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Article

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Business Sustainability Factors of Mining Companies Based on SEM Model

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Abstract

The main goal of the study is to determine the factors of business sustainability, that is, to investigate the effect of knowledge management (KM) on green innovation (GI) and sustainable business (SB), both at the constructs and at the dimensional level, as well as to investigate whether green innovation is a mediator in the relationship between KM activities and SB, and between KM and SB dimensions of mining companies. The research and pilot test were carried out between March and mid-July 2022, and 288 employees from 32 Serbian mining companies were selected using a non-probabilistic convenience sample. The causal relationship between KM, GI, and the SB of the mining industry was assessed using the structural equation modeling methodology. The bootstrap procedure was used to assess the indirect effects of KM through GI on SB and its dimensions. The results showed that KM significantly influences GI and SB, both at the constructs and at the dimensional level. In addition, GI significantly determine SB. At the dimensional level, each of the dimensions of KM significantly affects the dimensions of GI and the SB dimensions. The impact of GI dimensions on the SB dimensions are also significant. The relationship between KM and SB, as well as KM and SB dimensions, was found to be partially mediated by GI.

Keywords: *green innovation, knowledge management, sustainable development, mediation analysis*

JEL Classification: M12, Q01, Q56, L72, C19

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Introduction

In the last decades, with the continuous worsening of global environmental problems, in the business of organizations, the issue of dealing with environmental challenges is gaining more and more importance. Academic attention is increasingly occupied by the green practices of companies, where for the most part, the literature is based on the analysis of drivers and consequences of green products and green processes (e.g. Rennings, 2000; Ambec and Lanoie, 2008; Berrone et al., 2013; Dangelico et al., 2017; Ma et al., 2017; Xie et al., 2019), while only a few authors research and analyze the practices of green management innovations (e.g. Inoue et al., 2013; Damanpour, 2014; Li et al., 2018; Ma et al., 2018; Abbas and Sağsan, 2019).

On the other hand, Awan et al. (2021), as well as Farza et al. (2021), point out that knowledge management is one of the most effective ways to improve organizational innovation, and can also contribute to the discovery of new opportunities for sustainable business operations. Knowledge management helps organizations build the capabilities necessary for green innovation, which further enhances sustainable business. Green innovations, derived from knowledge management processes, contribute to the development of environmentally friendly operational processes and products. Based on the above, it can be concluded that knowledge management can play a fundamental role in achieving sustainable business. The knowledge and abilities of employees, as intangible resources, are key factors that enable the organization to create innovations for sustainable business. By introducing the concept of sustainable business, companies become socially responsible, directing their economic activities towards the maximum preservation of natural resources, as the main raw material base. Respecting this principle means reducing the consumption of primary supplies of mineral resources by increasing the efficiency of using these resources, reducing losses, increasing savings, and increasing recyclability.

Due to its specificity, the mining industry is one of the biggest polluters of the environment. For this reason, it can be said that the management of companies belonging to this industrial sector is specific and directed towards the fulfillment of the most important goal, i.e., sustainability. This means that managers must respect the principles of sustainable development, through every activity of the management process. Although a number of researchers have studied the relationship between knowledge management and sustainable development, from different aspects, this relationship is still insufficiently researched, especially when it comes to the role of knowledge management in the implementation of sustainable development through green innovations. This is supported by the fact that numerous authors emphasize the need to enrich the limited literature on the connection

between knowledge management, green innovations, and sustainable development (Lim et al., 2017; Mardani et al., 2018; Abbas and Sağsan, 2019; Davenport et al., 2019; Shahzad et al., 2021). Considering the above, the subject of this research is the factors of sustainable business for mining companies using the SEM approach.

1. Literature Review

1.1. Resource-Based Theory

Defined by Wernerfelt (1984) and developed through a series of works by different authors, the resource-based approach and the resource-based view of the firm explain how organizations achieve competitive advantage and profit through the ownership and management of assets, capabilities, knowledge and similar internal resources. According to this approach, an organization is a set of resources, capabilities, or routines that create value and cannot be easily imitated or appropriated by competitors (Miller, 2019). A knowledge-based view of the business emerged from the resource-based view, because knowledge is perceived as the strategically more significant inimitable resource (Grant, 1997). Adopting the RBV perspective, environmentalists have argued that green innovation can make an organization more competitive and improve its sustainable performance (Sarkis et al., 2011). Green innovation is a newly developed concept based on green philosophy, to help organizations to create and advance the features of the environmentally friendly product (Dangelico et al., 2017). Thus, knowledge resources can create core competencies for enhancing sustainable performance (Pemberton and Stonehouse, 2000). Knowledge as a basic organizational resource contributes to the improvement of organizational processes by encouraging the participation of employees in corporate issues (social aspect), improving competitiveness (economic aspect) and creating green products (ecological aspect). According to resource-based view, organizations with more effective knowledge management process have a greater chance of producing green and sustainable products that has less influence on the ecological, environmental and society at large.

1.2. Knowledge Management

Knowledge management is a concept that can be defined as a set of logical procedures and techniques, based on technologies and practices, which encourage the effective formation, collection, organization, dissemination, and use of knowledge, which can enable employees to be more productive and create value for their organizations (Ahmad, 2010). Syed-Ikhsan and Rowland (2004) define

knowledge management as the planned and organized intention of an organization to use its knowledge to provide services to the community and improve its performance. Lim et al. (2017) point out that knowledge, as an intangible asset and a source of competitiveness for organizations and individuals, is difficult to imitate. Knowledge management involves identifying and assessing available and required knowledge, and then additional planning and control of actions to develop knowledge tools to achieve organizational goals (Boikanyo et al., 2016). It is the process of acquiring, spreading, and efficient use of organizational knowledge resources (Darroch, 2005), but also one of the key organizational strategies and drivers of green innovations, as well as a process whose importance is undeniable when talking about examining some new directions for sustainable performance (Lim et al., 2017). Knowledge management is a multidimensional process. Abbas and Sağsan (2019), for example, list four dimensions, namely: creation, acquisition, sharing and application of knowledge. The relationship between knowledge and the act of knowing, which is accomplished through action, practice, and interpersonal interaction, leads to the creation of knowledge (Maravilhas and Martins, 2019). According to Attia and Salama (2018), knowledge acquisition refers to organizational actions that involve "acquiring", "extracting," and "organizing" knowledge from various sources. The process of imparting explicit or implicit knowledge to a person or group of individuals is known as knowledge sharing (Jarrahi, 2018). According to Mothe et al. (2017), knowledge application is the use or integration of newly acquired knowledge in the creation or provision of new goods and services.

1.3. Green Innovation

Innovations are necessary for the company's long-term competitiveness in addition to being an important component of a sustainable society, according to Urbancová and Vrabcová (2023). Green innovation, according to Fussler and James (1996), are brand-new goods and processes that offer benefits to consumers and businesses while significantly lowering their negative effects on the environment. Similar to this, Reid and Miedzinski (2008) define green innovation as the development of novel products, systems, processes, services, and practices at market-competitive costs that can meet human needs and guarantee quality of life for all, with minimal use of natural resources (materials, energy), as well as minimal release of toxic substances, over the course of their entire life cycles. Oltra and Saint Jean (2009) provided a clearer and more thorough definition of green innovations, stating that they are advancements that include new or modified procedures, practices, systems, and goods that benefit the environment and thereby support environmental sustainability. Green innovation are a multidimensional phenomenon,

and in the literature, green technological and green management innovation are often cited as their dimensions (e.g., Abbas and Sağsan, 2019). In order to create new or improved products or processes that help to lessen the negative effects of business operations on the environment and ecosystems, green technological innovations imply a connection between environmental science and technical sciences (Butt, 2016), and it can be utilized by companies of all sizes (Lončar et al., 2019). Green management innovation entail the adoption of new management structures, techniques, and tactics that will be advantageous to the company and aid in the improvement of its production processes (Li et al., 2018).

1.4. Sustainable Business

Due to environmental issues, the idea of sustainable business was developed. According to Ogrean and Herciu (2018), sustainable business entails integrating economic, social, and environmental goals into organizational operations while taking into account interests and claims of stakeholders. According to Lozano (2015), a company engaged in sustainable business seeks to strike a balance between economic, social, and environmental responsibility while conducting business and communicating with stakeholders. This balance must take into account both the present and the future. In order to accomplish economic growth without endangering the environment, a wide range of guiding concepts and corporate practices are referred to as economic sustainability. The social dimension entails conducting business in a way that reduces social inequality and raises the standard of living for all parties involved. (Popescu and Popescu, 2019). Initiatives taken by businesses to control their production processes to minimize their negative effects on the environment are included in the environmental sustainability dimension (Lozano, 2015). The implementation of sustainable business is considered an important task of managers with the aim of incorporating social and environmental issues into the practice of company management (Epstein, 2008; Shrivastava and Hart, 1995).

1.5. Relationships between Research Variables

1.5.1. Knowledge Management and Green Innovation

The ability to transform knowledge into innovation is, according to Prokop et al. (2017), becoming the foundation of regional and national economic systems. Since green innovations enable the production of high-quality goods and services with minimal consumption of natural resources, which is why they are a significant strategic catalyst for achieving sustainable development (Chang, 2011), to

promote them, Li et al. (2018) emphasize that the government should support, encourage and make it easier for firms to innovate. The acquired knowledge can be used by companies to improve innovation and performance (Kianto et al., 2017), where the connection between knowledge management and green innovation occurs when, using the competencies and knowledge of employees, top management invests in environmentally friendly and green resources for the development of innovation (Pérez-Luño et al., 2019). Knowledge management was identified by Jovanović and Stanković (2023) as the most important factor in their study, which examined the effects of organizational learning, organizational culture, leadership, knowledge management, and financial resources on the creation and adoption of green innovations. Studies by various authors indicate that knowledge management practices have a positive impact on green innovation. For example, Shahzad et al. (2020), and Shahzad et al. (2021), obtained results according to which knowledge acquisition, knowledge dissemination, and knowledge application have a direct positive impact on green innovations. Abbas and Sağsan (2019) examined the impact of knowledge management on green innovation, as well as the dimensional level of knowledge management (creation, acquisition, sharing, and application) on the dimensions of green innovation (green technology and green management innovation). The results of the study by the mentioned authors indicate a significant direct and positive impact of knowledge management on green innovations, as well as a significant positive impact of the creation, acquisition, exchange, and application of knowledge on the dimension of green technological innovation, and a significant positive impact of all dimensions of knowledge management on green management innovations, except for the dimension of knowledge creation, where the results point to a positive but not statistically significant impact on the dimension of green management innovation. Studies by other authors (Lin, 2007; Madhoushi et al., 2011; Wong, 2013; Ganguly et al., 2019) have also identified that knowledge management dimensions have a positive effect on green innovation.

1.5.2. Knowledge Management and Sustainable Business

From the aspect of sustainability, knowledge management is, above all, responsible for the creation and use of knowledge resources in a sustainable way by taking into account the social, environmental, and economic contexts (Lim et al., 2017). Davenport et al. (2019) suggest that a learning organization emphasizes combining knowledge management strategies with organizational strategies so that, in all spheres, sustainability can be achieved. The capacity to absorb knowledge has a significant impact on the environmental performance of an organization (Shahzad et al., 2019), and, therefore, knowledge management, combined with employee knowledge, can strengthen the s corporate stainability. The results

of studies by Abbas and Sağsan (2019), and Shahzad et al. (2020) indicate that green innovations have a significant positive impact on the sustainable business of companies. According to the results of the study by Xie et al. (2019), and Yu and Huo (2019) green innovation has a positive impact on an organization's financial performance. In this sense, green innovation is a generator of new technologies and processes, ensuring the organization's environmental acceptability and economic sustainability. When it comes to the dimensional level, the results of the study by Tajpour et al. (2022) showed that all dimensions of knowledge management (creation, transfer, and application) must be applied in all parts of the company, for technology-driven companies to be in a sustainable environment. The results of Kuhn's (2022) study showed that all three dimensions of knowledge management (acquisition, dissemination, and reception of knowledge) have a positive and significant impact on the sustainable business of organizations. Kordab et al. (2020) obtained results according to which all dimensions of knowledge management (acquisition, creation, storage, sharing, and application) positively and significantly affect sustainable business. Brix (2018) found a positive relationship between organizational knowledge creation activities, organizational learning, and social performance. Shahzad et al. (2019) point out that knowledge acquisition, as a dimension of knowledge management, is of crucial importance for achieving sustainable development. Abbas and Sağsan (2019) find a significant direct and positive connection between the dimensions of knowledge management (creation, acquisition, sharing, and application) and the dimensions of sustainable development of the company (creation, acquisition, sharing, and application), except when it comes to the relationship between the acquisition of knowledge and the social dimension of sustainable business, which is positive, but not statistically significant.

1.5.3. Green Innovation and Sustainable Business

As global economic competition increases, so do the challenges facing organizations. In this sense, the importance of innovation, as an important tool for improving competitiveness, is becoming greater. Studies have shown that innovation is one of the basic factors that can provide organizations with a competitive advantage, a dominant position in the market, and sustainable growth of net profit in a changing business environment (Aghion et al., 2005; Chang et al., 2015). Fernando et al. (2019) point out that green innovation is one of the basic means, among the numerous means of corporate innovation, by which organizations minimize or eliminate the negative impact of their production, as well as production operations, on the natural environment. The results of research by Eiadat et al. (2008) indicate that the implementation of the green innovation strategy reduces waste and pollution in the company's production process, which leads to an improvement in the

social reputation and an increase in the company's competitiveness. In addition, the empirical results of the study by Chen et al. (2021), who examined the role of green innovations in reducing SO_2, in Chinese provinces, in the period 2000 – 2016 suggest that green innovation research and development activities have a significant role to play in reducing SO_2 emissions, while Shekhar and Dwivedi (2021) point out that green innovation makes cities cleaner and does not endanger the environment for people. Previous studies emphasize that improvements in the production process and efficiency will increase opportunities to improve environmental performance (Montabon et al., 2007). Seman et al. (2019), Abbas and Sağsan (2019), as well as Wang et al. (2021), obtained results according to which green innovation practices significantly positively affect environmental performance. When it comes to the impact of green innovations on the dimensional level of sustainable business, the researchers also found a positive relation. For example, based on the findings of the study by Baeshen et al. (2021), green innovations have a positive impact on all three dimensions of sustainability (economic, social, and environmental). Similar results were obtained by El-Kassar and Singh (2019), according to which the dimensions of green innovations, that is, both green production and green process innovations, have a direct positive impact on all dimensions of sustainable business.

1.5.4. Green Innovations as a Mediator of the Relationship between Knowledge Management and Sustainable Business

Knowledge management is one of the leading strategies for increasing organizational innovation performance (Darroch, 2005) and researching new directions of sustainable development (Lim et al., 2017). Some researchers have provided relevant literature on the direct positive relationship between knowledge management processes and innovative performance (Kianto et al., 2014; Chen et al., 2009; Abbas and Sagsan, 2019; Shahzad et al., 2019; Shahzad et al., 2020; Shahzad et al., 2021), for the direct relationship of knowledge management with sustainable development (Abbas and Sagsan, 2019; Shahzad et al., 2019; Shahzad et al., 2020; Shahzad et al., 2021), as well as the direct relationship innovation with sustainable development (Triguero et al., 2013; Chang, 2016; Hojnik and Ruzzier, 2016; Abbas and Sagsan, 2019; Shahzad et al., 2020). In addition, a number of authors explored the relationship between the dimensional level of knowledge management, green innovation and sustainable development and, mostly, obtained results according to which there is a direct positive relationship between the dimensions of knowledge management and the dimensions of green innovation (e.g. Abbas and Sagsan, 2019; Shahzad et al., 2020), dimensions of knowledge management and dimensions of sustainable business (e.g. Abbas and Sagsan, 2019)

and dimensions of green innovation and dimensions of sustainable business (e.g. El-Kassar and Singh, 2019). However, earlier research indicated the necessity of further exploration, to better understand the mediating role of green innovations between knowledge management and sustainable business operations of companies (Abbas and Sağsan, 2019; Shahzad et al., 2019). In this sense, Shahzad et al. (2020), in their research, aimed to determine whether the knowledge management process directly affects the company's sustainable operations and whether green innovation act as a mediator in this relationship. According to the obtained results, the mentioned authors determined that green innovations play a mediator role in the relationship between knowledge management and sustainable development of companies, while the results supported complementary partial mediation. According to the findings of Jovanović et al. (2023) the relationship between the knowledge management dimensions and the sustainable business dimensions is significantly mediated by green innovation dimensions.

2. Research Methodology

2.1. Research Model

The conceptual model is shown in Figure 1. Figure 1 presents a conceptual model based on Abbas and Sağsan (2019), Shahzad et al. (2020), and Jovanović et al. (2023) methodology, illustrating the relationships between knowledge management, green innovation, and sustainable business. The examination of the mediating role of green innovation concept in the interaction between knowledge management concept and sustainable business dimensions (environmental, social and economic sustainability) is a novel aspect of this research.

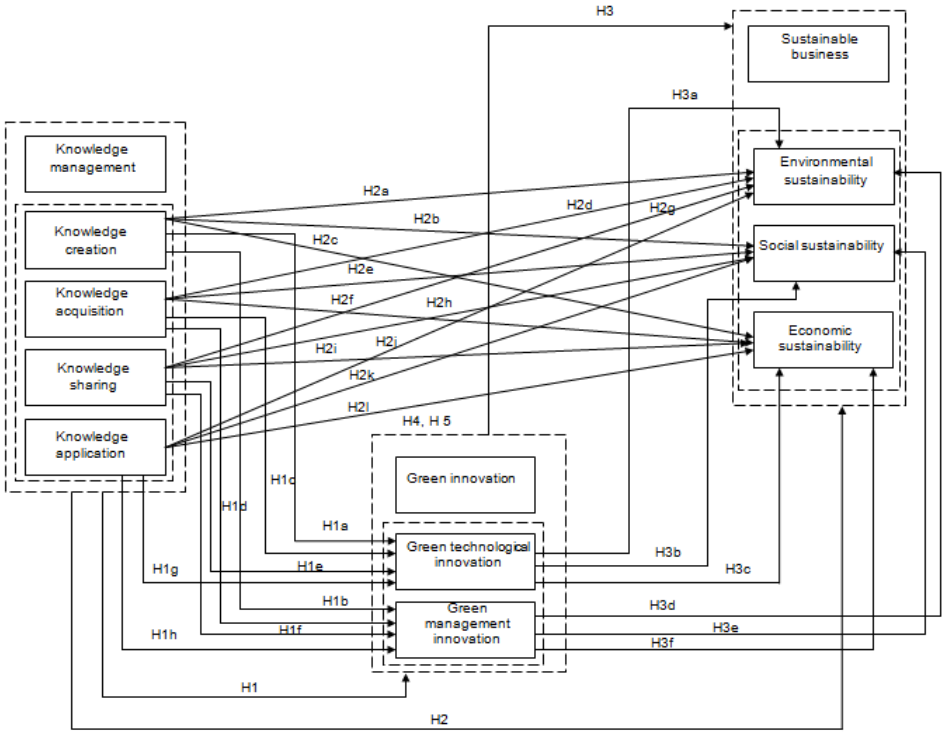
The research hypotheses (Appendix 2) were defined in light of the research's subject and goals, as well as earlier studies on the issue.

2.2. Sample

This study's population consisted of 32 companies that are involved in mining research, exploitation, and raw material processing in Serbia. These include coal mines, the extraction of non-metallic mineral raw materials, non-ferrous and precious metal ore mines, research and development organizations, and project organizations. According to the requirements of the ISO 9001, ISO 14001, and ISO 45001 standards, all companies have implemented management systems for quality, the environment, occupational health and safety. These companies were chosen because they are considered the biggest polluters of the environment. Data from individuals in managerial positions (senior, middle and lower management) were

gathered using a non-probabilistic convenience sample method because these individuals are in charge of making strategic decisions and were thought to be the most suitable subjects for this research. Online survey and face-to-face techniques were used to collect data. The link to the online survey was provided to the respondents along with a cover letter that explained the main goal and assured data confidentiality. The survey, including the pilot test, was conducted from the beginning of March to the middle of July 2022.

F i g u r e 1
The Conceptual Model



Source: Authors' presentation, based on Abbas and Sağsan (2019), Shahzad et al. (2020), and Jovanović et al. (2023) methodology.

Table 1 shows the demographic characteristics of the respondents who participated in the research. From the table, it can be seen that there were more men (68.8%) than women (31.3%) in the sample. Most respondents belonged to the age group of 41 – 50 years (26.7%). The majority of respondents have completed high school (65.6%). The largest percentage of respondents had more than 15 years of work experience in a mining company (34.4%). The sample consisted, in the largest percentage, of respondents who belong to the group of lower management (55.9%).

T a b l e 1
Demographic Structure of the Sample

		Frequency	Percent
Gender	Male	198	68.8
	Female	90	31.3
Age	≥ 30	54	18.8
	31 – 40	73	25.3
	41 – 50	77	26.7
	51 – 60	70	24.3
	≤ 61	14	4.9
Education	Medium	60	20.08
	High	189	65.6
	Master/PhD	39	13.5
Years of work experience	≥ 5	62	21.5
	6 – 10	65	22.6
	11 – 15	62	21.5
	≤ 15	99	34.4
Hierarchical level of work	Senior management	17	5.9
	Middle management	110	38.2
	Lower management	161	55.9

Source: Authors' own calculations on survey data.

2.3. Measures

According to Christmann (2000), the final questionnaire for this study was created using the following three procedures. First, we developed scales for every variable after carefully reviewing the pertinent literature. Second, we improved the measurement scale's clarity and understandability by contacting three academics. Third, the final questionnaire is broken down into four sections based on the methods employed to make the concepts clearer. Questions from the first section referred to the sociodemographic characteristics of participants. The second section contained items related to knowledge management – KM. This section contained 14 items, taken and adapted from Darroch (2003), Kordab et al. (2020), and Kun (2022). The third section contained items related to green innovation – GI. This section contained 6 items, taken and adapted from Ma et al. (2018) and El-Kassar and Singh (2019). The fourth section contained items related to sustainable business – SB. This section contained 10 items, taken and adapted from Kun (2022). Attitudes were measured using a five-point Likert scale, from 1 – I do not agree at all, to 5 – I completely agree. A total of 292 responses were gathered, but upon review, it was discovered that 4 questionnaires were incomplete, so the data from these questionnaires was disregarded from the rest of the research. A cover letter that explained the purpose of the study, the survey's anonymity, and the meaning of the variables was included with the questionnaire. A pilot test was also conducted to evaluate the reliability and validity of the chosen items. In this phase, 116 questionnaires were collected. With internal consistency scores ranging from 0.71 to 0.89, all of the survey's constructs met the 0.7 cutoff level recommended by Hair et al. (2010). The final questionnaire is shown in Appendix 1.

2.4. Analysis

To examine the causal links between knowledge management, green innovation and sustainable business, on the constructs and dimensional level, structural equation modeling (SEM) was used. A set of relationships between one or more independent variables that can be continuous or discrete and one or more dependent variables that can also be continuous or discrete can be studied using the statistical techniques that make up the SEM. Both the independent and dependent variables can be either latent (unobserved, not directly observable) and measurable variables (directly observed). SEM is also known as path analysis, causal analysis, simultaneous equation modeling, causal modeling, and simultaneous equation modeling (Ullman, 2006).

Utilizing the Bootstrap procedure, mediation analyses were carried out to examine the mediating role of green innovations in the relationships between knowledge management and sustainable business as well as between knowledge management and dimensions of sustainable business in mining businesses. Bootstrap is a statistical technique that generates numerous simulated samples by resampling a single dataset. According to Lindley and Walker (1993), the mediator variable represents the process by which the predictor predicts the criteria, explaining "how" and "why" this relationship is realized (Peyrot, 1996). The assumptions underlying the mediation analysis hold that a particular outcome is not just produced by the predictor's direct impact on the criterion, but also by the predictor's ability to change the mediator variable, which in turn influences the outcome. Complete mediation is when the mediator variable entirely explains the relationship between the predictor and the criterion, or when the predictor fully influences the criterion only through the mediator. If the predictor affects the criterion both directly and indirectly through influencing the mediator, this is referred to as partial mediation (Edwards and Lambert, 2007). The data were processed using the statistical software IBM SPSS 21 and AMOS graphics.

3. Data Analysis and Results

3.1. Examining the Dimensionality of Constructs

Exploratory and confirmatory factor analyses were used to examine the dimensionality, validity, and reliability of the scales designed to measure the constructs of knowledge management, green innovations, and sustainable business in mining companies. Factors with initial characteristic roots greater than 1 were identified through exploratory factor analysis, and then their structure was confirmed by confirmatory factor analysis (Table 2). In the research, knowledge management

was viewed as a second-order construct, consisting of four first-order constructs (knowledge creation – KC, knowledge acquisition – KAC, knowledge sharing – KS, and knowledge application – KAP), green innovation as a second-order construct, consisting of two first-order constructs (green technological innovation – GTI and green management innovation – GMI) and construct sustainable business as a second-order construct, consisting of three first-order constructs (economic – ECONS, social – SOCS, and environmental sustainability – ENVS), Factor loadings range from 0.634 – 0.884, average variance extracted (AVE) range from 0.522 – 0.756. Composite reliability (CR) values range from 0.764 – 0.917, while Cronbach alpha values range from 0.766 – 0.967. According to De Vellis (2003), the requirements for convergent validity and reliability are met when all factor loadings and AVE values are greater than 0.50, and Cronbach alpha (Cα) and composite realibility (CR) values are more than 0.70.

T a b l e 2

Results of Confirmatory Factor Analysis of Scales, Validity and Reliability

Constructs	Factor loading				CR	AVE	Cα
Knowledge management							
KC1	.870				.896	.741	.860
KC2	.848						
KC3	.865						
KAC1		.836			.785	.601	.766
KAC2		.829					
KAC3		.787					
KAC4		.631					
KS1			.884		.903	.756	.873
KS2			.883				
KS3			.840				
KAP1				.826	.917	.733	.881
KAP2				.858			
KAP3				.873			
KAP4				.867			
Green innovation							
GTI1	.634				.764	.522	.967
GTI2	.735						
GTI3	.789						
GMI1		.857			.898	.745	.843
GMI2		.873					
GMI3		.860					
Sustainable business							
ENVS1	.826				.872	.693	.862
ENVS2	.850						
ENVS3	.822						
SOCS1		.871			.895	.740	.896
SOCS2		.867					
SOCS3		.842					
ECONS1			.777		.882	.652	.842
ECONS2			.819				
ECONS3			.821				
ECONS4			.813				

Source: Authors' own calculations.

3.2. Sample Size, VIF and CMV

According to Lee et al. (2010), structural equation modeling presupposes the suitability of the research sample, the absence of multicollinearity issues, and the common method variance bias test (CMV). Hoelter (1983) suggests a sample size of at least 200, however this study enrolled 288 participants. There is no multicollinearity issue, as indicated by VIF (variance inflation factor) test results below 3 (range from 1.828 to 2.637). The Harman's single-factor test was used to investigate CMV. Podsakoff et al. (2012) point out that first factor should not explain more than 50% of the total variance. According to the results, the first construct explains 36.134% of the total variance, which means that there is no problem with CMV.

3.3. Measurement Model Analysis

Causal relationships between knowledge management, green innovation, and sustainable business in mining companies were tested using structural equation modeling. Anderson and Gerbing's (1988) two-step approach (measurement and structural model assessment) was used for the assessment of the conceptual model. The measurement model fitted well, according to the results of the confirmatory analysis: $\chi^2 = 49.186$; df = 24; $p < 0.05$; $\chi^2/df = 2.049$; NFI = 0.963; TLI = 0.971; CFI = 0.981; SRMR = 0.031; RMSEA = 0.060 (Table 3 and Appendix 3).

T a b l e 3

Structural Model Fit Indicators

Fitting indicators	Model fitting indicators	Model fitting level
χ^2/df ($\chi^2(24) = 49.186$, $p < 0.05$)	2.049	Adequate*
NFI	.963	Perfect*
NNFI (TLI)	.971	Perfect*
CFI	.981	Perfect*
SRMR	.031	Perfect*
RMSEA	.060	Adequate*

Note: * As per Hu and Bentler (1999); Byrne (1998).

Source: Authors' own calculations.

All factor loadings and average variance extracted (AVE) values are greater than 0.50, and Cronbach alfa (Cα) and composite realibility (CR) are greater than 0.70 indicating the fulfillment of the conditions of convergent validity (De Vellis, 2003). The results of convergent validity tests are shown in Table 4.

The AVE squared root values of each of the concepts in a pair are greater than the correlation between the concepts (Farrell and Rudd, 2009), indicating the fulfillment of the discriminant validity conditions (Table 5).

T a b l e 4

Factor Loading, Reliability Coefficient, and Convergent Validity

Construct	Factor loading	Cα	CR	AVE
Knowledge management		.853	.852	.592
Knowledge creation	.721			
Knowledge acquisition	.692			
Knowledge sharing	.807			
Knowledge application	.847			
Green innovation		.703	.704	.547
Green technological innovation	.655			
Green management innovation	.815			
Sustainable business		.837	.838	.633
Economic sustainability	.809			
Social sustainability	.804			
Environmental sustainability	.774			

Source: Authors' own calculations.

T a b l e 5

Discriminant Validity

	Knowledge management	Green innovation	Sustainable business
Knowledge management	.769*		
Green innovation	.647	.740*	
Sustainable business	.618	.627	.796*

Note: * Square root of the average extracted variance.

Source: Authors' own calculations.

3.4. Structural Model Analysis

According to Hair et al. (2016), the structural model illustrates the causal connection between external and endogenous factors. Estimates were made for the explanatory power (R^2) and path coefficient (β). The model's predictive ability was demonstrated by the R^2 value of green innovation, which was 0.557, and sustainable business (0.775), which prove the model's predictive ability (Hair et al., 2016).

Based on the results of hypothesis testing, shown in Table 6, KM practices have a direct positive and significant effect on GI ($\beta = 0.747$, $p < 0.001$) (Appendix 3), as well as dimensions of KM on dimensions of GI ($\beta_{H1a} = .278$, $\beta_{H1b} = .367$, $\beta_{H1c} = .318$, $\beta_{H1d} = .349$, $\beta_{H1e} = .444$, $\beta_{H1f} = .511$, $\beta_{H1g} = .400$, $\beta_{H1h} = .577$), all at a statistically significant level ($p < 0.001$). KM, also, has a significant positive direct effect on SB ($\beta = 0.365$, $p < 0.001$), as well as dimensions of KM on SB dimensions in mining companies ($\beta_{H2a} = .447$, $\beta_{H2b} = .458$, $\beta_{H2c} = .465$, $\beta_{H2d} = .433$, $\beta_{H2e} = .420$, $\beta_{H2f} = .532$, $\beta_{H2g} = .541$, $\beta_{H2h} = .503$, $\beta_{H2i} = .496$, $\beta_{H2j} = .568$, $\beta_{H2k} = .568$, $\beta_{H2l} = .553$), all at a statistically significant level ($p < 0.001$). GI has a significant positive direct effect on SB ($\beta = 0.446$, $p < 0.001$), as well as dimensions of GI on dimensions of SB in mining companies ($\beta_{H3a} = .443$, $\beta_{H3b} = .413$, $\beta_{H3c} = .453$, $\beta_{H3d} = .542$, $\beta_{H3e} = .535$, $\beta_{H3f} = .529$), all at a statistically significant level ($p < 0.001$).

T a b l e 6

Standardized Estimates of Measurement Model Parameters, T and P Values

Hypotheses	Paths	β	t	p	Decision
H1	KM → GI	.747	10.798	.0001	Supported
H1a	KC → GTI	.278	4.907	.0001	Supported
H1b	KC → GMI	.367	6.687	.0001	Supported
H1c	KAC → GTI	.318	5.680	.0001	Supported
H1d	KAC → GMI	.349	6.312	.0001	Supported
H1e	KS → GTI	.444	8.402	.0001	Supported
H1f	KS → GMI	.511	10.060	.0001	Supported
H1g	KAP → GTI	.400	7.401	.0001	Supported
H1h	KAP → GMI	.577	11.963	.0001	Supported
H2	KM →SB	.452	4.539	.0001	Supported
H2a	KC → ENVS	.447	8.474	.0001	Supported
H2b	KC → SOCS	.458	8.722	.0001	Supported
H2c	KC → ECONS	.465	8.904	.0001	Supported
H2d	KAC → ENVS	.433	8.145	.0001	Supported
H2e	KAC → SOCS	.420	7.833	.0001	Supported
H2f	KAC → ECONS	.532	10.633	.0001	Supported
H2g	KS → ENVS	.541	10.899	.0001	Supported
H2h	KS → SOCS	.503	9.868	.0001	Supported
H2i	KS → ECONS	.496	9.673	.0001	Supported
H2j	KAP → ENVS	.568	11.690	.0001	Supported
H2k	KAP → SOCS	.568	11.695	.0001	Supported
H2l	KAP → ECONS	.553	11.257	.0001	Supported
H3	GI → SB	.490	4.356	.0001	Supported
H3a	GTI → ENVS	.443	8.377	.0001	Supported
H3b	GTI → SOCS	.413	7.679	.0001	Supported
H3c	GTI → ECONS	.453	8.616	.0001	Supported
H3d	GMI → ENVS	.542	10.933	.0001	Supported
H3e	GMI → SOCS	.535	10.725	.0001	Supported
H3f	GMI → ECONS	.529	10.548	.0001	Supported

Source: Authors' own calculations.

3.5. Mediation Analysis

A mediation analysis was carried out using the Bootstrap procedure to assess the indirect impacts of KM on the SB of mining businesses and the indirect effects of KM on the SB dimensions by utilizing the two-step approach suggested by Hair et al. (2016). The first stage involved evaluating how indirectly KM affected SB through GI. The obtained results show that the indirect effect of KM is significant, i.e., $\beta = 0.366$, $p < 0.05$. In the subsequent stage, the direct impact of KM on SB was evaluated while mediators (GI) were present. The results show that the direct effect is also statistically significant ($\beta = 0.452$, $p < 0.05$), indicating partial mediation.

In order to examine the indirect effects of KM on the dimensions of SB of mining companies, three mediation analyzes were conducted for each dimension of SB separately. In the first step, the indirect effect of KM on the dimensions of SB through GI was assessed. The obtained results indicate the significance of the indirect effect of KM on the dimension: "environmental sustainability" ($\beta = 0.300$, $p < 0.05$); "social sustainability" ($\beta = 0.278$, $p < 0.05$), and "economic sustainability"

($\beta = 0.291$, $p < 0.05$). In the second step, the direct effect of KM on the SB dimensions was assessed, in the presence of a mediator (GI). According to the obtained results, the direct effect of KM on "environmental sustainability", "social sustainability" and economic sustainability in mining companies are statistically significant, which indicates partial mediation. The results of the analysis are shown in Table 7.

T a b l e 7

Standardized Indirect and Direct Effects in a Model with Green Innovation as a Mediator

Hypothesis	Paths	Indirect effect	Direct effect	Decision
H4	KM → GI → SB	.366***	.452***	Supported partial mediation
H5	KM → GI → ENVS	.300***	.356***	Supported partial mediation
	KM → GI → SOCS	.278***	.364***	Supported partial mediation
	KM → GI → ECONS	.291***	.368***	Supported partial mediation

Note: *** significance at the level of $p < 0.05$.

Source: Authors' own calculations.

4. Discussion

The obtained results indicate a direct positive and statistically significant effect of knowledge management on green innovation and on sustainable business, and, also, green innovation on sustainable business in mining companies. When it comes to the dimensional level, the obtained results indicate a positive, significant and direct relationship between all dimensions of the observed constructs. These results are consistent with the results of other authors' studies in the relevant literature (e.g., El-Kassar and Singh, 2019; Shahzad et al., 2020; Jovanović et al., 2023).

Based on the obtained results, it was determined that green innovation is a mediator of the relationship between knowledge management and sustainable business in mining companies. It was concluded that it was a partial mediation. The results are in line with the results of Shahzad et al. (2020), who, also, concluded that green innovation is a significant mediator of the relationship between knowledge management and sustainability. Research by other authors indicates the significance of this relationship, i.e., the role of green innovation as a mediator between knowledge management and sustainable business, and they emphasize the need to examine this relationship in future studies (Abbas and Sağsan, 2019; Shahzad et al., 2019).

The results of the conducted study indicate the mediating role of green innovation in the relationship between knowledge management and dimensions of sustainable business. In the relationship between knowledge management and

environmental, social and economic sustainability partial mediation was found. Jovanović et al. (2023), obtained results that indicate partial mediation, that is, significant direct and indirect effects of knowledge management dimensions on the sustainable business dimensions, through the green innovation dimensions. The results of the current study, however, cannot be compared to those of other authors' studies because, according to a review of the literature, as far as authors are aware, other studies did not deal with the research of relations between knowledge management, green innovation, and sustainable business operations in this way. Taking into account the positive and significant influences between these variables, which are indicated by the results of a large number of studies by different authors (Lim et al., 2017; Mardani et al., 2018; Abbas and Sağsan, 2019; Davenport et al., 2019; Shahzad et al., 2019; Shahzad et al., 2020; Jovanović et al., 2023), a significant role of green innovation, as a mediator, between knowledge management and dimensions of sustainable business can be expected.

Conclusion

This study aims to investigate how knowledge management improves green innovation and to define the significance of green innovation in attaining sustainable business following resource-based theory. According to the results, knowledge management has a statistically significant impact on green innovation and sustainable business, as well as on sustainable business in mining companies. The results also show statistically significant relationship between all of the observed constructs' dimensional components. The findings also point to the importance of green innovation in mediating the relationship between knowledge management and sustainable business as well as between knowledge management and sustainable business dimensions.

The practical implications of the conducted study are reflected in highlighting the importance of the role of green innovations, which together with knowledge management can facilitate organizations to achieve sustainable business. In addition, the importance of all knowledge management and green innovation elements for achieving sustainable development goals is emphasized.

The study also has certain limitations. First of all, the fact that this study's methodology relies on data analysis, which is a reflection of the respondents' subjective judgments, raises some concerns about the validity of the findings. Many of critics believe that then there is potential for the development of bias. Although, this study did not demonstrate that CMV is a problem, it is still possible that it exists. Therefore, data from additional sources, such as yearly reports, should be included in future studies. Second, it is limited to only the mining sector of one

country, so future research could be extended to other. Furthermore, future research may include moderating variables, such as, for example, environmental turbulence, organizational size, or organizational agility, and thus extend the proposed model.

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A p p e n d i x 1 / Questionnaire

Knowledge Management Process

Knowledge creating

Our company generates best practices from previous projects to improve future projects
Employees in the company develop new ideas through constructive dialogues
Employees in the company cooperate with each other when developing new ideas

Knowledge acquisition

Managers try to find out what is the real attitude of employees towards work
The company holds regular meetings where the needs of our employees are discussed
Employees in the company are encouraged to be innovative
The management of the company encourages employees to educate themselves and improve

Knowledge sharing

We encourage people with similar interests to work together to solve problems
Policy and procedure instructions are frequently updated in the company
Modern techniques and ways to involve all employees in solving quality-related problems are often used in the organization

Knowledge application

Our company is able to implement marketing plans effectively
Our company quickly obtains information about new technological developments, which could affect the business
Our company changes technical strategies frequently
Our company quickly obtains important information about the competition

Green Innovation

Green technological innovation

Whenever possible, our company uses materials that can be easily recycled, reused and decomposed
Whenever possible, our company uses less polluting or non-polluting/toxic materials, which are environmentally friendly
Managers in our company redesign production and operational processes to improve environmental efficiency

Green management innovation

Managers implement advanced environmental management techniques within our company
Managers implement advanced energy management in our company
Managers implement knowledge management within our company

Sustainable Business

Environmental sustainability

Our company responsibly stores tailings
Our company strives to use technology, which reduces the emission of harmful gases
The production of our company has a less harmful impact on the environment than in previous years

Social sustainability

Our company regularly communicates the company's environmental impacts and risks to the public
Our company adheres to the occupational health and safety program
The leadership of our company protects the demands and rights of indigenous people and the local community

Economic sustainability

In our company, profit maximization is still the most important goal
In recent years, in our company, input costs have been reduced for the same level of output
In recent years, in our company, waste management costs have been reduced for the same level of output
Our company uses every opportunity to generate income from the sale of waste

A p p e n d i x 2 / Hypotheses

H1: Knowledge management significantly effects green innovation in mining companies.
H1a: Knowledge creation has a direct positive effect on green technological innovation in mining companies.
H1b: Knowledge creation has a direct positive effect on green management innovation in mining companies.
H1c: Knowledge acquisition has a direct positive effect on green technological innovation in mining companies.
H1d: Knowledge acquisition has a direct positive effect on green management innovation in mining companies.
H1e: Knowledge sharing has a direct positive effect on green technological innovation in mining companies.
H1f: Knowledge sharing has a direct positive effect on green management innovation in mining companies.
H1g: Knowledge application has a direct positive effect on green technological innovation in mining companies.
H1h: Knowledge application has a direct positive effect on green management innovation in mining companies.
H2: Knowledge management significantly effects sustainable business in mining companies.
H2a: Knowledge creation has a direct positive effect on environmental sustainability in mining companies.
H2b: Knowledge creation has a direct positive effect on social sustainability in mining companies
H2c: Knowledge creation has a direct positive effect on economic sustainability business in mining companies.
H2d: Knowledge acquisition has a direct positive effect on environmental sustainability in mining companies.
H2e: Knowledge acquisition has a direct positive effect on social sustainability in mining companies
H2f: Knowledge acquisition has a direct positive effect on economic sustainability business in mining companies.
H2g: Knowledge sharing has a direct positive effect on environmental sustainability in mining companies.
H2h: Knowledge sharing has a direct positive effect on social sustainability in mining companies
H2i: Knowledge sharing has a direct positive effect on economic sustainability business in mining companies.

H2j: Knowledge application has a direct positive effect on environmental sustainability in mining companies.

H2k: Knowledge application has a direct positive effect on social sustainability in mining companies.

H2l: Knowledge application has a direct positive effect on economic sustainability business in mining companies.

H3: Green innovation significantly effects sustainable business in mining companies.

H3a: Green technology innovation has a direct positive effect on environmental sustainability in mining companies.

H3b: Green technology innovation has a direct positive effect on social sustainability in mining companies.

H3c: Green technology innovation has a direct positive effect on economic sustainability business in mining companies.

H3d: Green management innovation has a direct positive effect on environmental sustainability in mining companies.

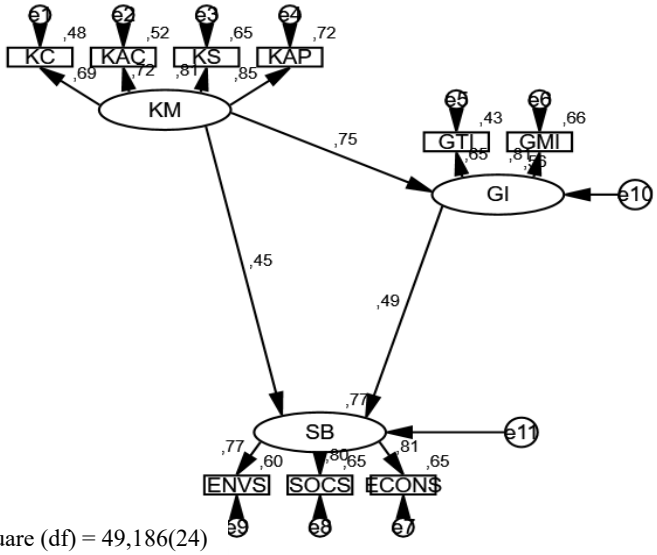
H3e: Green management innovation has a direct positive effect on social sustainability in mining companies.

H3f: Green management innovation has a direct positive effect on economic sustainability business in mining companies.

H4: Green innovation mediates the relationship between knowledge management and sustainable business in mining companies.

H5: Green innovation mediates the relationship between knowledge management and sustainable business dimensions in mining companies.

A p p e n d i x 3 / Structural Model



Chi-square (df) = 49,186(24)
p value = ,002
NFI = ,963
TLI = ,971
CFI = ,981
RMSEA = ,060