

# **IMCSM Proceedings**

ISSN 2620-0597

**Volume XX, Issue (1), (2024)**

An international serial publication for theory and  
practice of Management Science



**Editor-in-Chief: Prof. dr Marija Panić**

**Published by University of Belgrade, Technical Faculty in Bor,  
Department of Engineering Management**

**Bor, May 2024**

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The International May Conference on Strategic Management (IMCSM24) was held in a hybrid format (in person and online) on May 31, 2024, at Bor Lake, Serbia.

E-Book of Proceedings available at: <https://mksm.tfbor.bg.ac.rs/>

CIP - Каталогizacija u publikaciji  
Narodna biblioteka Srbije, Beograd

005.51(082)(0.034.2)

INTERNATIONAL May Conference on Strategic Management (20 ; 2024 ; Bor)

[XX] International May Conference on Strategic Management – IMCSM24, May 31, 2024, Bor [Elektronski izvor] / [editor in chief Marija Panić]. - Bor : University of Belgrade, Technical Faculty, Engineering Management Department, 2024 (Bor : Tercija). - 1 USB fleš memorija ; 1 x 2 x 6 cm. - (IMCSM Proceedings, ISSN 2620-0597 ; vol. 20, issue (1) (2024))

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-6305-150-8

a) Стратешки менаџмент -- Зборници

COBISS.SR-ID 145959177



**Conference is financially supported by the Ministry of Science,  
Technological development and Innovation of the Republic of  
Serbia**

**Konferencija je finansijski podržana od strane Ministarstva  
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The special section of IMCSM24 will be organized within the framework of the project SmartMiner, on a topic “**Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces**”. This project is funded by the Science Fund of the Republic of Serbia as a part of the Green program of cooperation between science and industry (Grant No. 5151).

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# SADRŽAJ

## *Plenary section*

### **DIVERGING PATHS TO ORGANIZATIONAL RESILIENCE: THE ROLE OF DYNAMIC MANAGERIAL CAPABILITIES, BENEVOLENT LEADERSHIP, ORGANIZATIONAL UNLEARNING AND PARADOXICAL THINKING**

Tomasz Ingram ..... 1

### **ICT PENETRATION AND STOCK MARKET DEVELOPMENT: EMPIRICAL EVIDENCE FROM EMERGING MARKET ECONOMIES**

Yilmaz Bayar ..... 15

### **EMPLOYEES' WORK-LIFE BALANCE IN THE CONTEMPORARY BUSINESS ENVIRONMENT IN SERBIA**

Nemanja Berber, Agneš Slavić, Dimitrije Gašić ..... 24

### **ENTERPRISE RISK MANAGEMENT USING THE FMEA-AHP APPROACH**

Marija Panić ..... 38

## *Smart miner section*

### **SMART, ERGONOMIC AND SUSTAINABLE MINING MACHINERY WORKPLACES: AN OVERVIEW OF THE SMARTMINER PROJECT**

Vesna Spasojević Brkić, Ivan Mihajlović, Đorđe Nikolić, Aleksandar Brkić ..... 49

### **DEVELOPING A NOVEL QUANTITATIVE APPROACH TO EVALUATE THE ORGANIZATIONAL FACTORS AFFECTING OCCUPATIONAL HEALTH AND SAFETY IN THE MINING INDUSTRY**

Anđelka Stojanović, Isidora Milošević, Đorđe Nikolić ..... 60

### **RELIABILITY-BASED RISK ASSESSMENT OF AUXILIARY MACHINERY IN OPEN-PIT MINES: A BACKHOE LOADER CASE STUDY**

Vesna Spasojević Brkić, Nemanja Janev, Nikola Petrović, Uglješa Bugarić ..... 69

### **SELECTION OF AN ALGORITHM FOR THE PREDICTION OF STOPPAGES AND/OR FAILURE OF EXCAVATION UNITS USING SUPERVISED MACHINE LEARNING**

Mirjana Misita, Vesna Spasojević Brkić, Ivan Mihajlović, Aleksandar Brkić, Martina Perišić, Neda Papić, Nemanja Janev ..... 79

### **THE IMPACT OF SAFETY FACTORS ON THE SAFETY SUSTAINABILITY OF OPERATORS IN MINING COMPANIES: A MANAGER'S PERSPECTIVE**

Isidora Milošević, Anđelka Stojanović, Que Xiaoju, Đorđe Nikolić, Sanela Arsić ..... 92

### **HARD HAT DETECTION FOR SAFETY PURPOSES BY USING YOLOV9**

Natalija Perišić, Radiša Jovanović ..... 101

### **A HYBRID RELIABILITY - FMEA METHODOLOGY IN RISK ASSESSMENT OF A BELT CONVEYOR SYSTEM**

Hetham Omer Mohamed Jama, Vesna Spasojević Brkić, Nikola Petrović, Uglješa Bugarić, Martina Perišić ..... 111

**A RISK EVALUATION OF BULLDOZER DOWNTIMES AND ITS ECONOMIC JUSTIFICATION IN OPEN-PIT MINES**

Uglješa Bugarić, Vesna Spasojević Brkić,  
Nikola Petrović, Nemanja Janev, Martina Perišić ..... 122

**AN OVERVIEW ON OPTIMAL MODELING OF HYBRID RENEWABLE ENERGY SYSTEMS FOR ENHANCING ENERGY MANAGEMENT STRATEGIES**

Branislav Petrović, Bogdan Ristić, Miloš Banjac, Ivan Božić ..... 132

**INTEGRATED PROCESS PLANNING AND SCHEDULING OF PRODUCTION SYSTEMS BASED ON MOUNTAIN GAZELLE OPTIMIZER**

Aleksandar Jokić, Milica Petrović, Zoran Miljković ..... 142

***IMCSM2024***

**THE INTEREST OF STUDENTS AND GRADUATES IN FAMILY BUSINESSES**

Silvia Puiu ..... 152

**EXAMINATION OF THE TAM MODEL EXTERNAL FACTORS' INFLUENCE ON THE PERCEIVED EASE OF USE – THE CASE OF SAP ERP SYSTEM**

Aleksandra Radić, Sanela Arsić, Đorđe Nikolić ..... 158

**THE IMPACT OF KNOWLEDGE MANAGEMENT ON CORPORATE SUSTAINABLE DEVELOPMENT (CSD): THE MEDIATING ROLE OF GREEN INNOVATION**

Sanela Golubović Corcione, Milica Veličković, Aleksandra Fedajev ..... 167

**THE ROLE OF STANDARDISATION IN THE ADOPTION OF ARTIFICIAL INTELLIGENCE IN THE WORKPLACE**

Ana Kićanović ..... 180

**THE RESILIENCE OF ITALIAN AND POLISH FAMILY ORGANIZATIONS: A COMPARATIVE STUDY USING FSQCA**

Barbara D'Aquino, Mario Carrassi, Tomasz Ingram ..... 189

**GOLD PRICE PREDICTION BASED ON THE MONTE CARLO METHOD**

Adrijana Jevtić, Dejan Riznić, Miša Tomić ..... 201

**DYNAMIC EFFECT OF ENTREPRENEURIAL UNIVERSITY ENVIRONMENT ON STUDENT'S ENTREPRENEURIAL SELF-EFFICACY,**

Zagorka Mitaseva, Ana Tomovska - Misoska ..... 210

**THE GRANGER CAUSALITY OF DIGITAL CONNECTIVITY AND TRADE GLOBALIZATION IN THE HEALTH CRISIS**

Ivana Petkovski, Aleksandra Fedajev, Isidora Milošević ..... 221

**DEVELOPMENT AND VALIDATION OF MEASUREMENT INSTRUMENT FOR GREEN KNOWLEDGE MANAGEMENT**

Aleksandra Radić, Ivan Jovanović, Nenad Milijić ..... 232

**CAREER PREFERENCES FOR UNIVERSITY STUDENTS FROM RUSSIA AND BULGARIA**

Julia Murzina, Albert Brand, Daniel Pavlov, Svetlana Shvab ..... 242

<b>SUSTAINABILITY AND RESILIENCE FROM THE PERSPECTIVE OF THE LABOUR MARKET OF CENTRAL AND EAST EUROPEAN (CEE) MEMBER STATES</b>	
Alina Haller .....	249
<b>POST-HOC ANALYSIS OF DIGITAL DEVELOPMENT IN PLS-SEM</b>	
Ivana Petkovski, Isidora Milošević .....	260
<b>POTENTIAL ASPECTS OF CLOUD-BASED RISKS AND PROTECTION STRATEGIES</b>	
Zoltán Nyikes, Norbert Cseh, László Tóth, Tünde Anna Kovács .....	271
<b>ENHANCING PRODUCTION PLANNING EFFICIENCY WITH DOCUMENT MANAGEMENT USING BPM TOOLS - THE BONITA APPROACH</b>	
Ana Đurić, Aleksandra Hornjak, Darko Stefanović, Dušanka Dakić .....	282
<b>EVALUATION OF CIRCULAR ECONOMY INDICATORS IN EU COUNTRIES</b>	
Rita Remeikienė, Justina Bankauskienė, Ligita Gasparėnienė .....	292
<b>THE IMPACT OF EXECUTIVE COACHING ON THE INNOVATION PERFORMANCE OF EMPLOYEES</b>	
Biljana Galovska, Ivan Gjorgjievski .....	301
<b>CROSS FUNCTIONAL TEAMS: A KEY FOR IMPROVING SYSTEMS THINKING IN AN ORGANIZATION</b>	
Ivan Gjorgjievski, Biljana Galovska, Filip Grujoski .....	310
<b>THE DEVELOPMENT OF E-CRIMES IN THE DIGITAL ECONOMY: CAUSES AND CONSEQUENCES</b>	
Rita Remeikienė, Andrius Trajanaukas, Ligita Gasparėnienė .....	318
<b>DESIGN OF A DIGITAL MODEL FOR RESERVE ESTIMATION AT THE BLED EL HADBA PHOSPHATE DEPOSIT- BIRELATER, TEBESSA</b>	
Aichouri Imen, Nettour Djamel, Chaib Rachid, Kerboua Kelthoum .....	327
<b>SELECTION OF CUTTING INSERT FOR LONGITUDINAL TURNING OF UNALLOYED STEEL USING ROBUST DECISION MAKING</b>	
Miloš Madić, Milan Trifunović, Goran Petrović .....	339
<b>LEVERAGING KNOWLEDGE MANAGEMENT FOR ADVANCING INNOVATIVE THINKING IN THE BANKING SECTOR: INSIGHTS FROM SOUTH AFRICA</b>	
Vusumzi M. Msuthwana .....	349
<b>CONSTRUCTION PRODUCTIVITY, LEAN PROCESSES AND SUSTAINABILITY</b>	
Magdalena Krstanoski .....	361
<b>TOWARDS A POLICY OF CONTINUOUS, SUSTAINABLE IMPROVEMENT IN HOSPITAL WASTE MANAGEMENT: A CASE STUDY</b>	
Rania Berrachedi, Rachid Chaib, Hafida Kahoul, Djamel Nettour .....	370
<b>OBSTACLES OF WOMEN MANAGERS IN THEIR CAREERS, THE GLASS CEILING PHENOMENON</b>	
Sreten Tešanović, Sanja Tešanović, Sara Tešanović .....	379
<b>SOLUTIONS FOR IMPROVING THE INTERACTION BETWEEN INVESTMENT AND PERSONAL DATA SECURITY</b>	
Klaudija Charlapavičiūtė .....	392

<b>OPERATIONAL RISK OF ACCOUNTING DIGITALIZATION</b>	
Ján Vlčko, Jitka Meluchová .....	401
<b>ECONOMICS AND ENVIRONMENTAL-HEALTH RISK ASSESSMENT FOR SUSTAINABLE DEVELOPMENT OF THE GOLD MINING INDUSTRY IN NIGERIA</b>	
Olugboyega Oyeranti .....	408
<b>WORKFORCE WELLBEING MANAGEMENT LEVERAGING SEMANTIC KNOWLEDGE GRAPH</b>	
Milorad Tosić, Nenad Petrović, Olivera Tosić .....	418
<b>YOUNG CONSUMERS' INSIGHTS ON BRAND ASSOCIATION, BRAND AWARENESS, PERCEIVED QUALITY, BRAND IMAGE, BRAND LOYALTY AND BRAND EQUITY</b>	
Thiruchelvi Arunachalam, Mayurigha Sivakumar, Ashvadhara Raveendran .....	428
<b>IMPACT OF STRATEGIC HUMAN RESOURCE MANAGEMENT ON MEDIATING THE RELATIONSHIP BETWEEN ENTREPRENEURIAL VENTURES AND SUSTAINABLE GROWTH</b>	
Aliyu Mohammed, Shanmugam Sundararajan, Dr.Subramani Senthil Kumar, Dr.Sanjoy Kumar Pal.....	437
<b>ASSESSMENT OF THE IMPACTS OF EXPERIENCE MARKETING ON THE BRAND IMAGE OF TEXTILE COMPANIES IN LATVIA</b>	
Vita Zarina, Velga Vevere, Inga Shina, Blesson Baby .....	453
<b>PREDICTORS OF THE LAYOFFS IN THE SYSTEM OF PROVISION OF THE PERSONNEL STABILITY</b>	
Olena Vartanova .....	463
<b>CUSTOMER RELATIONSHIP MANAGEMENT IN THE BANKING SECTOR</b>	
Tanja Džinić, Aleksandra Perić, Slavica Mitrović Veljković, Stevan Milisavljević, Đorđe Čelić.....	471
<b>NETWORK OPERATION CENTER FOLLOWING PROCEDURES</b>	
Jovan Zlatanović, Ivana Milosević, Mirko Milosević .....	481



## DEVELOPING A NOVEL QUANTITATIVE APPROACH TO EVALUATE THE ORGANIZATIONAL FACTORS AFFECTING OCCUPATIONAL HEALTH AND SAFETY IN THE MINING INDUSTRY

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**Abstract:** The mining industry is among those sectors that urge close attention to occupational health and safety (OH&S). Occupational Health and Safety management promotes many organizational practices based on carefully managing risks and reducing negative occurrences in the production process. Implementing different OH&S practices can also foster significant improvements in working conditions. However, the success of OH&S management efforts depends on workers' attitudes towards OH&S practices and, consequently, their engagement. Although many studies have explored factors influencing occupational health and safety management, few have focused on the mining sector. The main goal of this study is to propose and test measurement instruments for Organizational factors affecting Occupational Health and Safety in the mining sector. The study provides two levels of empirical validation: Exploratory and Confirmatory factor analysis. Exploratory Factor Analysis was conducted using SPSS, while AMOS was employed for Confirmatory Factor Analysis. Exploratory Factor Analysis exposed five factors defined by 21 items. Confirmatory Factor Analysis demonstrated the reliability of the obtained factor structure. The proposed measurement scale resulted in good fit indexes as well as convergent and discriminant validity. The study can significantly contribute to further research in the field.

**Keywords:** Occupational Health and Safety, Organizational factors, Mining industry, Measurement instrument

### 1. INTRODUCTION

Occupational Health and Safety (OH&S) is a universal issue in all industrial sectors. Companies constantly invest efforts and resources in order to adequately deal with OH&S problems, aiming to predict risks and prevent damages. Occupational Health and Safety Management aims to establish specific OH&S policies and practices to address OH&S issues adequately (Kim et al., 2019). Adequate management and implementation of OH&S practices

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requires significant commitment and involvement of all human resources in the company and integration of OH&S in all segments of the business production system (Zohar & Luria, 2005; Mohammadfam et al., 2016). The development of OH&S research and practice resulted in the implementing of numerous programs that can bring significant benefits to companies. Multiple benefits result from OH&S practices, including lower costs, less absenteeism, and fewer work interruptions, leading to increased productivity and profits. OH&S management assumes the incorporation of OH&S in job design, process design, HRM function, workers training and development. Including the OH&S elements in all segments of the business production processes contributes to a better organizational culture and acceptance of pro-safety behavior by workers, which improves performance and contributes to the organization's overall goals (Parker et al., 2017). Workers' familiarity with the organization's efforts and workers' perception of the importance of OH&S is necessary for the adoption of an organizational safety culture.

Research dealing with occupational health and safety has a long history (Stavrianidis & Rennie, 1996; Ghosh et al., 2004). Over the years, research has increasingly focused on certain influential aspects concerning, for example, the causes of injuries (Ghosh et al., 2004; Lenné et al., 2012; Liu et al., 2018), lifestyle factors (Sonntag & Pundt, 2016) etc. The primary focus of research is to understand and anticipate adverse events and take necessary measures to improve OH&S organizational culture. The attention in the studies is directed to certain sectors due to the specificity of the work environment and the different nature of the OH&S problems that may occur (Zohar, 2014). Mining is a sector with extremely high occupational hazards and still many accidents at work, and OH&S represents a critical element of the sustainability of mining practices (Parker et al., 2017; Tetzlaff et al., 2021). A literature review conducted by Nyoni et al. (2019) highlighted that the lack of research in the mining sector is a reliance on secondary data, usually sourced from reports published by companies or regulatory bodies, which raises concerns about the impartiality of the findings. On the other hand, there is a significant lack of empirical research that can provide answers to the questions of whether and how organizational factors contribute to workplace performance in mining organizations at the individual level (Lenné et al., 2012). Therefore, the existing studies do not provide a sufficiently developed measuring instrument for the attitudes of workers in the mining industry about the organizational factors of OH&S. For that reason, this study aims to conceptualize and validate an instrument for measuring organizational aspects of OH&S practices based on workers attitudes.

## **2. LITERATURE REVIEW**

Occupational Health and Safety Management (OHSM) performance measurement often faces significant difficulties (Petersen, 2001). Indicators based on which it is possible to measure the performance of OHSM occupy an important topic for researchers in this field. Haas and Yorio (2016) asked managers how they measure the effectiveness of OH&S practices in mining organizations. The survey consisted of 20 elements related to specific mining risks and hazards, each composed of several practices (133 in total). The results indicated three general types of performance measures: organizational performance, worker performance and interventions.

Nyoni et al. (2019) conducted extensive literature research on organizational factors in the mining industry as a domain that significantly impacts mining worker behavior. The study identified several common organizational factors in the mining industry and confirmed the connection between these factors and the effectiveness of risk control. The organization's vital role in creating a safety culture in the mining industry was emphasized by Tetzlaff et al. (2021), concluding that commitment and responsibilities are shared among all stakeholders (workers,

supervisors, management, unions, insurance...). Hermanus (2007) talked about the importance of OH&S for workers' health in the mining industry because their lives directly depend on their interest in OH&S procedures and rules. Hu et al. (2016) found that the support and following of the OH&S regulations by managers and supervisors significantly affect workers' compliance. Also, lack of unconstrained communication between workers and management about hazards and knowledge about the safe performance of tasks were pointed out as barriers to workers' more effective participation in the OH&S (Hermanus, 2007).

Parker et al. (2017) sought to develop a multilevel measurement instrument in order to deal with the contemporary challenges of the mining industry in Australia by measuring the perception of the impact of multiple factors on OH&S, with particular emphasis on health issues. The results of this research indicate that the positive perception of employees about OH&S is influenced by the safety climate created by managers, supervisors and co-workers, and therefore affects the behavior of individuals themselves and the development of behavior patterns based on health and safety. Antecedents of workers' safety performances were studied by Hadjimanolis et al. (2015). The findings suggest that many organizational practices, such as safety training provided by the firm, safety information available to workers, participation in safety decisions and organizational commitment, are positively correlated with the organization's safety performance.

Research indicates that OH&S management is complex and dynamic and depends on multiple factors. There are numerous interdependencies between the components of OH&S factors, among which it is impossible to bypass management and its commitment to the implementation of OH&S practices, communication about the importance of health and safety, and the attitudes and participation of workers in creating a safety environment (Mohammadfam et al., 2016).

The current research is focused on large mining companies in Serbia that employ, according to the Republic Institute of Statistics, about 30 000 workers. The goal is to propose and test measurement instruments for Organizational factors affecting Occupational Health and Safety, which will examine the current and emerging problems of the mining sector. The effects of organizational factors will be measured through the proposed tool by measuring workers' attitudes in mining companies. Such a measuring instrument can provide a comprehensive overview of OH&S practices and indicate the different levels of responsibility for their implementation, whether it is managers, supervisors or workers.

The following steps were taken to design and test theoretical constructs:

1. An items pool was created based on previous similar research.
2. The factor structure was examined using Exploratory Factor Analysis (EFA) through the use of SPSS (v.25).
3. The factor structure was confirmed by conducting Confirmatory Factor Analysis (CFA) with AMOS (v.22).

### **3. RESEARCH METHOD**

An extensive literature review revealed various relevant indicators for measuring the Organizational aspect of Occupational Health and Safety (Zohar & Luria, 2005; Milijic et al., 2013; Haas & Yorio, 2016; Parker et al., 2017). The goal is to define the main indicators and constructs in order to determine a representative measurement scale. After choosing the initial list of possible indicators, experts - participants of the SmartMiner project iteratively evaluated them. In that process, 35 organizational indicators were selected. Based on the literature review, several organizational factors were assumed, as explained in the text above. All the proposed measures were included in a questionnaire that had to be filled out by workers in mining

companies. The respondents expressed their views of the proposed measures on a five-point Likert scale.

The table Sample size for  $\pm 10\%$  precision level where confidence level is 95% and  $P=0.5$  was used to determine the required sample for testing the proposed scale (Israel, 1992; Singh & Masuku, 2014). According to the sample size table, a sample size of 100 subjects is sufficient to test large populations. In order to obtain an adequate number of properly completed surveys, oversampling was applied, and the surveys were sent to respondents from several mining companies in the territory of the Republic of Serbia by random selection.

Finally, the sample for testing the proposed measuring instrument consisted of 106 respondents, the demographic structure of whom is presented in Table 1.

Table 1. Demographic structure of the sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Age	Less than 25 years old	7	6.7	6.7	6.7
	Between 26 and 35 years old	29	27.6	27.6	34.3
	Between 36 and 45 years old	32	30.5	30.5	64.8
	Between 46 and 55 years old	22	21.0	21.0	85.7
	More than 56 years old	15	14.3	14.3	100.0
Gender*	Male	85	81.0	92.4	92.4
	Female	7	6.7	7.6	100.0
Level of education	Semi-qualified	4	3.8	3.8	3.8
	Qualified	11	10.5	10.5	14.3
	Secondary education	61	58.1	58.1	72.4
	Higher vocational	21	20.0	20.0	92.4
	Magistracy/Master's degree	6	5.7	5.7	98.1
	Doctoral degree	2	1.9	1.9	100.0
Total work experience (years)	Under 5 years	19	18.1	18.1	18.1
	Between 5 and 10 years	20	19.0	19.0	37.1
	Between 11 and 15 years	15	14.3	14.3	51.4
	Between 16 and 20 years	15	14.3	14.3	65.7
	Between 21 and 25 years	10	9.5	9.5	75.2
	Between 26 and 30 years	10	9.5	9.5	84.8
	More than 31 years	16	15.2	15.2	100.0
Position in the organization*	Operational management	33	31.4	32.7	32.7
	Operator of working machines	49	46.7	48.5	81.2
	Maintenance worker	19	18.1	18.8	100.0
In my career I experienced an injury at work	No	76	72.4	73.1	73.1
	Yes	28	26.7	26.9	100.0

\*There is missing data in the dataset as some of the respondents did not declare their information.

In order to determine the factor structure, an Exploratory Factor Analysis (EFA) was conducted, where all items (35 questions) were tested. First, the suitability of the sample for factor analysis was checked. Kaiser–Meyer–Olkin (KMO) test has a high value of 0.889, while Bartlett's test of sphericity is statistically significant ( $p < 0.001$ ), which confirms the adequacy of the sample (Ho, 2006; Coakes, 2013). Principal Component Analysis and varimax rotation with Kaiser normalization as the rotation method were used for factor extraction (Coakes, 2013). As criteria for selecting indicators, the cut-off of 0.50 for factor loading was used, and items with significant loadings on more than one factor were removed (Ho, 2006). Five factors with 21 indicators were extracted, which can explain 82.09% of the variance in the proposed model. The Cronbach's  $\alpha$  coefficient values were analyzed against the recommended value of

0.7 to check the internal reliability of the obtained factors. The results of EFA and Cronbach's  $\alpha$  values are presented in Table 2.

Table 2. Extracted factors and Cronbach's  $\alpha$  values

	Factors				
	1	2	3	4	5
Org 1	.922				
Org 2	.942				
Org 3	.943				
Org 4		.910			
Org 5		.724			
Org 6		.891			
Org 7		.925			
Org 8		.910			
Org 9			.898		
Org 10			.900		
Org 11			.942		
Org 12				.912	
Org 13				.931	
Org 14				.928	
Org 15				.923	
Org 16				.848	
Org 17					.786
Org 18					.801
Org 19					.887
Org 20					.897
Org 21					.863
<b>Cronbach's <math>\alpha</math></b>	.929	.922	.897	.947	.898

Based on the literature, the grouped indicators are defined in the following organizational factors: O1- Co-worker support; O2-Supervisor support; O3-Trainings related to safety and health at work; O4-Management commitment; O5-Rules and procedures on safety at work. In order to validate the obtained factors, a Confirmatory Factor Analysis (CFA) was carried out using AMOS. The obtained results are presented in Figure 1 and Table 3.

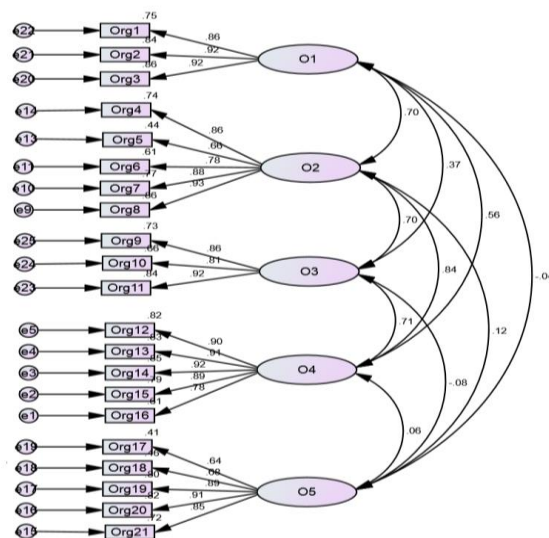


Figure 1. CFA model in AMOS

Table 3. Results of CFA

		Standardized factor loading	Standard error	t value	R <sup>2</sup>	CR	AVE
O1	Org1	0.864	0.07	13.149***	0.746	0.929	0.814
	Org2	0.916	0.066	15.008***	0.84		
	Org3	0.925			0.855		
O2	Org4	0.86	0.064	13.5***	0.74	0.914	0.683
	Org5	0.661	0.079	8.318***	0.437		
	Org6	0.78	0.084	10.726***	0.608		
	Org7	0.876	0.064	13.993***	0.768		
	Org8	0.928			0.862		
O3	Org9	0.857	0.084	12.57***	0.734	0.898	0.746
	Org10	0.812	0.089	11.324***	0.66		
	Org11	0.919			0.844		
	Org12	0.903	0.109	10.658***	0.816		
	Org13	0.909	0.108	10.761***	0.827		
O4	Org14	0.923	0.106	10.99***	0.852		
	Org15	0.888	0.09	12.719***	0.789		
	Org16	0.779			0.607		
	Org17	0.637	0.122	7.053***	0.405		
O5	Org18	0.679	0.111	8.042***	0.461	0.898	0.641
	Org19	0.894	0.098	11.688***	0.8		
	Org20	0.907	0.088	11.934***	0.823		
	Org21	0.848			0.719		

\*\*\* statistical significance at the 0.001 level

The observed standardized factor loadings have high values as well as t values with statistical significance  $p < 0.001$ . Values of critical ratio (CR) are calculated to confirm composite reliability. Hair et al. (2014) suggested CR values of 0.60 and above to verify that all indicators represent the investigated construct consistently. Average variance extracted (AVE) is used to assess the convergent validity of constructs, the value of which should be above 0.50 (Hair et al., 2014). According to the data presented in Table 3, it can be concluded that composite reliability and convergent validity of constructs have been demonstrated. High R<sup>2</sup> values mean that predictors explain a high percentage of their variances.

The discriminant validity of the proposed measuring instrument is checked based on the ratio of correlations between the obtained constructs and the square root of AVE. The condition of discriminant validity is that the correlations between two constructs should be less than the connected square root of the AVE (Hair et al., 2014), which is confirmed by the results presented in Table 4.

Table 4. Discriminant validity of constructs

	O1	O2	O3	O4	O5
O1	<b>0.902</b>				
O2	0.696	<b>0.826</b>			
O3	0.371	0.7	<b>0.864</b>		
O4	0.371	0.843	0.71	<b>0.882</b>	
O5	-0.044	0.118	-0.084	0.06	<b>0.801</b>

CFA in AMOS also allowed analysis of the fit of the entire model through several goodness of fit criteria. Fit indices CMIN/DF=1.70 CFI=0.942, IFI= 0.943, TLI= 0.929, RMSEA=0.083 are considered acceptable (Hair et al., 2014; Alavi et al., 2020).

Considering the results of EFA and CFA, it can be concluded that an instrument for measuring the organizational factors of OH&S has been obtained.

#### **4. DISCUSSION**

This study aimed to define, create and test a measuring instrument that can be used to evaluate the organizational aspect of OH&S in the mining industry. First, a question pool was created based on the literature review, which was distributed as a questionnaire to respondents - workers in mining companies to express their attitudes on OH&S practice. The pilot survey included 106 workers in the mining sector in the Republic of Serbia. Both EFA and CFA were conducted to check the validity and reliability of the resulting measurement instrument.

The results of the analysis indicate that the organizational component of OH&S is a multidimensional construct consisting of five factors that can be measured with 21 items. Factors such as O1-Co-worker support, O2-Supervisor support, and O4-Management commitment were recognized in several studies (Parker et al., 2017; Nyoni et al., 2019). Within factor O1, "Co-worker support", questions related to confidence, communication and help workers receive from their colleagues concerning OH&S were grouped. The group of questions within factor O2, "Supervisor support", presupposes all expected activities undertaken by immediate supervisors to bring closer, demonstrate and empower workers to act according to OH&S practices. Factor O3, "Training related to safety and health at work", has been recognized in the research of Haas and Yorio (2016) and Nyoni et al. (2019), indicating employees' positive attitudes about OH&S training. Factor O4, "Management commitment", recognized by analysis, is the involvement of operational and higher levels managers in activities to create a safe working environment and improve safety culture. O5, "Rules and procedures on safety at work", as a factor was recognized in the works of Haas and Yorio (2016) and Nyoni et al. (2019). However, the items that were singled out within this factor in this research mostly had negative connotations because the questions refer to cases of non-compliance with OH&S procedures, and therefore, the correlation results with other factors have weak or negative values.

#### **5. CONCLUSION**

The use of both inductive (EFA) and deductive (CFA) techniques to discover an adequate factor structure allowed a comprehensive and reliable identification of Organizational OH&S factors. The findings presented in this paper may be helpful in more extensive research into the attitudes of workers in the mining industry toward OH&S practices. After identifying organizational factors related to OH&S, the next step in the research can be an examination of the degree of their influence on workers' behavior concerning safety as well as satisfaction at the workplace. Consequently, the interests can focus on insights into the effects of OH&S on various performances. Also, this paper did not examine the potential relationships of organizational factors with other factors, such as technical or human factors, that can significantly affect OH&S in mining companies. Future research addressing these relationships can significantly contribute to understanding obstacles and ways to accept OH&S management and practices and promote sustainable mining operations.

#### **ACKNOWLEDGMENT**

Part of this research was supported by the Science Fund of the Republic of Serbia, #GRANT No. 5151, Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces – SmartMiner.

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