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Ljubiša Balanović
Dejan Tanikić

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

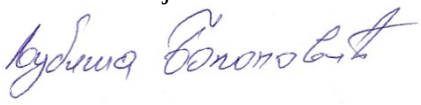
We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović



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CIRCULAR ECONOMY IN THE ERA OF INDUSTRY 5.0

Isidora Milošević[1], Anđelka Stojanović[1], Sanela Arsić[1], Ivica Nikolić[1], Ana Rakić[2]

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Abstract

The circular economy is an emerging concept based on the circulation of materials in the economy, in which waste is recycled, reused, or repaired. By recycling waste, new raw materials are obtained from which products or certain materials can be made, and devices can have alternative uses. A circular economy is needed to change outdated business practices based on a linear production-consumer paradigm into creative, innovative semi and final products. Industry 5.0 puts people at the center of the production process and uses innovative technical advances to ensure a sustainable and resilient path to smart manufacturing. Therefore, the circular economy and Industry 5.0 lay the foundations of intelligent and sustainable production based on real-time data collection, contributing to society's smart industry. This paper examines whether companies need to transform from a linear production-consumer paradigm to a circular economy to achieve sustainable development in the era of the new industrial revolution known as Industry 5.0.

***Keywords**: Circular economy, Industry 5.0, Sustainable development, Transform*

1. INTRODUCTION

Traditional business practice based on a linear production-consumption paradigm is a concept that remains behind us [1]. As an alternative to this traditional model, an approach that transforms the use of resources, known as the Circular Economy (CE), appears [2]. Therefore, the Circular Economy is a concept based on the circulation of materials in economics. It refers to the production and consumption of goods in a closed material flow cycle [3] in order to achieve the maximum efficiency of the use of limited resources with a gradual transition to renewable resources and the reuse of materials and products at the end of their life cycle [1]. The basic principles of the circular economy are efficient use of material resources, waste collection, recycling, and reuse in production. By applying these principles, organizations can manage their resources more effectively through cost savings, finding new income streams, becoming more resistant to external disturbances, etc. [4]

With the transformation of the production-consumption paradigm into a circular economy, a parallel transformation of the industrial paradigm into a socio-technological one is imposed [5]. This phenomenon, known as Industry 5.0, could be described as a "humanized vision of technological transformations in the industry" [6], which supports the circulation of materials in the economy, balancing the needs of society with the sustainable optimization of energy consumption and the extension of the product lifecycles. In that manner, Industry 5.0 puts people at the center of the production process and uses innovative technical advances to ensure a sustainable and resilient path to smart manufacturing [7, 8]. Therefore, Circular Economy and Industry 5.0 lays the foundations of intelligent and sustainable production based on real-time data collection, contributing to society's smart industry [4, 9].

Although many studies have dealt with the Circular Economy in the fourth industrial revolution era [10, 11, 12, 13], this relationship in the context of the Circular Economy and Industry 5.0 is almost unexplored in the literature. This paper step further with the existing academic literature in

order to fill this gap. Hence, the research examines whether companies need to transform from a linear production-consumer paradigm to a circular economy to achieve sustainable development in the era of the new industrial revolution known as Industry 5.0.

2. METHODOLOGY

2.1 Sample and collection of data

This study investigated whether companies need to transform from a linear production-consumer paradigm to a circular economy to achieve sustainable development in the era of the new industrial revolution known as Industry 5.0. Therefore, the online questionnaire was utilized and distributed to companies through LinkedIn in the second half of 2022. A total of 205 respondents participated in the research. The target group of respondents consisted of all employees of companies in Serbia. The need for a transition from a linear to a Circular Economy was measured, consisting of seven indicators displayed in Table 1.

Table 1 - Defined variables

Measurement	Variables	Label
Circular Economy	The company should provide an active response to environmental challenges	CE1
	The resources necessary for the functioning of the economy are constantly decreasing	CE2
	The electricity sources available to the economy are constantly decreasing	CE3
	The company has an increasing need for energy	CE4
	The waste generated by the economy is constantly increasing	CE5
	The emission of green gases generated by the economy is constantly increasing	CE6
	Customers increasingly choose products from ecological companies	CE7

2.2 Analysis and research results

Exploratory factor analysis (EFA) is a statistical method used to describe the variability among observed, correlated variables. For this research, EFA was employed to summarize the information contained in a more significant number of observable variables into a smaller number of latent variables, i.e., to define the items of the factor determining the measurement scale for Circular Economy. The summary statistic of the examined variables was implemented on 205 respondents, and obtained values are shown in Table 2.

Table 2 - Statistics of the examined variables

Measurement	Label	Mean	Std. Deviation	Factor loadings
Circular economy	CE1	3.849	1.010	0.920
	CE2	3.817	0.883	0.898
	CE3	3.892	0.902	0.851

	CE4	3.913	0.880	0.787
	CE5	3.784	0.942	0.908
	CE6	3.978	0.820	0.767
	CE7	3.871	0.862	0.798

The results of PCA, the reliability of measurement scales, and convergent validity (AVE) are depicted in Table 3. The presented results indicate that the data collected are adequate for carrying out the factor analysis, given that Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO test) values are above the recommended threshold value of 0.6 [14]. The obtained values of factor loadings are very high and give substantial weight to the selected factor. Also, the reliability of the measurement scale was applied to establish internal consistency and confirmed by Cronbach's Alpha coefficient [15]. The recommended values the internal consistency are above 0.7 [16]. The obtained value of Cronbach Alfa coefficient is 0.935, which is a very satisfying value, and the internal consistency is confirmed. Also, convergent validity is proved, indicated by AVE values greater than recommended values above 0.5 [14]. Finally, correlation analysis was utilized to examine whether there is a relationship between two variables or two data sets (Table 3). Correlation analysis was used to determine whether there is a relationship between two variables or two data sets (Table 3). The results of the correlation analyze was discovered that there is a significant correlation among variables.

Table 3 - Measurement scales and Correlation Matrix

Measurement	KMO Test	% of variance explained*	Cronbach's Alpha	The average variance extracted (AVE)
Circular economy	0.884	72.086	0.935	0.721

CE1	1						
CE2	0.857	1					
CE3	0.757	0.793	1				
CE4	0.609	0.650	0.631	1			
CE5	0.868	0.813	0.765	0.633	1		
CE6	0.665	0.579	0.452	0.614	0.626	1	
CE7	0.664	0.596	0.624	0.572	0.647	0.672	1

3. CONCLUSION

Until a few decades ago, the concept of Circular Economy was not applicable since the existing technology could not support its application. However, with the development of a new industrial revolution known as Industry 5.0, the importance of research and innovation to support the industry in its long-term service to humanity is emphasized. Considering that the existing economic model imposed a disposable lifestyle, which needs to be stopped, this paper has established a nuanced link between Circular Economy and Industry 5.0.

With the idea to analyze the companies' need to transition from a linear to a Circular Economy, this paper suggests a set of indicators that could be used for reliable assessment applicable to the

Circular Economy. Furthermore, these indicators could serve managers and other decision-makers in companies to develop a roadmap for implementing the circular economic business model in its operations to achieve sustained economic growth.

This study has some limitations. The main limitation is the measurement scale which was not cover all research questions that reflect the need to transform from a linear to a circular economy. Therefore, future investigations will be focused on expanding the listed questions. Also, it would be useful to study the relationships between Industry 5.0 and the Circular economy in specific industry sectors to study circularity within their sphere of operation.

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REFERENCES

[1] D. Ubavin. Man. Sys. and Techn. for the N. Fron., (2018) 537-542.
[2] S. Sauvé, S. Bernard, P. Sloan, Environ. Dev. 17 (2016) 48-56.
[3] M. Haradhan. J. of Ec. Dev. Environ. and Peop. 9 (3) 2020 38-62.
[4] K. Voulgaridis, T. Lagkas, C.M. Angelopoulos, S.E. Nikoletseas. Comp. Net. (2022) 219.
[5] Barataa, J., &, Kayser, I., Proc. Comp. Sci. 219 (2023) 778–788.
[6] J. Lindström, E. Lejon, P. Kyösti, M. Mecella, D. Heutelbeck, M. Hemmje, M. Sjödahl, W. Birk, B. Gunnarsson. Proc. CIRP. (2019) 880–885.
[7] P.K.R. Maddikunta, Q.V. Pham. J. of Ind. Infor. Integ. 26 (2022) 100257.
[8] X. Xu, Y. Lu, B. Vogel-Heuser. J. of Man. Sys. 61 (2021) 530–535.
[9] European Commission. (2021) https://ec.europa.eu/info/research-and-innovation/researcharea/industrial-research-and-innovation/industry-50_en.
[10] D. Findik, A. Tirgil, F.C. Özbuğday. J. of Clean. Prod. (2021) 410.
[11] Y. Ren, R. Li, K. Wu, M. Tseng, Clean. and Respons. Consump, 9 (2023) 100123.
[12] A. Behl, R. Singh, V. Pereira, B. Laker. Technol. Forecast. Soc. 189 (2023) 122363.
[13] A. Upadhyay, K. C. Balodi, F. Naz, M. Di Nardo, L. Jraisat. (2023). Comput. Ind. Eng. 177 (2023) 109072.
[14] A. Upadhyay, K. C. Balodi, F. Naz, M. Di Nardo, L. Jraisat. (2023). Comput. Ind. Eng. 177 (2023) 109072.
[15] J.F. Hair, W.CBlack, B.J. Babin, R.E. Anderson, Pearson Education Limited, Harlow, England and Associated Companies throughout the world 2014.
[16] L.J. Cronbach. Psychom. 16 (1951) 297-334.
[17] J.C. Nunnally, I. Bernstein, J.T. Berge, New York: McGraw-Hill 1967

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