sciendo CzOTO 2023, volume 5, issue 1, pp. 66-74

THE ROLE OF LEADERSHIP IN INDUSTRY 4.0

doi: 10.2478/czoto-2023-0008
Date of submission of the article to the Editor: 15/10/2023
Date of acceptance of the article by the Editor: 06/12/2023

Inna Balahurovska[2] – *orcid id: 0000-0003-3642-9506*
Joint Doctoral School, Silesian University of Technology, 44-100 Gliwice, **Poland**
Department of Applied Social Sciences, Faculty of Organization and Management, Silesian University of Technology, 26 Roosevelt 26 Street, 41-800 Zabrze, **Poland**
Department of Management, Sumy State University, 2, Rymskogo-Korsakova st., 40007 Sumy, **Ukraine**

Abstract: In modern society, the use of technology occurs constantly, and it is already impossible to imagine human life without it. The spread and implementation of artificial intelligence in social processes form a specific interaction between this technology and society. Achieving only positive results from using intelligent software and systems requires awareness and responsibility from people when interacting with smart machines. The managerial responsibility of the leader when using artificial intelligence is an important topic of modern management.
The article examines the role of artificial intelligence in the fourth industrial revolution era and considers statistical forecasts regarding its future impact on various spheres of human activity. The author analyzed the features of leadership in modern conditions of technology development and substantiated the specific role of a leader who uses the functions of artificial intelligence in management activities. The author proposed a hierarchical scheme of interaction of the participants of the production process in the organization, which arises when using intelligent systems to achieve the set goals.
The main result of the work is the development of a scheme that reveals the need for the formation of a structure in the interaction of the organizational system with the technological potential of artificial intelligence. Using the proposed scheme by practitioners-managers will make it possible to use the latest technological developments as efficiently and safely as possible.
Keywords: leadership, artificial intelligence, leadership 4.0

1. INTRODUCTION

The development of information and communication technologies and their implementation in all spheres of social life during the third digital revolution became the beginning of the fourth industrial revolution. The concept of the Industry 4.0 era is the maximum automation of production processes in the industry. An essential technology of the fourth industrial revolution is artificial intelligence. The use of artificial intelligence systems occurs in almost all processes at enterprises. The introduction of intelligent

software and systems ensures the economic development of various spheres of people's social activity.

An essential role in using artificial intelligence tools in the organization belongs to the leader, who can influence the obtaining of beneficial results from using smart machines to achieve the set goals. Integrating intelligent systems into the various production processes of the enterprise and obtaining the necessary results of management activity requires excellent attention from the leader to the observance of social norms for the development of a team of followers. The specific direction of the proposed research in management science is the study of the theoretical foundations of observing the hierarchy of the main participants of the human-technology interaction: the leader as a representative of the organization and artificial intelligence as a technology for the organization's development. Understanding the relevant role of a leader who manages a socio-technical system (organization) to achieve set goals in the era of digitalization is an essential element in the formation of economically developed enterprises today.

The role of persuasive leadership, especially appreciated by the so-called "*Generation Z*" can be strongly strengthened by the use, especially in written materials, of AI tools that are increasingly entering the area of industrial applications. This will be of great importance in the implementation of organizational (Bilan et al., 2022) and pro-ecological solutions such as new materials (Bajdur et al., 2016), wind turbines (Kasner et al., 2019) and renewable energy (Skowron et al. 2023), fire protection in transport (Radek and Dwornicka, 2020), or solutions in construction (Djokovic et al., 2022). Among the more typical issues related to Industry 4.0 (Pietraszek et al., 2020), these include maintaining quality assurance systems (Mazur, 2018), logistics and quality in heavy industry (Ulewicz et al., 2020), but also the social effects of automation (Kuzior, 2022). Possible solutions should be sought not only in the area of economic and social sciences, but also by implementing new, cheaper and less harmful material solutions (Ulewicz et al., 2013; Kuciel et al., 2019) as well as new technological (Radek et al., 2018) and analytical methods (Gadek-Moszczak and Zmudka, 2013; Mazur et al., 2021).

The **methodology** employed in this research aims to investigate the nuanced interaction between human-leaders and artificial intelligence systems in organizational settings. The study seeks to provide insights into how leaders engage with artificial intelligence, the impact on decision-making processes, and the dynamics of collaboration between human and machine intelligence. A comprehensive analysis of existing scientific works devoted to leadership, artificial intelligence, and their interaction indicates that previous studies focused on the need for constant participation and control by the manager at all stages of the use of technology in the organization in order to comply with social norms during the integration of intelligent systems into production processes (Cao et al., 2021; Mogaji et al., 2021; Akyüz et al., 2021; Kuzior et al., 2023; Ingaldi and Ulewicz, 2020). An analysis of statistical data on the potential impact of artificial intelligence in different sectors was carried out to understand the importance of using artificial intelligence to increase productivity and optimize production processes in the organization. The author reviewed the key aspects and principles of leadership 4.0. In a schematic form, the hierarchy of the leader's interaction with artificial intelligence in the performance of the organization's tasks is presented.

2. INDUSTRY 4.0 AND ARTIFICIAL INTELLIGENCE

Industry, as a sphere of economic activity of society and the basis of industrialization of the economy, is characterized by a high technological level of material production, which has a decisive effect on the development of productive forces. The development of the

technological level of production processes is the cause of "industrial revolutions" (Lasi et al., 2014; Kuzior et al., 2019; Vasylieva et al., 2021; Ingaldi and Klimecka-Tatar, 2023; Mohamad et al., 2022). The First Industrial Revolution began in England in about 1750–1760 and lasted between 1820 and 1840. The mechanization of production processes characterized it (Mohajan, 2019). The Second Industrial Revolution - 1860–1914 - was characterized by the use of electrical energy and the development of electrical communication technologies (Mohajan, 2020). The Third Industrial Revolution began in the 1950s and it continues at present. A feature of this period is the digitization of processes in organizations (Fitzsimmons, 1994). The era of the Fourth Industrial Revolution builds on the third, the digital revolution. It is characterized by a fusion of technologies that blurs the boundaries between the physical, digital, and biological spheres of people's lives (Xu et al., 2018). Industry 4.0 provides automation of processes in organizations. The development trends of Industry 4.0 affect the economic state of society and contribute to transformational changes in the interaction between people and technologies. Through Industry 4.0, intelligent systems would enable the replacement of human beings in specific tasks and ease the working environment (Erboz, 2017; Deja et al. 2023).

A characteristic technology of Industry 4.0 is artificial intelligence, which, broadly, means implementing economical and timely production with the help of digitalization and intelligent machines. (Jan et al., 2022; Klimecka-Tatar and Ingaldi, 2022; Rusly et al., 2021). The technological potential of artificial intelligence improves human capabilities by helping to solve complex problems, analyze large amounts of data, and make decisions in production processes, but does not replace workers.

According to the statistical data of the international auditing and consulting corporation PricewaterhouseCoopers (PwC) (2020), forecasts were made regarding the future impact of artificial intelligence on various areas of human activity. (Table 1). Potential scores range from 1-5, with 5 indicating the highest potential impact due to artificial intelligence, and 1 being the lowest.

Table 1
The potential impact of artificial intelligence in different sectors

Sector/Subsector	**Potential artificial intelligence Consumption Impact**
Healthcare (Providers/Health Services, Pharma/Life Sciences, Insurance, Consumer Health)	3.7
Automotive (Aftermarket & Repair, Component suppliers Personal Mobility as a Service, OEM, Financing)	3.7
Financial Services	3.3
Transportation and Logistics	3.2
Technology, Communications and Entertainment	3.1
Retail	3.0
Energy	2.2
Manufacturing	2.2
Grand Total	3.1

Source: PWC-Sizing the Price

The data presented in Table 1 indicate that artificial intelligence is predicted to become a source of transformations in the economic part of various spheres of human activity. The competitive advantages formed by using technology are powerful and create new conditions for achieving financial results in organizations (Kuzior et al., 2023). Implementing artificial intelligence in the manufacturing process opens up new opportunities for creating innovative products and services, which contributes to the development of organizations. Automation of tasks and processes using the technological potential of artificial intelligence allows for more efficient use of resources and increases the speed of task execution. Integrating artificial intelligence into various processes opens new markets and opportunities to empower organizations by identifying and exploiting niche segments. These factors define artificial intelligence as an essential tool for achieving financial success and stability in organizations where high-speed decision-making and innovation are critical elements of competitiveness.

1. Concept of leadership 4.0

The concept of leadership 4.0 arises in the context of the fourth industrial revolution, characterized by integrating technologies such as artificial intelligence and other digital innovations and new approaches to management (Oberer et al., 2018). Technology interaction with social and ethical aspects is integral to holistic leadership, also reflected in the leadership 4.0 approach. Thus, the concept of holistic leadership influences the formation of leadership 4.0. According to the holistic approach, leadership intelligence includes the following types of intelligence (Gage, 2016) (table 2).

Table 2
Types of intelligence of a leader

№	Intelligence	Definition
1	Emotional intelligence (Goleman, 2011)	A leader with a high level of emotional intelligence can effectively recognize, understand, and manage his own emotions, as well as the emotions of other people; that is, effective communication and cooperation with team members is formed.
2	Social intelligence (Northouse, 2021)	A leader's ability to perceive and understand other people's needs, beliefs, and motivations. Social intelligence allows a leader to effectively interact with different team members, build relationships, and create a positive work environment.
3	Cognitive intelligence (Boyatzis et al.,2012)	It includes the mental abilities of a leader, such as logical thinking, problem-solving, and making quick and effective decisions. Cognitive intelligence is essential for understanding complex situations and leading a team through strategic planning and decision-making.
4	Creative intelligence (Sternberg, 2002)	Ability as a leader to generate new ideas, see opportunities, and develop innovative concepts. Creative intelligence helps the leader find new ways to achieve goals and develop the organization.
5	Ethical intelligence (Alade et al.,2020)	The ability of a leader to a higher level of ethical thinking, making ethically based decisions and taking into account moral aspects in their activities, as well as the ability to show empathy, understand ethical standards, and lead by them.

Source: developed by the author based on (Goleman, 2011; Northouse, 2021; Boyatzis et al.,2012; Sternberg, 2002; Alade et al., 2020)

Therefore, the described types of intelligence can interact and reinforce each other, making the leader more effective in the manager role. Successful leaders often combine types of intelligence to achieve strategic goals and positively impact their team (Rutkauskas et al., 2013; Kuzior et al., 2022). Development and learning in management work as a leader of intelligence will contribute to successful management in today's fast-changing and technologically oriented business environment, ensuring efficiency and supporting the development of its teams. Considering modern technological trends, such as artificial intelligence, digital transformation, and data analytics, leadership 4.0 requires flexibility, agility in management, and the use of advanced technologies to achieve strategic goals.

2. Interaction between a modern leader and artificial intelligence

The interaction between leadership 4.0 and artificial intelligence is determined by the need for leaders to adapt to new conditions and actively use technology to achieve strategic goals (Balahurovska, 2023). The shared use of intellectual resources, including artificial intelligence, facilitates the collective brain work of the team and the adoption of more deliberate decisions (Peifer et al., 2022). Leaders 4.0 can implement collaborative systems with artificial intelligence to increase the efficiency and innovation of the organization's activities. When using intelligent technologies, leaders need to understand that essential aspects of work require human intervention, such as creativity, interpersonal relationships, and solving complex situations. The interaction between the leader and artificial intelligence creates a new standard of leadership, where efficiency and innovation are considered through the prism of modern technologies and a deep understanding of the human factor. Diagram 1 proposes a hierarchy of interaction between the leader and intelligent technologies in the era of Industry 4.0.

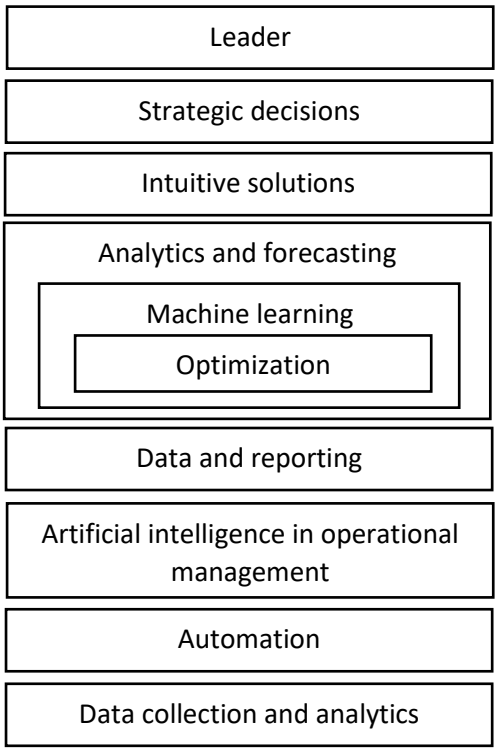

Fig. 1. Hierarchy of interaction between the leader and artificial intelligence

The leader at the highest level of the hierarchy plays a crucial role in determining the strategic directions for the organization's development. He makes strategic decisions,

setting the main goals and defining the overall strategy that will be implemented at all levels of the organization (Shvindina, 2017).

All strategic decisions are subject to analysis and forecasting to provide the leader with information for informed decisions. Analytics and forecasting are critical in making strategic decisions, allowing us to consider objective data and trends.

At the next level of the hierarchy are machine learning and optimization. Technologies are used to automate processes and improve problem-solving. Machine learning allows the system to improve, and optimization aims to achieve maximum efficiency.

Automation represents the implementation of strategic decisions in practice. This level includes automatic execution of tasks and operations, which helps to improve productivity and reduce errors.

The final stage is data collection and analytics, which process and analyze information that provides the leader with the necessary information for further strategic decisions and planning.

The proposed interaction hierarchy shows how the strategic decisions of the leader form the basis for the implementation of technologies and processes at different levels of the organization. The leader not only determines strategic orientations but also acts as a catalyst for introducing technologies and processes that provide the organization with stability and high efficiency in conditions of constant change (Moldenhauer, et al., 2018). The scheme reflects the leadership's contribution to strategic management and its role in implementing technological innovations, which makes the organization flexible and ready for the challenges of the modern business environment.

DISCUSSION

The article presents an analysis of the current state of the use of artificial intelligence in the business environment and identifies key challenges. Discussing the interaction hierarchy of Leader 4.0 and artificial intelligence is a crucial aspect of the research, as it identifies how people and technology can collaborate and complement each other in management processes. From an ethical point of view, the leader is responsible for the social and human aspects of decision-making, including those related to artificial intelligence. Integrating ethical principles into AI algorithms and regularly updating standards can ensure high accountability. Solving ethical issues and moral dilemmas should remain within the leader's competence. The leader defines the ethical standards and responsibilities attached to the AI algorithms, but the resolution of ethical cases always requires human intuition and judgment.

CONCLUSIONS

Leadership plays a crucial role in implementing and successfully using artificial intelligence in organizations. The leader must show a strategic approach and be able to adapt the team to new technological realities. The author describes the leadership qualities necessary for the successful use of artificial intelligence, such as the development of various types of intelligence and the ability to interact with technologies. The study analyzed the importance of creating an effective tandem between leaders and artificial intelligence. A leader must skillfully integrate technology into work processes and effectively manage a team in a fundamentally new context of the modern world.

The described hierarchy of the 4.0 leader and artificial intelligence interaction involves joint work, where each participant contributes their unique competencies. The leader acts

as the leading actor, coordinating the work of intelligent systems. It is the leader 4.0 who distributes tasks between himself and artificial intelligence according to their strengths. Artificial intelligence can be engaged to solve analytical tasks while the leader concentrates on strategic decisions. The leader is responsible for the ethical aspect of decision-making, while artificial intelligence can be included in the control of compliance with ethical standards and safety. Thus, the interaction hierarchy creates a favorable platform for the synergy of human leadership and the intellectual potential of artificial intelligence in modern management.

REFERENCES

Akyüz, A., Mavnacıoğlu, K., 2021. *Marketing and financial services in the age of artificial intelligence*, Financial Strategies in Competitive Markets: Multidimensional Approaches to Financial Policies for Local Companies, 327-340

Alade, K., Windapo, A. O., 2020. *Developing effective 4IR leadership framework for construction organisations,* Engineering, Construction and Architectural Management, ahead-of-print(ahead-of-print). DOI: 10.1108/ecam-07-2020-0576

Bajdur, W.M., Włodarczyk-Makuła, M., Idzikowski, A., 2016. *A new synthetic polymer used in removal of pollutants from industrial effluents*, Desalination and Water Treatment 57(3),1038-1049. DOI: 10.1080/19443994.2015.1043495

Balahurovska, I., 2023. *The Development of Technological Support Organizations as an Indicator of Management Efficienc,* Management Systems in Production Engineering, 31(2), 242–247. DOI: 10.2478/mspe-2023-0026

Bilan, S., Šuleř, P., Skrynnyk, O., Krajňáková, E., Vasilyeva, T., 2022. *Systematic Bibliometric Review of Artificial Intelligence Technology in Organizational Management, Development, Change and Culture.* Business: Theory and Practice, 2022, 23(1), pp. 1–13, DOI: 10.3846/btp.2022.13204

Boyatzis, R. E., Good, D., Massa, R., 2012. *Emotional, Social, and Cognitive Intelligence and Personality as Predictors of Sales Leadership Performance*, Journal of Leadership & Organizational Studies, 19(2), 191–201. DOI:10.1177/1548051811435793

Cao, G., Duan, Y., Edwards, J. S., Dwivedi, Y. K., 2021. *Understanding managers' attitudes and behavioral intentions towards using artificial intelligence for organizational decision-making*, Technovation, 106, 102312, DOI:10.1016/j.technovation.2021

Deja, A., Ślączka, W., Dzhuguryan, L., Dzhuguryan, T., Ulewicz, R. *Green technologies in smart city multifloor manufacturing clusters: A framework for additive manufacturing management*, Production Engineering Archives 2023, 29(4), 428-443

Djoković, J.M., Nikolić, R.R., Bujnak, J., Hadzima, B., Pastorek, F., Dwornicka, R., Ulewicz, R., 2022. *Selection of the Optimal Window Type and Orientation for the Two Cities in Serbia and One in Slovakia*, Energies, 15(1), art.323.

Erboz, G., 2017. *How to Define Industry 4.0: The Main Pillars of Industry 4.0*, Managerial Trends in the Development of Enterprises in Globalization Era, Nitra, 761-767.

Fitzsimmons, J., 1994. *Information technology and the third industrial revolution*, The Electronic Library, 12(5), 295–297. DOI: 10.1108/eb045307

Gage, T., Smith, C., 2016 *Leadership intelligence: Unlocking the potential for school leadership effectiveness,* South African Journal of Education, 36(4). DOI: 10.15700/saje.v36n4a1328

Gadek-Moszczak, A., Zmudka, S., 2013. *Description of 3d microstructure of the composites with polypropylene (pp) matrix and tuf particles fillers*, Solid State Phenomena 197186-191. DOI: 10.4028/www.scientific.net/SSP.197.186

Gadek-Moszczak, A., Zmudka, S., 2015. Description of 3d microstructure of the composites with polypropylene (pp) matrix and tuf particles fillers, Solid State Phenomena 197186-191. DOI: 10.4028/www.scientific.net/SSP.197.186

Goleman, D. 2011. *Leadership: The Power of Emotional Intellegence*, More Than Sound.

Ingaldi, M., Ulewicz, R. 2020, Problems with the implementation of industry 4.0 in enterprises from the SME sector, Sustainability12(1), 217

Ingaldi, M., Klimecka-Tatar, D., 2022. *Digitization of the service provision process - Requirements and readiness of the small and medium-sized enterprise sector*, Procedia Computer Science, 200, 237-246, DOI: 10.1016/j.procs.2022.01.222.

Jan, Z., Ahamed, F., Mayer, W., Patel, N., Grossmann, G., Stumptner, M., Kuusk, A., 2022. *Artificial Intelligence for Industry 4.0: Systematic Review of Applications, Challenges, and Opportunities.* Expert Systems with Applications, 119456. DOI: 10.1016/j.eswa.2022.119456

Klimecka-Tatar, D., Ingaldi, M., 2022. *Digitization of processes in manufacturing SMEs - Value stream mapping and OEE analysis*, Procedia Computer Science, 200, 660-668, DOI: 10.1016/j.procs.2022.01.264

Kuzior, A., 2022. *Technological Unemployment in the Perspective of Industry 4.0 Development*, Virtual Economics, 5(1), 7-23. DOI: 10.34021/VE.2022.05.01(1)

Kuzior, A., Arefiev, S., Poberezhna, Z., 2023. *Informatization of innovative technologies for ensuring macroeconomic trends in the conditions of a circular economy,* Journal of Open Innovation: Technology, Market, and Complexity, 9(1), 10–20. DOI: 10.1016/j.joitmc.2023.01.001

Kuzior, A., Arefieva, O., Kovalchuk, A., Brożek, P., Tytykalo, V., 2022. *Strategic Guidelines for the Intellectualization of Human Capital in the Context of Innovative Transformation*. Sustainability, 14(19), 11937, DOI: 10.3390/su141911937

Kuzior, A., Kwilinski, A., Tkachenko, V., 2019. *Sustainable development of organizations based on the combinatorial model of artificial intelligence*. Entrepreneurship and Sustainability Issues, 2019, 7(2), pp. 1353–1376, DOI: 10.9770/jesi.2019.7.2(39)

Kuzior, A., Sira, M., Brożek, P., 2023. *Use of Artificial Intelligence in Terms of Open Innovation Process and Management,* Sustainability, 15(9):7205. DOI: 10.3390/su15097205

Kuzior, A., Yarovenko, H., Brożek, P., Sidelnyk, N., Boyko, A. Vasilyeva, T., 2023. *Company Cybersecurity System: Assessment, Risks and Expectations,* Production Engineering Archives, 29(4) 379-392, DOI: 10.30657/pea.2023.29.43

Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., Hoffmann, M., 2014. *Industry 4.0,* Business & Information Systems Engineering, 6(4), 239–242. DOI: 10.1007/s12599-014-0334-4

Mazur, K., Gadek-Moszczak, A., Liber-Knec, A., Kuciel, S., 2021. *Mechanical behavior and morphological study of polytetrafluoroethylene (PTFE) composites under static and cyclic loading condition*, Materials, 14(7), art.1712. DOI: 10.3390/ma14071712

Mazur, M., 2018. *Analysis of production incompatibilities and risk level in series production of assembly elements for the automotive industry*, MATEC Web of Conf., 183, art.03011. DOI: 10.1051/matecconf/201818303011

Mogaji, E., Nguyen, N. P., 2021. *Managers' understanding of artificial intelligence in relation to marketing financial services: insights from a cross-country study,* International Journal of Bank Marketing. DOI: 10.1108/ijbm-09-2021-0440

Mohajan, H., 2019. *The First Industrial Revolution: Creation of a New Global Human Era,* Journal of Social Sciences and Humanities, 5(4), 377-387

Mohajan, H., 2020. *The Second Industrial Revolution has Brought Modern Social and Economic Developments*, Journal of Social Sciences and Humanities, 6(1), 1-14

Mohamad, S., Pantamee, A. A., Keong, O. C., Hieu, V. M., Mutira, P., Chong, K. W. 2022. *Impact of industry 4.0 revolution and leadership support on the operational efficiency management of the manufacturing industry in asean countries,* Polish Journal of Management Studies, 25(2), 191-204. DOI:10.17512/pjms.2022.25.2.12

Moldenhauer, L., Londt, C., 2018. *Leadership, artificial intelligence and the need to redefine future skills development,* Kidmore End: Academic Conferences International Limited.

Northouse, P. G., 2021. *Leadership: Theory and Practice*. SAGE Publications, Inc.

Oberer, B., Erkollar, A., 2018. *Leadership 4.0: Digital Leaders in the Age of Industry 4.0,* International Journal of Organizational Leadership, 7(4), 404–412, DOI: 10.33844/ijol.2018.60332

Pietraszek, J., Radek, N., Goroshko, A.V., 2020. Challenges for the DOE methodology related to the introduction of Industry 4.0, Production Engineering Archives, 26(4), 190-194. DOI: 10.30657/pea.2020.26.33

Peifer, Y., Jeske, T., Hille, S., 2022. *Artificial Intelligence and its Impact on Leaders and Leadership,* Procedia Computer Science, 200, 1024–1030.

PwC, 2020. *Sizing the Prize. What's the Real Value of AI for Your Business and How Can You Capitalise?* Retrieved from: https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf

Radek, N., Dwornicka, R., 2020. Fire Properties of Intumescent Coating Systems for the Rolling Stock, Communications - Scientific Letters of the University of Žilina 22(4), 90-96. DOI: 10.26552/com.C.2020.4.90-96

Radek, N., Pietraszek, J., Goroshko, A., 2018. The impact of laser welding parameters on the mechanical properties of the weld, AIP Conference Proceedings, 2017, art.020025. DOI: 10.1063/1.5056288

Rutkauskas, A. V., Stasytyte, V., 2013. *Leadership Intelligence: How to Get there?* Procedia - Social and Behavioral Sciences, 75, 52–61. DOI: 10.1016/j.sbspro.2013.04.007

Rusly, F. H., Talib, Y. Y. A., Hussin, M. R. A., Abd Mutalib, H. 2021. *Modelling the Internal Forces of SMEs digital adaptation strategy towards industry Revolution 4.0*, Polish Journal of Management Studies, 24(1), 306-321. DOI: 10.17512/pjms.2021.24.1.18

Shvindina, H., 2017. *Leadership as a driver for organizational change*, Business Ethics and Leadership, (1), 74–82. DOI: 10.21272/bel.2017.1-09

Skowron, Ł., Chygryn, O., Gąsior, M., Lyeonov, S., Drozd, S., Dluhopolskyi, O., 2023. *Interconnection between the Dynamic of Growing Renewable Energy Production and the Level of CO2 Emissions: A Multistage Approach for Modeling*. Sustainability (Switzerland), 2023, 15(12), 9473, DOI: 10.3390/su15129473

Sternberg, R. J., 2002. *Successful intelligence: A new approach to leadership*. In R. E. Riggio, S. E. Murphy, F. J. Pirozzolo (Eds.), Multiple intelligences and leadership, 9–28, Lawrence Erlbaum Associates Publishers.

Vasilyeva, T., Kuzmenko, O., Kuryłowicz, M., Letunovska, N., 2021. *Neural network modeling of the economic and social development trajectory transformation due to quarantine restrictions during covid-19.* Economics and Sociology, 14(2), pp. 313–330, DOI:10.14254/2071-789X.2021/14-2/17

Xu, M., David, J. M., Kim, S. H., 2018. *The Fourth Industrial Revolution: Opportunities and Challenges,* International Journal of Financial Research, 9(2), 90. DOI: 10.5430/ijfr.v9n2p90