atyrau region is the clear leader in this segment, with 32.2% of total FDI in Q1 2022 (Demeuov et al., 2023). Kazakhstan's three key oil and gas consortia - Tengiz, Kashagan, and Karachaganak - which together account for 65% of the country's oil and gas market, also attract the largest amount of investment. Figure 4 shows the major suppliers of foreign investment in Kazakhstan in 2022.

Figure 4. Key FDI Providers, 2022



Source: Author's calculation, based on National Bank of Kazakhstan (2023b)

Foreign participation in Kazakhstan's oil and gas sector is characterized by high concentration around a small number of very large players, including Royal Dutch Shell (UK-Netherlands), BG Group (acquired by Royal Dutch Shell, Eni (Italy), Lukoil (Russia), Rosneft (Russia), Chevron (US), ExxonMobil (US), CNPC (China) (Chakeeva et al., 2023).

The European Union has traditionally been Kazakhstan's number one investment partner. The positive dynamics of cooperation between Kazakhstan and the EU, in particular in the field of investment, found

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its legislative expression in the replacement of the Partnership and Cooperation Agreement (PCA) signed back in 1995, by the Enhanced Partnership and Cooperation Agreement (EPCA) signed in December 2015 and fully entering into force in 2020. The EPCA aims to stimulate cooperation between European countries and Kazakhstan in several key areas, including the energy sector. In particular, the comparison of the wording of the two agreements showed a more frequent use of the word "energy" in the EPCA, which indicates the prioritization of the development of exchanges in this area (Mukasheva & Akhmedyanova, 2023).

On a country-wide scale, the Netherlands is the leading investor, maintaining a clear predominance in FDI flows to Kazakhstan. FDI from the Netherlands accounted for 30% of total FDI inflows in 2020, and 25% in 2022) (Nationalbank, 2023b). Most of the FDI from the Netherlands is directed to Kazakhstan's oil and gas sector, mainly through the British-Dutch company Royal Dutch Shell, which was one of the first international investors to enter Kazakhstan's oil and gas sector back in the 1990s. It has invested more than USD 18 billion in its operations in Kazakhstan and remains one of the largest foreign investors in the country. Royal Dutch Shell owns a 29.25% share of Karachaganak Petroleum Operations, a consortium of international companies that also includes ENI (Italy), Chevron (US), Lukoil (Russia), and Kazakhstan's national oil and gas company KazMunayGas, which operates a major oil and gas field located in Western Kazakhstan (Heim et al., 2023). The company also participates with a 16.81% share in the North Caspian Sea production share agreement and holds a 7.4% share of Caspian Pipeline Consortium.

BG Group (owned by Royal Dutch Shell) is also one of the first investors to enter Kazakhstan's oil and gas sector back in 1992. Like Royal Dutch Shell, it holds a 29.25% share in the Karachaganak oil and gas condensate field as a joint operator through the Karachaganak Operating Company. It also participates in the Caspian Pipeline Consortium (BG Group, n.d.) with a 2% share. Italy is also present in Kazakhstan, through Eni company, which has had a share in Karachaganak Petroleum Operating Company (29.25%) since 1992. Italy's Eni is also part of North Caspian Consortium. In 2018, it entered into a joint operation of the Isatay exploration block with KazMunayGas, and in 2019 the joint venture expanded to exploration and production of hydrocarbons at the Abay block. Eni also participates in Kashagan field with a 16.81% share. The company also operates in the field of renewable energy in Kazakhstan.

Another long-term investor, the French company Total, has also been present in Kazakhstan since 1992. It is part of the North Caspian Consortium (Kashagan field) and operates two solar power plants in the country: M-KAT (100 MWp) and Nomad (28 MWp), located in the Zhambyl and Kyzylorda regions, which became operational in 2019. Unlike other major European investors, Total is concentrating its activities in Kazakhstan in the renewable energy sector, having sold its 60% participation in the Dunga oilfield to Kazakhstan's Oriental Sunrise Corp Ltd in November 2022 (Forbes Kazakhstan, 2022).

Belgium is more diversified in terms of its activities in Kazakhstan. However, it is also investing in the oil and gas sector. For example, Sarens Group recently participated in the construction of a gas-chemical complex in Atyrau in 2020. Atlas Copco and TD Williamson SA are also active in the country's oil and gas sector. The US maintains its position as the second largestest source of FDI for Kazakhstan. The main activities in the country are carried out through oil and gas giants Chevron and ExxonMobil. Chevron is a participant in two of Kazakhstan's three largest oil and gas consortia – the Tengiz with 50% share, developing the Tengiz and Korolev fields, and the Karachaganak with an 18% share. Chevron is the largest private shareholder in The Caspian Pipeline Consortium with a 15% share, and the sole shareholder of The Atyrau Polyethylene Pipe Plant, which produces pipes for domestic and industrial use with a production capacity of 17,000 tons of polyethylene pipe per year. The company is actively developing its operations in Tengiz, where it is implementing the Pressure Booster Unit project aimed at increasing the production capacity of the field improving oil recovery (2022-2023). In 2017, the Caspian Pipeline Expansion Project was implemented, with plans to further increase capacity (Chevron, 2023). ExxonMobil, another US oil and gas company, has been present in Kazakhstan for 25 years. The company has a 25% share in Chevron-led Tengiz oil production joint venture and a 16.8% share in the Kashagan field.

China is also among the most important investors in Kazakhstan, having entered its oil and gas industry in 1997 when China National Petroleum Corporation (CNPC) acquired a 60% of the shares of JSC

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Aktobemunaygas. Together with another Chinese oil and gas company, CITIC, the companies are active in Mansystau, Aktobe and Kyzylorda regions of Kazakhstan. Over the years of their presence in Kazakhstan, they have invested more than USD 42 billion in the country's oil and gas industry and paid USD 50 billion in taxes. The four largest Sino-Kazakh joint ventures in oil and gas industry are Aktobemunaygas (investments of over USD 10.5 billion), Mangistaumunaygas, the Kazakh-Chinese Pipeline Company (investments of over USD 1.5 billion), the Asian Gas Pipeline Company (investments of over USD 6.5 billion invested) (Han et al., 2023).

Finally, although the events of 2022 have had an impact on the partnership that is too early to analyze, Russia remains one of Kazakhstan's closest partners, including one of its important investors. Russia's Lukoil has been present in Kazakhstan since 1995, having invested USD 7 billion into the industry over the years. It has a 5% share in Tengiz, a 13.5% share in Karachaganak, owns a 50% share of Kumkol field in Kyzylorda, sharing it with China's CNPC, and is also part of the Caspian Pipeline Consortium with a 12.5% share. Since the sanctions imposed in 2022, Russian companies have also been actively cooperating with Kazakhstan to supply oil to China. For example, Rosneft has recently extended its agreement on oil transportation to China, receiving an additional 10 million tons (Kazakh Telegraph Agency, 2023).

It can be noted that key oil and gas giants mainly concentrate their activities in the western part of Kazakhstan, participating in Kazakhstan's three main oil and gas consortia - Tengiz, Kashagan, and Karachaganak, as well as the Caspian Pipeline Consortium, while Russia and China spread their activities to a greater extent to the east and Kyzylorda region.

Further Segments

Although most FDI in Kazakhstan's mining and quarrying industry is directed to the oil and gas sector, the country's other natural resources are also attractive for foreign investors. The country has significant reserves of copper and uranium. For example, the third largest investor in Kazakhstan, Switzerland, has a significant presence in the country's copper production. Glencore is one of the leading copper producers in Kazakhstan. It is the general investor in Kazzinc, a major zinc producer operating mainly in the East Kazakhstan, Akmola and Ulytau regions of Kazakhstan (Kazzinc, 2023).

Another major investor is the Russian Copper Company. It holds 22 mining and production licenses in Russia and Kazakhstan (Australian Trade and Investment Commission, 2019), and recently announced a USD 1 billion investment in February 2023 into the construction of a mining and processing plant at the Aidarly copper deposit in the Abay region. China has also entered the country's copper industry by participating in the development of the Koksay project in Almaty through China Nonferrous Metal Industry's Foreign Engineering and Construction Co (Mining Technology, 2023).

Kazakhstan plays a major role in the global uranium supply, accounting for 40%. Major investors in the Kazakhstan's uranium industry are involved in 10 of 13 Kazakhstan's uranium mining projects. Uranium Ore, taken over by Russia's Rosatom, owns 70% (USD 350 million) in Betpak Dala JV (South Inkai, Akdala mines), 50% in JV Karatau (Budenovskoye-2 deposit), 50% in Akbastau JSC (Budenovskoye- 1, 3, 4 deposits), 30% in Kyzylkum JV now Khorosan-U (Kharasan 1 mine), and 49.67% in Zarechnoye JSC (Zarechnoye & S.Zarechnoye mines). Thus, Russia has a major presence in Kazakhstan's uranium industry. Among other major participants are Canada, with its Cameco, owning a 40% share of Inkai in-situ leach uranium mine in south central Kazakhstan, and Orano, owning 51% of Katco JV (Moinkum, Tortkuduk mines), Japan with Sumitomo (25% share) and Kansai (10% share) at Appak JV (W.Mynkuduk), and the consortium Energy Asia participating in Kyzylkum JV now Khorosan-U (Kharasan 1 mine) and Baiken-U JV (Kharasan 2 mine), China with CNNC owning 49% of Zhalpak, and CGN owning 49% of Semizbai-U JV (Irkol, Semizbai mines) (World Nuclear Association, 2023).

Prospects

The turbulences in 2022 have not yet had a significant impact on the main characteristics of FDI inflows to Kazakhstan's mining and quarrying industry. Key partners have not showed any considerable changes,

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and the operation of major projects has not been disrupted. ExxonMobil (Valle, 2023) raised concerns about the reliability of the Caspian Pipeline Consortium in the face of 2022 sanctions and a challenging dialogue with Russia, but there have been no disruptions and the pipeline is characterized as reliable.

However, a series of global crises – the COVID-19 pandemic, followed by the Russia-Ukraine conflict and resulting sanctions – are likely to impact the overall availability of resources for investment. The COVID-19 pandemic affected FDI, which declined in 2020, and the current crisis may also have an impact on investment. While changes in the global cooperation and investment flows may be beneficial to Kazakhstan, which attracts a number of companies leaving Russia, the same crisis contributes to investor uncertainty about Kazakhstan being Russia's close neighbor (International Trade Administration, 2022).

Another challenge for investment inflows into the country is the relatively low amount of geological exploration being carried out in the country. This could be a potential risk for FDI inflows, as more geological exploration is required to attract investors in new projects. The other weakness of Kazakhstan's mining and quarrying industry is similar. Much of the equipment at mining sites is outdated and needs to be modernized. Such modernization would, in turn, will require increasing the level of digitalization of the mining and quarrying industry. Investments in the digitalization of the industry are growing, but the level of digitalization is still insufficient (Ashurov et al., 2020; Korauš et al. 2021; Gombár et al 2022;). Exploration, modernization and digitalization will not only increase productivity (Straková et al 2021; Šimberová et al 2022; Azhibay, 2022) and thus the investment attractiveness of the industry, but will also help to provide investors with geological data from exploration and give them a ready base from which to build their projects (Isataeva et al., 2022).

Insufficient digitalization of the mining and quarrying industry is related to another problem facing Kazakhstan. The country is a leader in Central Asia in terms of foreign investment, but the flow of resources into R&D remains low. Indeed, Kazakhstan is at the end of the list of emerging economies ranked by the share of R&D in GDP. This can be explained by the fact that most FDI in the mining and quarrying sector goes directly to oil and gas extraction, which provides little incentive to invest resources in research and development (Heim et al., 2023).

Being the source of a number of problems, the 2022 crisis has the potential to be a solution to the digitalization problem in Kazakhstan, as the country has recorded a significant influx of IT specialists relocating from Russia. This increase in the number of available highly qualified personnel could be a solution to the shortage of specialists in mining and quarrying and IT. Accelerated development of the IT sector itself is likely to lead to a technology spillover into the mining industry. Modernization and digitalization will then facilitate the process of geological exploration (Isataeva et al., 2022).

As we can see, FDI entering Kazakhstan through the mining and quarrying industry is heavily concentrated around a few large players, investing mainly in the oil and gas sector (Chakeeva et al., 2023). Large investors seem to be more focused on generating income from extraction and trade of raw materials than on diversification and processing/manufacturing (Demeuov et al., 2023). This is particularly characteristic of large investors from the US and from the EU, for whom the energy sector is the most important point of cooperation with Kazakhstan. Kazakhstan accounts for 6% of EU oil consumption and 70% of oil exports are directed to EU partners (Mukasheva & Akhmedyanova, 2023).

In general, the US and the EU appear to be focused on operations within the three major oil and gas consortia, while Russia, which is closely linked to the entire Kazakhstan's industrial sector, and China, which is actively developing its presence in the country, are investing in a wider range of projects in general, and in the mining and quarrying industry in particular (Arupov & Otarbayeva, 2020). This concentration leads to difficulties in promoting the geological exploration and processing segments, as well as modernization and digitalization of the industry, which in the long term may hinder the attraction of new investments.

It could potentially become more difficult for Kazakhstan to work on reducing the concentration of FDI, directing it less towards oil and gas extraction and more towards exploration, processing, and other industries, such as construction and manufacturing. FDI from Russia and China is more diversified, so the

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increase in investment from these countries has allowed Kazakhstan to move towards diversifying the industries receiving investment (Arupov & Otarbayeva, 2020). However, since Russia is unlikely to invest intensively, and the US and the EU are mostly oil and gas oriented, China remains the only major investor that can provide a significant level of diversification for Kazakhstan.

In the new environment, where global FDI flows, having recovered from the COVID-19 shock, are again facing a new threat in the form of the conflict between Russia and Ukraine, access may prove more difficult (Demeuov et al., 2023). To sustain the current growth in FDI inflows, Kazakhstan may need to place special emphasis on achieving its goals in a number of areas: intensifying geological exploration, identifying promising areas for mining and quarrying, improving mining infrastructure, modernizing equipment, and digitalizing the mining and quarrying sector (Isataeva et al., 2022).

Finally, it is too early to draw any definite conclusions, but despite the difficult situation and the overall decline in FDI, it can be noted that in 2022, the volume of investment from abroad in Kazakhstan's mining and quarrying industry increased. The main challenge for the country now is to maintain this trend in the unstable external environment.

As part of the analysis, we will focus on the impact of the COVID-19 pandemic on mining: coal, oil, gas and iron ore.

The COVID-19 pandemic affected the world and at the same times the global economy in 2019. Methodologically, based on the prediction of historical data (since 1990) with the use of artificial neural networks, we will try to predict, based on data from the period 1990 to 2018, the development of the extraction of the resources in question for the pandemic years 2019 to 2022 and subsequently compare these predictions with real data for the given period, thereby fulfilling the primary goal of analysing the impact of the COVID-19 pandemic in selected mining areas. The secondary goal will then be the prediction of the extraction of selected raw materials for the years 2023 to 2026.

Coal [1·103 ton]

For the initial analysis of data for the period 1990 to 2018, regression analysis of time series was used in the Neural Networks module of the STATISTICA 14.2 program. In the first step, it is necessary to define, analyse and subsequently select a suitable neural network in a defined time period. From a large group of possible solutions, 5 basic models were selected, the basic specifications of which are listed in tab.1.

Table 1. Basic Characteristics of Selected Neural Networks of the Coal Variable (1990-2018)

Net. name	MLP 1-5-1	RBF 1-3-1	RBF 1-10-1	MLP 1-11-1	RBF 1-9-1
Training perf.	0.8964	0.5672	0.8322	0.8981	0.9307
Test perf.	0.9988	0.8366	0.9967	0.9984	0.9922
Validation perf.	0.8176	0.8257	0.8196	0.8209	0.8324
Training algorithm	BFGS 2	RBFT	RBFT	BFGS 208	RBFT
Error function	SOS	SOS	SOS	SOS	SOS
Hidden activation	Sine	Gaussian	Gaussian	Sine	Gaussian
Output activation	Identity	Identity	Identity	Sine	Identity

MLP - Multilayer Perceptron, RBF - Radial basis functions, BFGS - Broyden-Fletcher-Goldfarb-Shanno training algorithm

In tab.1, the corresponding type of neural network (MLP, RBF) is indicated by the name of the network, and then the network type is followed by three numbers separated by a dash. The first number tells about the number of inputs, the second number about the number of neurons in the hidden layer and the last number about the number of outputs of the model. The use of the training algorithm depends on the type

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of neural network. BFGS training algorithm (Broyden-Fletcher-Goldfarb-Shanno training algorithm). The BFGS algorithm is a variant of the second-order optimization algorithm, which means that it uses the second-order derivative of the objective function and comes from the categorization of algorithms referred to as quasi-Newton methods, which approximate the second derivative - referred to as the so-called Hessian, for optimization problems where the second derivative cannot be quantified. The BFGS algorithm is probably one of the most widely used second-order algorithms for numerical optimization and is usually used to adapt machine learning algorithms. The BFGS algorithm comes from a group of algorithms that are an extension of the Newton method optimization algorithm, referred to as Quasi-Newton methods. Newton's method is a second-order optimization algorithm that uses the Hessian matrix. A limitation of Newton's method is that it needs to calculate the inverse of the Hessian matrix. This is a computationally expensive operation and may not be stable depending on the attributes of the target function. Quasi-Newton methods are among the most widely used nonlinear optimization methods. They are incorporated into several software libraries and are effective in finding solutions to a wide variety of small to medium-sized problems, especially when the Hessian version is difficult to compute. The primary difference between the various quasi-Newton optimization algorithms is the particular way in which the approximation of the inverse Hessian is quantified. The BFGS algorithm is one particular way to update the inverse Hessian calculation instead of recomposing each iteration. It or its extension may be one of the most widely used quasi-Newtonian or even second-order optimization algorithms used for numerical optimization. The advantage of using the Hessian, if available, is that it can be used to decide both the direction and the step size to move to change the input parameters to minimize (or maximize) the objective function. Quasi-Newtonian strategies like BFGS approximate the inverse Hessian, which can then be used to decide the direction of movement, but we no longer have the step size. The BFGS algorithm solves this by searching for rows in the selected direction to decide how far to move in that direction. More detailed information about the BFGS algorithm can be found in studies such as (Wu, Huang, Nguyen 2020), (Nezhad, Shandiz, Jahromi 2013). On the other hand, the methods used to train radial basis networks are fundamentally different from those used for MLPs. This is mainly due to the nature of RBF networks with their hidden neurons (basis functions) forming a Gaussian mixture model that estimates the probability density of the input data (Bishop 1995). For RBF with linear activation functions, the training process involves two phases. In the first phase, we fix the position and radial extension of the basic functions using the input data (no targets are considered in this phase). In the second phase, we fix the weights connecting the radial functions with the output neurons. For identity output activation functions, this second stage of training involves a simple matrix inversion. Thus, it is accurate and does not require an iterative process.

In order to choose the most suitable network for describing the change in the value of the Coal variable in the time period from 1990 to 2018, in the next step we define the differences between the actual values and the values predicted by individual neural network models in the sense of tab.1. The basic descriptive statistics of these differences are presented in tab. 2.

Table 1. Deskriptívna Štatistika Odchýlok Modelov Od Skutočných Hodnôt Premennej Coal (1990-2018)

	MLP 1-5-1	RBF 1-3-1	RBF 1-10-1	MLP 1-11-1	RBF 1-9-1
Valid N	28	28	28	28	28
Mean	-2.797%	-4.492%	1.464%	0.290%	1.458%
Median	-1.341%	-0.364%	1.404%	1.895%	2.056%
Minimum	-29.381%	-68.672%	-28.534%	-24.988%	-18.132%
Maximum	11.996%	24.208%	28.950%	21.779%	15.584%
Lower Q	-9.723%	-13.907%	-5.120%	-5.738%	-3.997%
Upper Q	5.568%	9.663%	5.692%	6.323%	6.526%
Range	41.377%	92.880%	57.483%	46.767%	33.716%
Quartile	15.291%	23.570%	10.812%	12.061%	10.523%
Std.Dev.	10.216%	20.157%	10.915%	9.839%	8.258%
Std. Error	1.931%	3.809%	2.063%	1.859%	1.561%

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Valid N – number of valid cases, Mean – arithmetic mean estimate, Median – median estimate, Minimum – minimum deviation, Maximum – maximum deviation, Lower Q – lower (25%) quantile, Upper Q – upper (75%) quantile, Range – range, Quartile – interquartile range, Std.Dev. – estimate of standard deviation, Std. Error – standard error of arithmetic mean estimation.

Table 2 shows that despite the fact that the model marked as MLP 1-11-1 achieves the lowest value of average deviations (0.290±3.815%) of the model from the actual values of the Coal variable for the time period 1990-2018, its range is at the level of 46.767% and at the same time the interquartile range is at the level of 12.061%. Based on the data presented in tab.2, the last model labelled as RBF1-9-1 appears to be the most suitable neural network model for describing the studied variable Coal in the period 1990-2018. Even though the average value of the deviations (1.458±3.202%) of the modelled and actual values of the investigated variable is the second lowest in the order, and at the same time the median (2.056%) of the deviations reaches the highest value (tab.2), the value of the range (33.716%) and the interquartile range (10.523 %) of deviations reaches the lowest value. At the same time, the model marked as RBF 1-9-1 also reaches the minimum value in the standard deviation (8.258±4.712%). A graphic representation of the deviations of neural network models (table 1) from the actual values of the Coal variable in the years 1990 to 2018 is shown in Fig. 1.

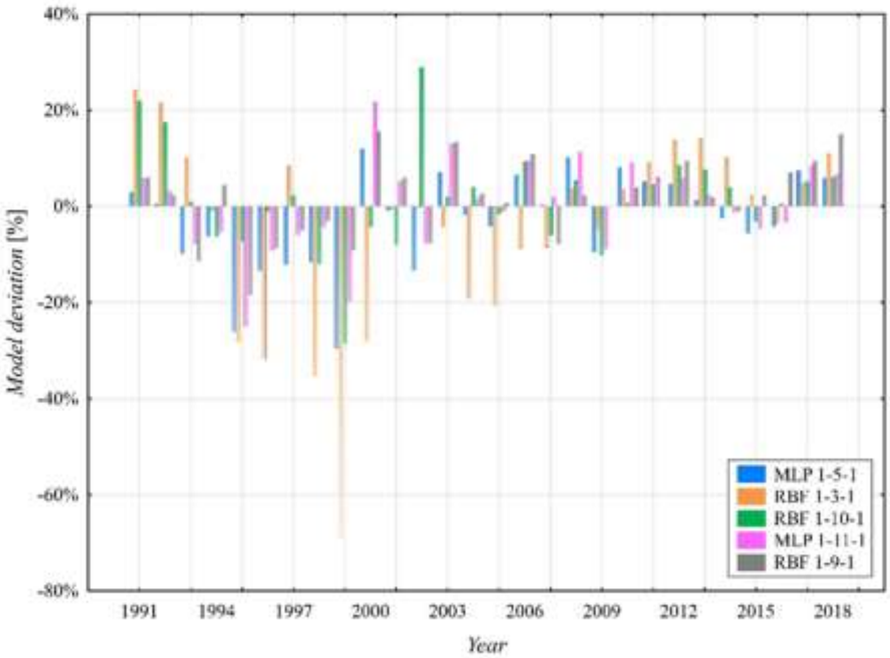

Figure 1. Deviations Of Neural Network Models fromtThe Actual Values of the Coal Variable (1990-2018)

If we repeat the same procedure for the entire data set of the Coal variable for the time period from 1990 to 2022, then the most suitable model of the neural network is the model with the designation RBF 1-18-1, while the average deviation of the real and modelled data of the studied variable is 0.064 ±2.500%, with a standard deviation at the level of 6.933±2.284%. The lowest negative deviation is -15.687% and the highest positive deviation is 15.928%, which creates a spread at the level of 31.614%. The interquartile range represents a value of 5.129%. A graphic display of all the above-mentioned relationships, including the prediction for the years 2023 to 2027, is shown in Fig. 2.

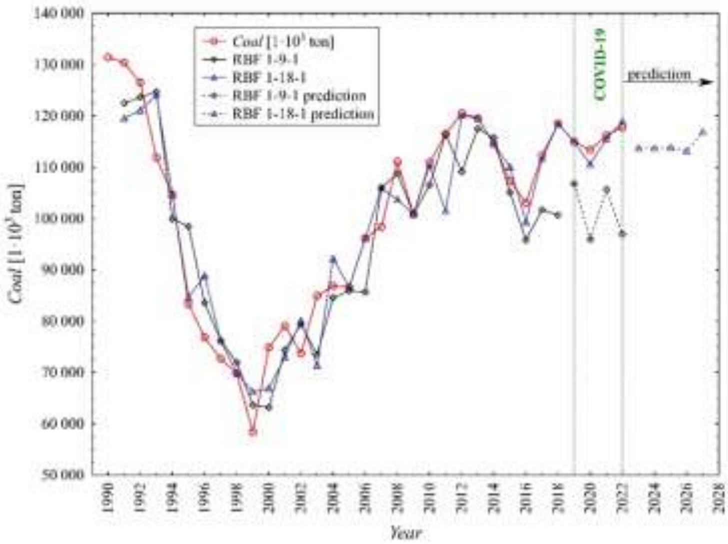

Figure 2, Graphical Representation of The Change in The Value of The Coal Variable for the Time Period 1990 to 2022, Including Estimates Using Neural Network Models and Predictions for the Years 2023 To 2027.

So, if in the next step we compare the actual values of the studied variable Coal and the values predicted using the neural network model designated as RBF 1-9-1 in the time period of 2019 to 2022 (Fig. 2), which corresponds to the time period of the global pandemic COVID-19 (tab.3) using a standard t-test, we come to the conclusion that the actual values of coal mining increased by 2.369% between 2019 and 2022. If we take a closer look at the pandemic years, between 2019 and 2020, coal mining decreased by 1,412%. When comparing the years 2020 and 2021, we observe a re-increase in coal mining by 2.426%, while we also observe an annual increase by 1.335% when comparing the years 2022 and 2021. On the other hand, the prediction of coal mining volume values using the RBF 1-9-1 neural network model for the period 2019 to 2022 based on historical data (1990 to 2018) predicted a decline in coal mining. The differences between the actual and predicted values in the monitored period of 2019 to 2022 represent an average of 12.317%. Based on the analysis presented in tab.3, it can be concluded that the actual average values of coal mining in the monitored period of 2019-2022 are significantly higher (p=0.0015) than the values modelled by the RBF 1-9-1 neural network at the selected level of significance α= 0.05. The global COVID-19 pandemic did not reduce the volume of coal mining as predicted by the neural network model, but on the contrary, after a certain decrease in 2019, there is an increase in the volume of coal mining from 2020.

Table 3. Comparison of Actual and Predicted Values of the Coal Variable in the Years 2019 to 2022.

Variable	*Obs*	*Mean*	*Std.err*	*Std.dev*	*95 % CI*	
Real (2019-2022)	4	115602.40	930.39	1860.79	112641.40	118563.30
Prediction (2019-2022)	4	101347.50	2838.96	5677.91	92312.65	110382.30
Combined	8	108474.90	3028.16	8564.93	101314.40	115635.40
diff (2019-2022)		14254.88	2987.53		6944.66	21565.09
diff=mean(*real*)-mean(*prediction*)					t=	4.7715
H0: diff=0				Degrees of freedom=		6
Ha: diff<0		Ha: diff≠0				Ha: diff>0
Pr(T<t)=0.9985		Pr(|T|>|t|)=0.0031*				Pr(T>t)=0.0015*

Obs – number of cases, Mean – estimate of the arithmetic mean, Std.err – standard error of the estimate of the arithmetic mean, Std.dev – standard standard deviation, 95% CI – 95% confidence interval of the estimate of the arithmetic mean, diff – difference, * - significant at the level significance α=0.05.

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At the conclusion of the above analysis (Fig. 2), we also present a certain estimate of the development of coal mining for the years 2023 to 2027 based on data for the years 1990 to 2022. The second applied neural network model designated as RBF 1-18-1 predicts a decrease in coal mining in 2023 and that is by 3.569% compared to the year 2022. Based on the prediction, the following years 2024-2026 should bring relatively constant values of the volume of coal mining (-0.157%) with a subsequent growth of the volume of coal mining in 2027 by 3.152%. However, the given values represent only a prediction with a certain accuracy, which can be influenced by a large number of other factors.

Oil [1·103 ton]

When analyzing oil production, we will proceed from the same procedure as in the previous case. The MLP 1-20-1 model appears to be the most suitable artificial neural network for describing historical oil production data from 1990 to 2018. The BFGS training algorithm was used to create the model, while the exponential function was used as the activation function of the hidden layer, and the constant (Identity) function was used to activate the output layer. The average deviation of the modeled and real data expressed by the arithmetic mean represents the value of -0.713±2.547% for the MLP 1-20-1 model with a standard deviation of 6.569±2.372%. The lowest negative deviation of real historical data and data calculated by the model is -19.020% and the maximum positive deviation is 12.429%. The deviation range of the model is thus 31.448% and at the same time the interquartile range reaches 8.523%. A graphical display of model deviations from oil production data for the period 1990 to 2018 is shown in Fig. 3a. In the second step of the analysis of oil production, we will create a model that describes the data for the period from 1990 to 2022. In this case, the model labeled MLP 1-12-1 with the BFGS training algorithm appears to be the most suitable artificial neural network. The logistic function was used as the activation function of the hidden layer, and the sinusoidal function was used as the activation function of the output layer. The average deviation of oil production data for the period from 1990 to 2022 is -0.256±2.249% with a standard deviation of 6.236±2.055%. The lowest negative deviation of real oil production data for the monitored period and data calculated by the model is -17.289%, and the maximum positive deviation is 12.103%. The deviation range of the model is thus 29.932% and at the same time the interquartile range reaches 7.947%. A graphical display of model deviations from oil production data for the period 1990 to 2022 is shown in Fig. 3b.

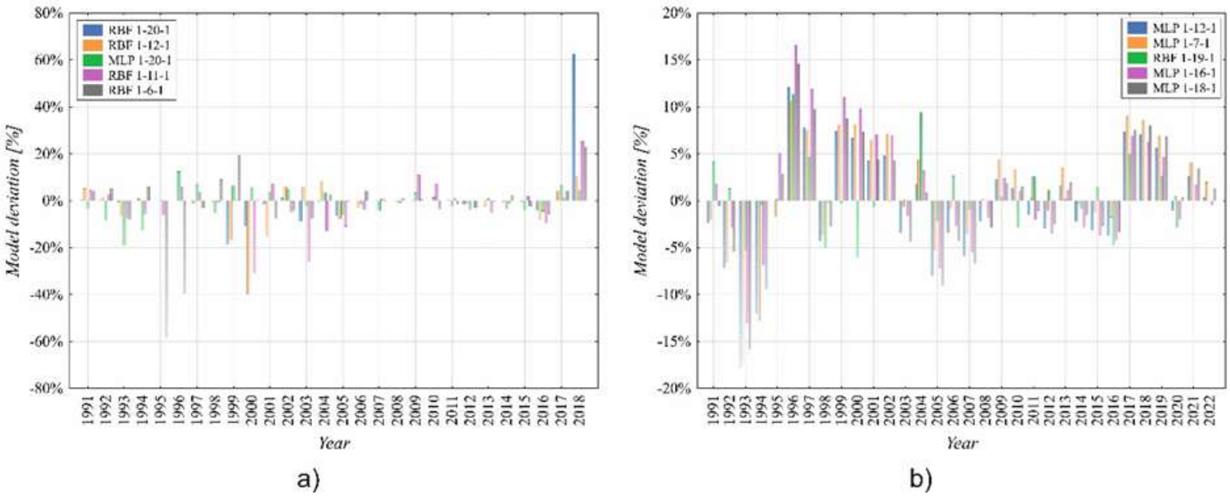

Figure 3. Deviations of Individual Models of Artificial Neural Networks from Real Data on Oil Production for the Monitored Period (A) 1990 To 2018, B) 1990 To 2022)

A graphical display of real data on oil production, values modeled using neural networks labeled MLP 1-20-1 (1990 to 2018) and MLP 1-12-1 (1990 to 2022) and corresponding predictions of values using defined models are presented in Fig. 4.

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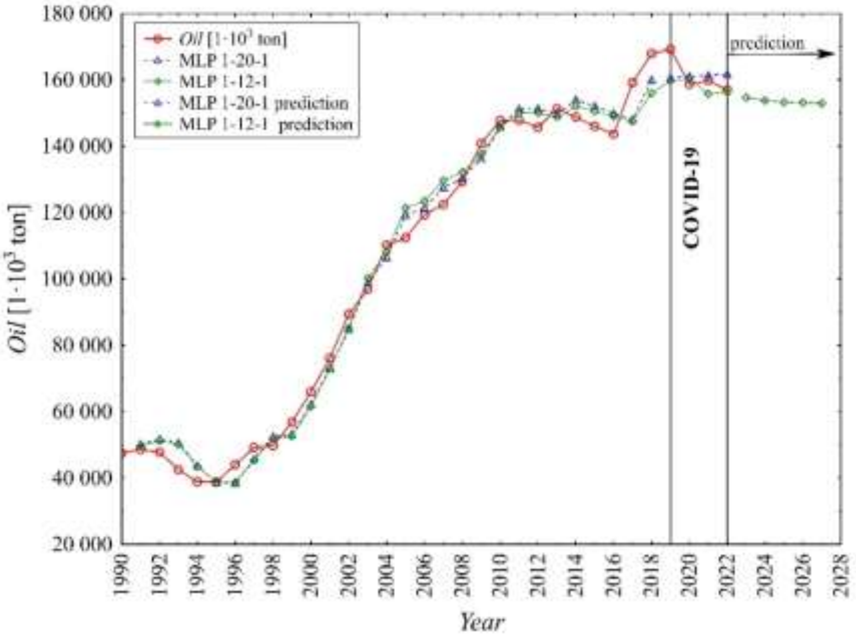

Figure 4. Graphical Representation of the Change in The Value of The Oil Variable for the Time Period 1990 to 2022, Including Estimates Using Neural Network Models and Predictions for the Years 2023 To 2027.

Fig. 4 shows that the actual value of oil production after a period of rapid growth in the years 2016 to 2018 and at the same time in 2019, in the years 2020 to 2022, i.e. in the period of the global pandemic, records a decrease of approximately 6,641% between the years 2019 and 2020. This is followed by a slight increase in oil production of 0.717% in 2021, followed by a decrease of 1.891% in 2022. The prediction model defined by a neural network labelled MLP 1-20-1, on the other hand, predicts based on historical data from 1990 to 2018 for the years 2019 to 2022 slight increase in oil production by 0.290% (2020), 0.215% (2021) and 0.159% (2022). The real average difference in oil production values in the pandemic period of 2019 to 2022 between the real value and the value predicted by the MLP 1-20-1 model (tab. 4) is not significant at the chosen level of significance α=0.05, and thus it is possible to say that the neural model network correctly estimated the decline in oil production between 2019 and 2022. The pandemic period caused a decrease in oil production by an average of 7,878% between 2019 and 2022.

Table 4. Comparison of Actual and Predicted Values of the Oil Variable in the Years 2019 To 2022.

Variable	*Obs*	*Mean*	*Std.err*	*Std.dev*	*95 % CI*	
Real (2019-2022)	4	161128.10	2758.55	5517.10	152349.20	169907.10
Prediction (2019-2022)	4	161179.20	232.14	464.27	160440.40	161918.00
Combined	8	161153.70	1291.51	3624.66		
diff (2019-2022)		-51.09				
diff=mean(*real*)-mean(*prediction*)					t=	-0.0185
H0: diff=0				Degrees of freedom=		6
Ha: diff<0		Ha: diff≠0				Ha: diff>0
Pr(T<t)=0.4929		Pr(|T|>|t|)=0.9859				Pr(T>t)=0.5071

Obs – number of cases, Mean – estimate of the arithmetic mean, Std.err – standard error of the estimate of the arithmetic mean, Std.dev – standard standard deviation, 95% CI – 95% confidence interval of the estimate of the arithmetic mean, diff – difference, * - significant at the level significance α=0.05.

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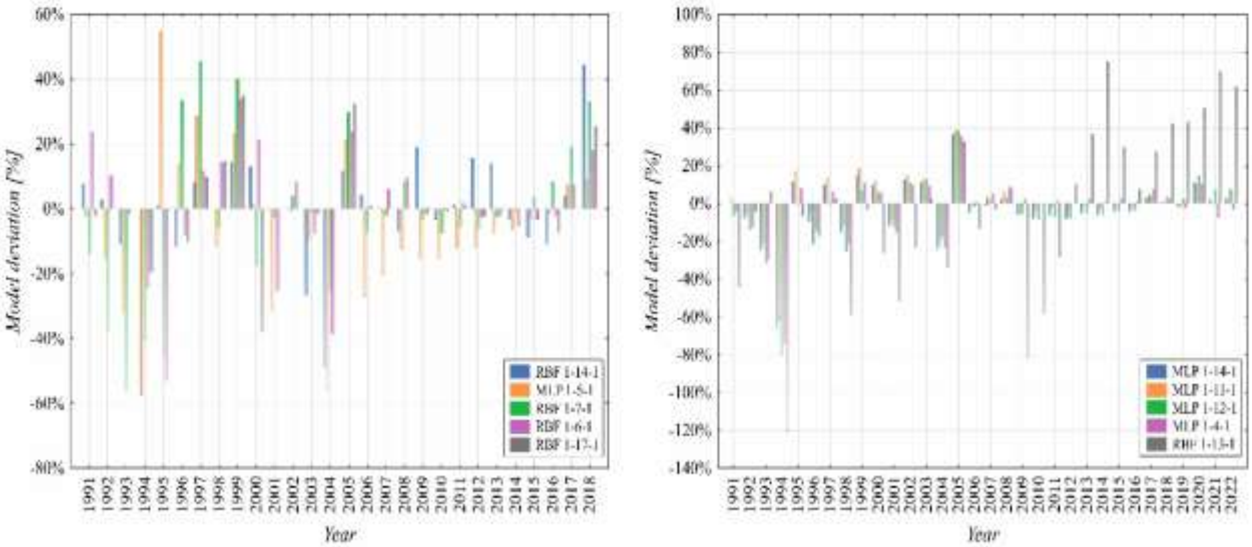
The prediction of the development of oil production for the years 2023 to 2027 using the neural network model labeled MLP 1-12-1 (Fig. 4) points to a further decrease in oil production by 1,447% in 2023 compared to the actual value in 2022. Year Based on the model, 2024 brings another decrease of 0.558%, and this decrease in the volume of oil production gradually decreases to a value of 0.081% in the last predicted year, 2027. As with the previous investigated variable, the performed analysis represents only a basic starting point for estimating the development of oil production for the years 2023 to 2027 based on historical data.

Gas [1·106 m3]

For the description of gas production data from 1990 to 2018 with subsequent prediction for the period from 2019 to 2022, the neural network with the designation RBF 1-17-1 appears to be the most suitable. The RBFT training algorithm was used to create the mentioned model, while the Gaussian function was used as the activation function of the hidden layer, and the constant (Identity) function was used to activate the output layer. The average deviation of real and modeled data based on the RBF 1-17-1 model is 1.271±5.393% with a standard deviation of 13.857±5.005%. The lowest negative difference between the actual and modeled value of gas production is -37.937%, and at the same time the highest positive difference is 35.003%. The range of deviations thus reaches the value of 72.940% and the interquartile range the value of 1.479%. A graphical representation of the deviations of the model from data on gas extraction for the period from 1990 to 2018 is shown in fig. 5a. The MLP 1-11-1 model appears to be the most appropriate neural network model for modeling gas production in the entire observed period from 1990 to 2022 with subsequent prediction for the years 2023 to 2027. The BFGS algorithm was used as a

training algorithm, while an exponential function was used as the activation function of the hidden layer, and a sinusoidal function was used to activate the output layer. For this model (MLP 1-11-1), the average difference between actual gas extraction values and modeled values using the MLP 1-11-1 model is 0.021±5.750% with a standard deviation of 15.947±5.255%. The smallest negative deviation of the actual and modeled gas extraction values is -60.883% and the highest positive deviation is 38.120%. Based on these values, the margin of variation is 99.003% and the value of the interquartile range is 12.284%. A graphical representation of the deviations of the model from the gas production data for the period 1990 to 2022 is shown in fig. 5b.



a) b)

Figure 5. Deviations of Individual Models of Artificial Neural Networks from Real Data on Gas Extraction for the Monitored Period (A) 1990 To 2018, B) 1990 To 2022)

Graphic display of real data on gas production, values modeled using neural networks marked RBF 1-17-1 (1990 to 2018) and MLP 1-11-1 (1990 to 2022) and corresponding predictions of values using defined models are shown in Fig. 6.

Fig. 6 shows that when using the neural network model labeled RBF 1-17-1 (1990-2018), this model fairly well describes the real values of gas production until 2014. After 2014, there is a significant difference between the real values of gas extraction and modeled values. This difference is on average (2014 – 2018) 12,710%, but the modeled trend of the development of gas extraction from 2018 has the opposite trend to the real development. Despite this, the prediction of gas production based on the RBF 1-17-1 model has the same trend compared to the real values in the period from 2019 to 2022, but the difference is 27.696%. However, if we analyze the entire monitored period from 1990 to 2022 with the MLP 1-11-1 model, then the deviations of the modeled and actual values of gas production are minimal (0.021±5.750%). Based on Fig. 6, the MLP 1-11-1 model captures the trend of the pandemic period from 2019 to 2022 very well, and at the same time, the prediction of gas production for the period from 2023 to 2027 can be considered relevant. The development in the mentioned time period, based on the MLP 1-11-1 model, assumes a decrease in gas extraction for the period of 2023 to 2027 by an average of 0.412%. The most significant decrease at the level of 1.292% is observed between the last real data for the year 2022 and the predicted value in 2023. Subsequently, this decrease has a decreasing character, namely 0.360% (2024), 0.211% (2025), 0.125% (2026) and 0.074% (2027).

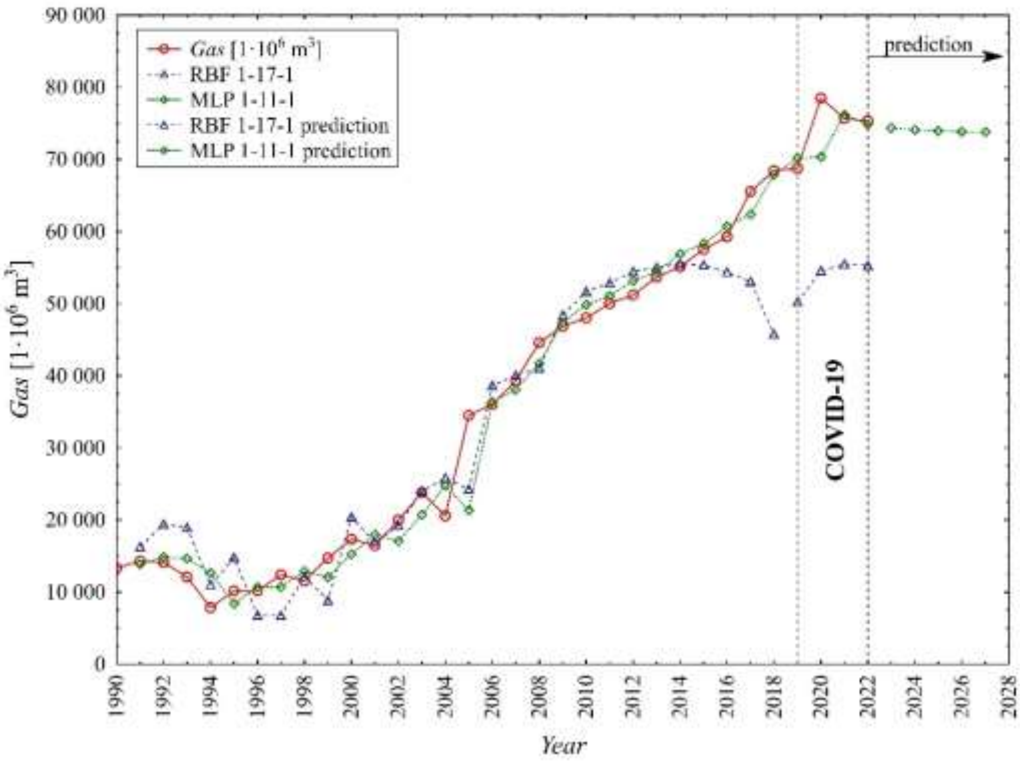


Figure 6. Graphical Representation of the Change in the Value of the Gas Variable for the Time Period 1990 to 2022, Including Estimates Using Neural Network Models and Predictions for The Years 2023 To 2027.

Iron ore [1·103 ton]

For the description of iron ore mining data from 1990 to 2018 with subsequent prediction for the pandemic period from 2019 to 2022, based on the analysis of deviations of real and modeled data, the most suitable neural network with the designation MLP 1-8-1 (a) appears. The BFGS training algorithm was used to create the mentioned model, while an exponential function was used as the activation function of the hidden layer and a sinusoidal function was used to activate the output layer. The average deviation of real and modelled

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data based on the MLP 1-8-1 model (a) represents -2.570±10.350% with a standard deviation at the level of 26.694±9.640%. The lowest negative difference between the actual and modeled value of iron ore extraction is 109.075%, and at the same time the highest positive difference is 25.772%. The range of deviations thus reaches the value of 134.846% and the interquartile range the value of 26.020%. A graphical representation of the deviations of the model from the data on iron ore mining for the period from 1990 to 2018 is shown in Fig. 7a.

For the modeling of iron ore mining in the entire observed period from 1990 to 2022 with subsequent prediction for the years 2023 to 2027, the model labeled MLP 1-12-1 appears to be the most suitable neural network model. The BFGS algorithm was used as the training algorithm, while the constant function was used as the activation function of the hidden layer, and the logistic function was used to activate the output layer. For this model (MLP 1-12-1), the average difference between actual gas extraction values and modeled values using the MLP 1-12-1 model is -7.303±10.041% with a standard deviation of 27.852±9.176%. The smallest negative deviation of actual and modeled gas production values is -121.025% and the highest positive deviation is 38.270%. Based on these values, the range of deviation is 159.295% and the value of the interquartile range is 21.417%. A graphical representation of the deviations of the model from the gas production data for the period 1990 to 2022 is shown in fig. 7b. Significant values of the range of deviations for both mentioned models are primarily caused by a sharp decrease in iron ore mining in 1998. The annual decrease compared to the previous year (1997) is 114,533%. The year 1999 also brings a reduced value of iron ore mining (compared to 1998) by 1,857% with a subsequent significant increase in the volume of iron ore mining by 45,472% in 2000. None of the applied models (MLP 1-8-1 (a). 1).

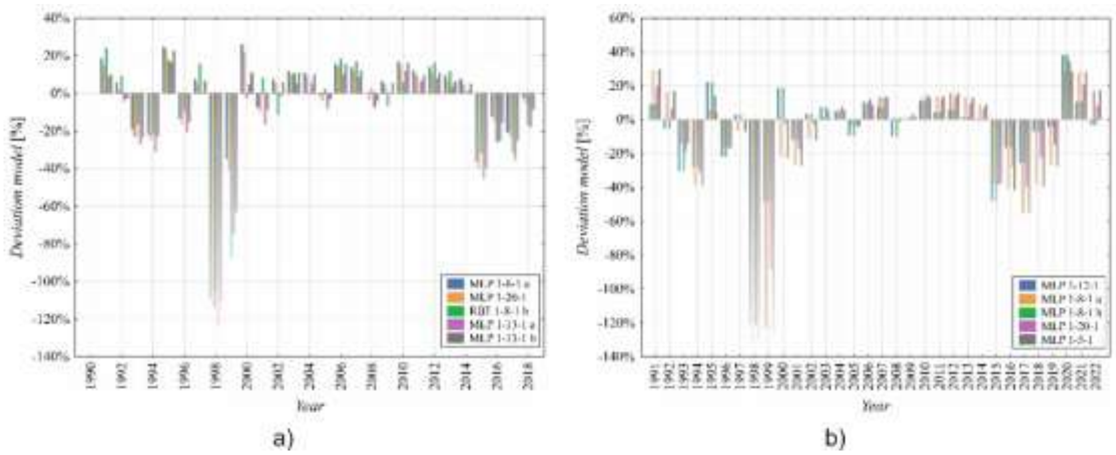

Figure 7. Deviations of Individual Models of Artificial Neural Networks from Real Data on Iron Ore Mining for the Monitored Period (A) 1990 To 2018, B) 1990 To 2022)

Graphical display of real data on iron ore, values modeled using neural networks labeled MLP 1-8-1 (a) (1990 to 2018) and MLP 1-12-1 (1990 to 2022) and corresponding predictions of values using defined models are presented at Fig. 8.

Fig. 8 shows that the MLP 1-8-1 (a) model created on the basis of data on iron ore mining for the years 1990 to 2018 can fairly accurately predict the amount of iron ore mining in the first year (2019) of the COVID-19 pandemic. The deviation of the modelled and real value of iron ore mining in 2019 is 1.667%. However, the prediction model labelled MLP 1-8-1 (a) estimates a continuous, moderate increase in the volume of iron ore mining for the following pandemic years (2020 to 2022) by 4.282% in 2020, by 2.425% in 2021 and by 1.364% in 2022. Despite the pandemic, however, the real volume of iron ore mining increased sharply by 43,636% in 2020 compared to 2019, with a minimal growth of 0.034% in 2021 and a subsequent decrease of 15,312% in 2022. The second prediction model with by the designation MLP 1-12-1 created from data on iron ore mining for the years 1990 to 2022, just like the previous model in 2019 creates a deviation from the real value by 3.775% and also, the model failed to capture the increase in iron ore mining in 2020 and so the real difference between the actual and modelled value is 38.270%. The model

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captures a certain approximation only in 2021 (10.417%) with a subsequent levelling off in 2022 with a deviation at the level of -3.319%.

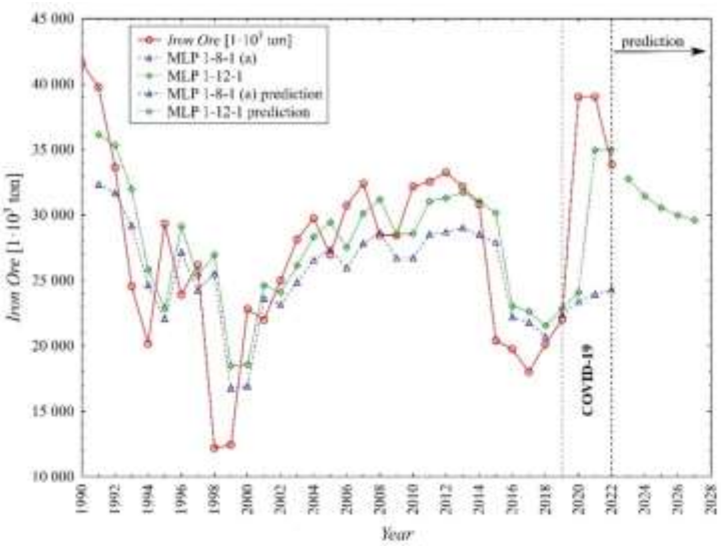

Figure 8. Graphical Representation of The Change in the Value of the Variable Iron Ore for the Time Period 1990 To 2022, Including Estimates Using Neural Network Models and Predictions for The Years 2023 To 2027.

Fig. 8 further shows that the MLP 1-12-1 model captures the decreasing trend of the volume of iron ore mining in the predicted period of 2023 to 2027. The predicted decrease in iron ore mining in 2023 compared to the real value from 2022 represents 3.269% with followed by a 4,275% decline in 2024, a 2,839% decline in 2025, a 1,919% decline in 2026, and a 1,308% decline in the last predicted year of 2027.

Based on the performed analysis of the mining of selected commodities with a focus on the pandemic period (2019-2022), it can be said that the volume of coal mining (Fig. 2) recorded a certain decrease in 2020 with subsequent growth in the years 2021 to 2022 with a slightly positive prediction for the years 2023 to 2027. The volume of oil extraction (Fig. 4) has a decreasing character throughout the observed period of 2019 to 2022 with a negative prediction for the years 2023 to 2027. The volume of gas extraction (Fig. 6) and iron ore (Fig. 8) record a similar trend in the first two years of the pandemic period, namely a significant increase in 2020 compared to 2019. However, after this sharp increase, the volume of gas extraction continues to decline in 2021 and 2022, while the volume of iron ore extraction significantly decreases only in 2022. Both commodities however, they record negative trend predictions.

Conclusion

The mining and quarrying industry, which is one of the pillars of Kazakhstan's economy, has been developing intensively and attracting the interest of foreign investors since the opening of Kazakhstan's economy to foreign markets in the early 1990s. The structure, dynamics and trends of FDI inflows into the mining and quarrying industry mostly repeat the characteristics of the mining and quarrying industry itself: they are characterized by the presence of a smaller number of giant companies that largely concentrate their investments on commodities that generate quick return.

The largest investors from the EU and the US are mainly focused on oil and gas extraction in the Caspian region, mainly within the three key consortia. Although countries such as China and Russia bring slightly more diversification into the FDI flowing into Kazakhstan, the core of their investment also flows into oil and gas as well as a number of other natural resources extraction industries. Switzerland and Japan, being less oil and gas oriented, also invest mainly in natural resources extraction. Such functioning has provided Kazakhstan with a significant inflow of investment over the years, but the number of problems that the industry has to face is increasing, and the environment in which solutions to these problems are to be found, is rather unstable.

The country is already aiming to diversify the economy in general and the mining and quarrying sector in particular, trying to channel investments into more processing and manufacturing industries. However, the level of diversification of the Kazakhstan's economy remains rather limited. In addition, the mining sector itself faces a number of challenges, including outdated infrastructure and equipment, as well as the need for increased digitalization and geological exploration. Significant changes in global trade caused by numerous 2022 sanctions and trade route disruptions have brought additional complications to the functioning and development of the industry as well as to the processes of attracting investors and diversifying the economy.

The changing international environment presents some challenges, but it can also be a source of growth, attracting new investors to the country's mining and quarrying sector, and offering new opportunities for modernization and digitalization. In a volatile international environment, in order to capitalize on the potential opportunities for the mining and quarrying industry and As part of the analysis, we will focus on the impact of the COVID-19 pandemic on mining the economy in general, Kazakhstan needs to adopt a carefully considered strategy to develop the industry and engage with current and potential investors to face old and new challenges, find new partners, and take advantage of potential market opportunities.

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