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IMPACT OF ARTIFICIAL INTELLIGENCE INNOVATIONS ON THE LABOR MARKET OF THE EUROPEAN UNION

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Purpose: The aim of this article is to examine whether the use of artificial intelligence by enterprises affects the level of unemployment. Three research questions were posed: RQ1: Is there a statistically significant relationship between R&D expenditure and the unemployment rate? RQ2: Is there a statistically significant relationship between R&D expenditure and the level of AI technology usage? RQ3: Is there a relationship between the use of AI technology by enterprises and the unemployment rate?
Design/methodology/approach: The study considered three variables: the level of AI technology usage in enterprises, the level of unemployment, and the expenditure on research and development (R&D) in individual EU countries. The research area selected is the countries of the European Union. Statistical data available on the Eurostat website www.ec.europa.eu were used for the calculations.
Findings: The presented study did not show a statistically significant correlation between R&D expenditures of individual EU countries and their unemployment rates. However, it confirmed an inversely proportional relationship between R&D expenditures and the level of AI technology usage. No link was found between AI exposure and a decrease in employment in EU countries.
Research limitations/implications: The study's findings are limited by the exclusive use of statistical data from Eurostat and the focus on EU countries, which may not capture the full range of factors influencing the relationship between AI technology usage and unemployment globally.
Practical implications: Policymakers and business leaders in the EU should consider that while increased R&D expenditure may enhance AI technology usage, it does not directly correlate with higher unemployment rates, suggesting that investments in AI can be pursued without immediate concern for increasing technological unemployment
Originality/value: This paper provides new insights into the relationship between R&D expenditure, AI technology usage, and unemployment in EU countries, offering valuable information for policymakers and researchers interested in the economic impacts of AI adoption.
Keywords: Artifical Intelligence (AI), the level of unemployment, labor market, European Union.
Category of the paper: Research paper.

1. Introduction

The rapid increase in interest in the use of artificial intelligence (AI) worldwide raises numerous questions about the impact of this technology on the economy and the economy's ability to adapt to modern AI solutions. The extent of this increase can be demonstrated, among other things, by the number of patents filed in recent years for AI-based solutions. In 2021, as many as 141,240 patents were filed worldwide, more than 30 times the number in 2015 (HAI, 2022, p. 36). The development of the AI market offers organizations the opportunity to increase productivity, improve supply chain efficiency, and enhance customer satisfaction. However, this also raises several concerns. The primary concerns are related to recruitment processes in companies. On one hand, companies are unsure if they can keep up with the demand for AI-skilled labor. On the other hand, there is the question of whether the widespread adoption of AI solutions will drastically reduce the demand for workers, thereby significantly worsening the living standards of many people.

The aim of this article is to investigate whether the use of AI by enterprises affects the level of unemployment. The research area selected is the European Union countries. The calculations were performed using statistical data available on the Eurostat website www.ec.europa.eu.

The topic of AI has also been frequently addressed by scientists. Particularly in recent years, there has been a significant increase in interest. The number of publications found in the Web of Science database under the term "artificial intelligence" was 602 in 2000, 1398 in 2010, and as many as 23,964 in 2022. This group includes publications dedicated to the relationship between AI technology and unemployment levels in current market conditions. However, they primarily focused on new trends in the labor market and the links between the rapid implementation of AI technology and the demand for workers with specific skills and competencies. This study extends existing scientific research on artificial intelligence by presenting the results of research on the correlation between the number of enterprises using AI technology and the level of unemployment in a given country.

2. Literature review

The concern regarding technological unemployment has been known to humanity for a long time. Predictions about unemployment caused by the replacement of human labor with machines were already presented by J.M. Keynes in 1930 (2021, p. A12). His fears that technological development would lead to an increase in the percentage of unemployed people in the 20th century were not confirmed. However, artificial intelligence is a technology that far exceeds previous scientific achievements. In general terms, this concept refers to a not yet

existing computer software that can fully think and act independently. In a narrower sense, artificial intelligence refers to such computer software that uses special algorithmic techniques to find patterns in data and predict future events related to the presented data (Raj, Seamans, 2019, p. 3). The fundamental difference between previous technologies and artificial intelligence is that previous (traditional) algorithms are programmed to perform a task, whereas an AI algorithm is programmed to learn how to perform the task (Bordot, 2022, p. 118).

According to the Artificial Intelligence Index Report 2022 created at Stanford University (HAI, 2022, p. 19), publications related to AI technology produced between 2010 and 2021 were mainly focused on pattern recognition (e.g., Alawneh et al., 2022; Amiri et al., 2022; Song, Fan, 2022), machine learning (e.g., Kuntz and Wilson 2022; Olugbade et al. 2022; Krajcer 2022), computer vision (e.g., Kitaguchi, 2022; Corke et al., 2022; Gumbs et al., 2022), algorithms (e.g., Zhu, Jing, 2022; Ma et al., 2022; Long, Gao, 2022), data mining (Huang et al., 2022; Cai et al., 2022), natural language processing (e.g., Moranding et al., 2022; Shaik et al., 2022), and human-computer interaction (e.g., Shao, 2022; Balmcombe, De Leo, 2022).

As mentioned in the introduction, the topic of the correlation between AI development and unemployment has also been addressed by scientists. In the Web of Science database, a total of 37 entries dedicated to both artificial intelligence and unemployment were found (search path: "artificial intelligence" AND "unemployment," author keywords), of which only 19 entries were published between 2020-2022 (5 in 2020, 8 in 2021, and 6 in 2022). After a literature review, it was found that only 10 publications actually address the impact of AI use on unemployment. The authors' views are presented in Table 1.

Table 1.
Impact of AI on unemployment levels in selected publications

Source	Does AI affect unemployment levels, and if so, how?
G. Kohli (2020)	It will increase the number of jobs as long as employees are continuously educated in new technologies.
W. Naude (2021)	In the short term, it does not increase unemployment, but such an increase is possible in the long term.
J. Mutascu (2021)	With low inflation, it increases unemployment; otherwise, there is no impact.
G. Anakpo, U. Kollamparambil (2022)	No negative impact was found. Further investments in robotics are recommended.
F. Fossen, A. Sorgner (2022)	It has an impact, the direction of which depends on the type of AI solution. Technologies that displace workers contribute to increased unemployment, while technologies that augment the workforce improve employee productivity and thereby positively affect their position in the labor market.
F. Santoni de Sio, T. Almeida, J. van den Hoven (2022)	It is predicted to have an impact. There is no definitive statement on what that impact will be.
F. Bordot (2022)	Increases unemployment.
D. Bailey (2022)	It will increase unemployment (the author focuses on the negatives in the article).
C. Lu, Chia-Hui Lu. (2022)	Decreases unemployment.
V. Nguyen (2022)	Increases unemployment up to a certain inflation threshold, then decreases it.

Source: Own study.

The opinions of researchers are presented chronologically in Table 1, based on the publication date of the articles. As seen, views on the impact of AI technology on employment levels are very divided. According to some experts, artificial intelligence will create more jobs than the market demands. However, for this to happen, people must continuously improve their education to keep up with the ever-evolving technology (Kohli, 2020). The positive impact of artificial intelligence on the job market is also noted by C. Lu and Chia-Hui Lu (2022) and G. Anakpo and U. Kollamparambil (2022). W. Naude (2021) believes that in the short term, AI will not increase unemployment, but emphasizes that such an increase is possible in the long term. Some researchers link the impact of AI on unemployment rates to the level of inflation (Mutascu, 2021; Nguyen, 2022). F. Fossen and A. Sorgner (2022) argue that the type of AI solutions used in organizations is crucial in this matter: some may lead to the creation of new jobs, while others will increase unemployment. F. Bordot (2022) and D. Bailey (2022) present the negative impact of AI on employment levels, whereas F. de Sio, T. Almeida, and J. van den Hoven do not definitively state whether and how artificial intelligence will correlate with unemployment rates.

E. Felten et al. (2019) also studied the impact of AI on employment levels. They created the AIOI index to measure the relationship between artificial intelligence and wages, employment, and labor market polarization. Their research showed that between 2012 and 2019, in occupations strongly related to computer use, greater use of AI technology translated into higher employment growth. Conversely, in the overall analyzed professions, no clear relationship was found between the use of artificial intelligence and employment levels. Thus, the research disproved the notion that the development of AI technology causes an increase in unemployment.

M. Thomas (2022) points out the increasing presence of artificial intelligence technology in human life. This is particularly evident in the following sectors: manufacturing, healthcare, education, media, customer service, and transportation. The development of AI is associated with the emergence of new professions and jobs requiring employees to have knowledge and skills directly related to this technology. In 2021, as many as 3.3% of all job advertisements in the IT sector in the USA were directly related to AI (HAI, 2022, p. 147). According to the AI employment index created by LinkedIn in 2021, the countries most frequently employing in the AI sector are New Zealand, Hong Kong, Ireland, Luxembourg, and Sweden. The percentage of LinkedIn-registered individuals with AI skills who started working for a company specializing in AI technology during the studied period was 2.42%, 1.56%, 1.28%, 1.26%, and 1.24%, respectively (HAI, 2022, p. 142).

3. Methodology

The aim of this article is to examine whether the use of artificial intelligence by enterprises affects the level of unemployment. The research area specified includes the countries of the European Union (current as of January 12, 2023). This relationship was investigated based on three types of data presented in Figure 1.

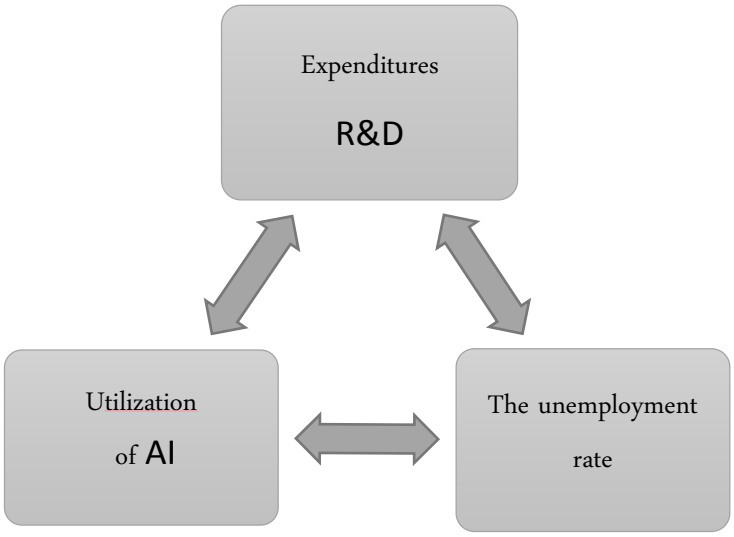

Figure 1. Data used in the study.

Source: Own study.

As shown in Figure 1, the study took into account the level of AI technology usage, the unemployment rate, and the expenditure on research and development (R&D) in individual EU countries. The first two variables directly relate to the study's objective. R&D expenditure data were included to better describe the technological reality of the countries and to deepen the analysis. Three research questions were posed:

RQ1: Is there a statistically significant relationship between R&D expenditure and the unemployment rate?

RQ2: Is there a statistically significant relationship between R&D expenditure and the level of AI technology usage?

RQ3: Is there a relationship between the use of AI technology by enterprises and the unemployment rate?

Document analysis was chosen as the research method. Statistical data available on the Eurostat website www.ec.europa.eu were used, covering: the percentage of enterprises with more than 10 employees using AI technology for 2021, excluding the financial sector (Eurostat, 2022a), the unemployment rate for 2021 (Eurostat, 2022b), national R&D expenditure GERD for 2021 (Eurostat, 2022c), business enterprise R&D expenditure BERD for 2021 (Eurostat, 2022d), and the employment expectation index EEI for November 2022 (Eurostat, 2022e).

For the first four sources (Eurostat, 2022a, 2022b, 2022c, 2022d), data analysis in percentage format was decided upon. The first two sources presented percentage data. Therefore, the GERD and BERD data, which were initially in millions of EUR, were modified. It was decided to adopt the percentage change in expenditure between 2020 and 2021 and between 2012 and 2021, using the expenditure levels from the previous year (respectively: 2012 and 2020) as the baseline for calculating the change. This modification was necessary because currency-form data can be influenced by many additional variables, such as the size of the country. The EEI index, due to the specific way Eurostat calculates it, was left unchanged.

Data obtained from the aforementioned sources were prepared for analysis by standardizing the units and compiled in Table 2.

Table 2.
Data analyzed

Country	UR (%)	UR change 2021-2020 (%)	Companies using AI (%)	GERD: 2021-2020 (%)	GERD: 2021-2012 (%)	BERD: 2021-2020 (%)	BERD: 2021-2012 (%)	EEI
BE	6,3	0,5	10,3	4,71	83,35	6,81	97,97	98,1
BG	5,3	-0,8	3,3	4,9	116,46	2,30	135,43	112,4
CZ	2,8	0,2	4,5	10,96	65,28	14,29	96,42	99,6
DK	5,1	-0,5	23,9	2,33	24,78	3,24	18,26	94,0
GE	3,6	-0,1	10,6	5,88	42,65	5,85	39,78	104,6
EE	6,2	-0,7	2,8	14,57	44,73	16,41	40,48	94,4
IE	6,2	0,3	7,9	-2,04	64,66	5,81	82,91	95,6
EL	14,7	-2,9	4,2	5,65	97,01	8,29	171,52	109,6
ES	14,8	-0,7	7,7	9,39	28,81	10,60	36,68	104,7
FR	7,9	-0,1	6,7	3,92	18,91	3,25	20,77	108,2
HR	7,6	0,1	8,7	15,73	119,73	12,46	123,01	110,9
IT	9,5	0,2	6,2	5,95	29,34	5,25	46,56	108,2
CY	7,5	-0,1	2,6	12,58	143,78	19,09	598,47	103,1
LV	7,6	-0,5	3,7	11,51	58,48	18,27	130,23	98,0
LT	7,1	-1,4	4,5	7,62	108,59	9,48	279,91	99,8
LU	5,3	-1,5	13,0	7,48	31,71	-2,78	10,50	ND
HU	4,1	0	3,0	15,24	101,31	13,74	131,46	100,5
MT	3,4	-1	10,2	10,19	60,36	9,55	75,35	98,3
NL	4,2	-0,7	13,1	4,44	54,37	5,83	84,13	108,2
AT	6,2	0,2	8,8	6,17	39,45	6,17	37,71	103,8
PL	3,4	0,2	2,9	13,16	140,62	13,62	307,93	93,8
PT	6,6	-0,4	17,3	10,16	53,65	14,52	83,06	111,8
RO	5,6	-0,5	1,4	11,22	77,15	13,93	174,77	108,5
SI	4,8	-0,2	11,7	10,87	20,33	11,02	16,63	111,1
SK	6,8	0,1	5,2	9,47	56,92	13,44	112,69	109,0
FI	7,7	0	15,8	8,05	9,65	10,95	9,75	98,5
SE	8,8	0,3	9,9	7,54	29,82	6,85	37,67	103,6

Source: Own study.

The abbreviations of country names in Table 2 are listed in the order of their appearance in Eurostat reports. The individual abbreviations in the column names respectively denote: UR – unemployment rate in 2021, UR Change: 2021-2020 – change in the unemployment rate between 2021 and 2020, GERD: 2021-2020 – percentage change in national GERD expenditure between 2021 and 2020, GERD: 2021-2012 – percentage change in national GERD expenditure

between 2021 and 2012, BERD: 2021-2020 – change in business sector BERD expenditure between 2021 and 2020, BERD: 2021-2012 – change in business sector BERD expenditure between 2021 and 2012, EEI – employment expectations index for managers.

Calculations were performed using Excel and Statistica. Data were considered statistically significant for $p > 0.05$.

4. Research Results

To determine the level of unemployment, the unemployment rate for 2021 (UR), the change in the unemployment rate compared to 2020 (UR Change: 2021-2020), and the employment expectations index for managers (EEI) were used. In the area of R&D expenditure, the change in national GERD expenditure between 2021 and 2020 (GERD: 2021-2020) and between 2021 and 2012 (GERD: 2021-2012), as well as the change in business sector BERD expenditure between 2021 and 2020 (BERD: 2021-2020) and between 2021 and 2012 (BERD: 2021-2012), were analyzed.

To answer the research questions posed, the relationship between R&D expenditure and the unemployment rate, between R&D expenditure and the level of AI technology usage, and the relationship between the use of AI by enterprises and the unemployment rate (as per Figure 1) were examined. Spearman's rank correlation was used. Spearman's R and p values are presented in Table 3.

Table 3.
Spearman's R for individual variables

Variables	R Spearmana	p
GERD: 2021-2020 vs. UR	-0,122231	0,543612
GERD: 2021-2012 vs. UR	-0,213904	0,284014
BERD: 2021-2020 vs. UR	-0,009473	0,962597
BERD: 2021-2012 vs. UR	-0,069977	0,728718
GERD: 2021-2020 vs. UR Change 2021-2020	0,011950	0,952825
GERD: 2021-2012 vs. UR Change 2021-2020	-0,005209	0,979427
BERD: 2021-2020 vs. UR Change 2021-2020	0,070477	0,726852
BERD: 2021-2012 vs. UR Change 2021-2020	-0,039835	0,843615
GERD: 2021-2020 vs. EEI	-0,053028	0,796969
GERD: 2021-2012 vs. EEI	-0,034554	0,866919
BERD: 2021-2020 vs. EEI	-0,111187	0,588684
BERD: 2021-2012 vs. EEI	0,044133	0,830492
GERD: 2021-2020 vs. enterprises using AI	-0,473515	0,012602
GERD: 2021-2012 vs. enterprises using AI	-0,603572	0,000859
BERD: 2021-2020 vs. enterprises using AI	-0,464051	0,014758
BERD: 2021-2012 vs. enterprises using AI	-0,710426	0,000033
Enterprises using AI vs. UR	-0,067237	0,738968
Enterprises using AI vs. UR Change 2021-2020	0,037236	0,853706
Enterprises using AI vs. EEI	0,071856	0,727218

Source: Own study.

The first part of the table refers to research question P1: Is there a statistically significant relationship between R&D expenditure and the unemployment rate? As shown, the analysis did not reveal any significant correlations between these two variables. It is important to consider the multitude of factors affecting the unemployment rate, such as social, political, and economic changes in a given area, pandemic-related restrictions, access to natural resources, and so on.

Question P2 concerned the relationship between R&D expenditure and the level of AI technology usage (the second part of the table). The analysis showed a statistically significant relationship between all types of expenditures (GERD: 2021-2020, GERD: 2021-2012, BERD: 2021-2020, BERD: 2021-2012) and the percentage of enterprises using AI. However, it is surprising that the correlation is negative, meaning that as investment expenditures increase, the percentage of firms using AI technology decreases. It should be noted that the presented data on R&D expenditures refer to general national (GERD) or business sector (BERD) investments in research and development. They do not specifically pertain to investments in AI technology development. Higher expenditures might be allocated to research dedicated to other types of technology used by enterprises that do not utilize AI.

Finally, the main research question P3 was analyzed: Is there a relationship between the use of AI technology by enterprises and the unemployment rate? The study did not find any statistically significant relationships between the percentage of enterprises using AI and the variables adopted to determine the level of unemployment: the unemployment rate for 2021, the change in this rate between 2020 and 2021, and the EEI index, which indicates managers' employment expectations. In other words, there is no evidence of an increase in technological unemployment caused by increased use of artificial intelligence. Thus, the study results do not confirm the analyses by F. Bordot (2022) and D. Bailey (2022), which suggest that AI technology contributes to higher unemployment. At the same time, the analyses presented in this article do not confirm the results described by G. Kohli (2020) and C. Lu and Chia-Hui Lu (2022). At this point, the presented results are closer to the research published by G. Anakpo and U. Kollamparambil (2022), who, due to the lack of observed negative impact, recommend further investments in robotics.

5. Summary

According to estimates by Markets and Markets (2022, p. 7), the AI market is expected to grow at an annual rate of 38-40% from 2021 to 2026, reaching a value of $300-310 billion in 2026 (value in 2021: $55-60 billion). This represents a tremendous growth opportunity for AI solution providers. The projected growth in the BFSI sector is $550-560 million, in telecom & IT $490-500 million, in retail and e-commerce $470-480 million, in healthcare and life sciences $460-470 million, in the automotive and transportation sector $270-282 million,

in government and defense $280-300 million, and in manufacturing $240-254 million. The question of the relationship between the use of AI technology and the level of technological unemployment is therefore extremely relevant and important for both science and enterprises and their employees.

The presented study did not show a statistically significant correlation between R&D expenditures of individual EU countries and their unemployment rates. However, it confirmed an inversely proportional relationship between R&D expenditures and the level of AI technology usage. No link was found between AI exposure and employment decline in EU countries. It is important to note that there are many determinants of unemployment. These include not only the level of technological development but also the legal regulations adopted in a given administrative unit, its size, natural resource deposits, the education level of the population, and social changes. The study considered data from 2021, a period during which the clear impact of the COVID-19 pandemic on the economic indicators of individual countries could be observed. Therefore, further research is needed to determine the degree of human labor replacement by AI technologies. It is also worth comparing the relationship between AI usage levels and unemployment rates in countries from other geographic areas, particularly in countries where AI usage is high, such as New Zealand, Hong Kong, China, and the USA (HAI, 2022, p. 143).

Above all, it is imperative to closely monitor the level of interaction between artificial intelligence and humans, heeding the words of physicist S. Hawking: "Artificial intelligence is shaping the future of humanity across nearly every industry. It is already the main driver of emerging technologies like big data, robotics, and IoT, and it will continue to act as a technological innovator for the foreseeable future" (Thomas, 2022).

References

1. Alawneh, I., Gonorazky, H., Alawnah, S. (2022). C. 2 Muscular MRI pattern recognition for muscular dystrophies: the era of artificial intelligence beyond a systematic review. *Canadian Journal of Neurological Sciences, 49(s1),* S6-S7, doi: 10.1016/j.nmd.2022.07.227.
2. Amiri, M., Jafari, A.H., Makkiabadi, B., Nazari, S. (2022). Recognizing intertwined patterns using a network of spiking pattern recognition platforms. *Scientific Reports, 12(1),* 1-17, doi: 10.1038/s41598-022-23320-8.
3. Anakpo, G., Kollamparambil, U. (2022). Effect of automation on unemployment: The case of Southern Africa. *Development Southern Africa, 39(4),* 516-527, doi: 10.1080/0376835X.2021.1978931.

4. Bailey, D.E. (2022). Emerging Technologies at Work: Policy Ideas to Address Negative Consequences for Work, Workers, and Society. *ILR Review, 75(3),* 527-551, doi: 10.1177/00197939221076747.
5. Balcombe, L., De Leo, D. (2022, February). Human-Computer Interaction in Digital Mental Health. *Informatics, Vol. 9, No. 1.* MDPI, p. 14, doi: 10.3390/informatics9010014.
6. Bordot, F. (2022). Artificial intelligence, robots and unemployment: Evidence from OECD countries. *Journal of Innovation Economics Management, 37(1),* 117-138, doi: 10.3917/jie.037.0117.
7. Cai, Z., Li, H., Cui, W. (2022). Design of Multiobjective Dynamic Software Development Based on Data Mining Algorithm. *Security and Communication Networks*, doi: 10.1155/2022/4444061.
8. Corke, P., Dayoub, F., Hall, D., Skinner, J., Sünderhauf, N. (2019, October). *What can robotics research learn from computer vision research?* The International Symposium of Robotics Research. Cham: Springer, pp. 987-1003, doi: 10.1007/978-3-030-95459-8_61.
9. Eurostat (2022a). *Artificial intelligence by size class of enterprise*, ISOC_EB_AI, https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_AI/default/table?lang=en&category=isoc.isoc_e.isoc_eb, 28.12.2022.
10. Eurostat (2022b). *Unemployment by sex and age – annual data,* UNE_RT_A, https://ec.europa.eu/eurostat/databrowser/product/view/UNE_RT_A, 28.12.2022.
11. Eurostat (2022c). *GERD by sector of performance*, RD_E_GERDTOT, https://ec.europa.eu/eurostat/databrowser/view/RD_E_GERDTOT__custom_1637912/bookmark/table?lang=en&bookmarkId=999ebe67-78b5-4e71-910e-29166b557063, 28.04.2023.
12. Eurostat (2022d). *BERD by NACE*, RD_E_BERDINDR2, https://ec.europa.eu/eurostat/databrowser/view/rd_e_berdindr2/default/table?lang=en, 28.04.2023.
13. Eurostat (2022e). *Employment expectations indicator*, EI_BSEE_M_R2, https://ec.europa.eu/eurostat/databrowser/view/EI_BSEE_M_R2/default/table?lang=en&category=euroind.ei_bcs.ei_bcs_bs, 28.04.2023.
14. Felten, E.W., Raj, M., Seamans, R. (2019). *The occupational impact of artificial intelligence: Labor, skills, and polarization.* NYU Stern School of Business, doi: 10.2139/ssrn.3368605.
15. Fossen, F.M., Sorgner, A. (2022). New digital technologies and heterogeneous wage and employment dynamics in the United States: Evidence from individual-level data. *Technological Forecasting and Social Change, 175,* 121381, doi: 10.1016/j.techfore.2021.121381.
16. Georgieff, A., Hyee, R. (2021), Artifivial intelligence and employment: New cross-country evidence. *OECD Social, Employment and Migration Working Papers, No. 265*, doi: 10.1787/1815199X.

17. Gumbs, A.A., Grasso, V., Bourdel, N., Croner, R., Spolverato, G., Frigerio, I., ..., Elyan, E. (2022). The advances in computer vision that are enabling more autonomous actions in surgery: a systematic review of the literature. *Sensors, 22(13),* 4918, doi: 10.3390/s22134918.
18. HAI (2022). *Artificial Intelligence Index Report 2022*. Stanford University, https://hai.stanford.edu/research/ai-index-2022, 28.04.2023.
19. Huang, Z., Feng, C., Feng, Z. (2022). Analysis of Ideological and Political Classroom Based on Artificial Intelligence and Data Mining Technology. *Wireless Communications and Mobile Computing,* doi: 10.1155/2022/7081165.
20. Keynes, J.M. (2021), Ekonomiczne perspektywy dla naszych wnuków, *Dziennik Gazeta Prawna, no. 255(5408)*.
21. Kitaguchi, D., Watanabe, Y., Madani, A., Hashimoto, D.A., Meireles, O.R., Takeshita, N., ..., Ito, M. (2022). Artificial intelligence for computer vision in surgery: A call for developing reporting guidelines. *Annals of Surgery, 275(4),* e609-e611, doi: 10.1097/SLA.0000000000005319.
22. Kohli, G. (2020). Pitfalls of digitization with respect to traditional businesses and employment. *JIMS8M: The Journal of Indian Management & Strategy, 25(1),* 28-33, doi: 10.5958/0973-9343.2020.00004.6.
23. Krajcer, Z. (2022). Artificial Intelligence in Cardiovascular Medicine: Historical Overview, Current Status, and Future Directions. *Texas Heart Institute Journal, 49(2),* e207527, doi: 10.14503/THIJ-20-7527.
24. Kuntz, D., Wilson, A.K. (2022). Machine learning, artificial intelligence, and chemistry: How smart algorithms are reshaping simulation and the laboratory. *Pure and Applied Chemistry*, doi: 10.1515/pac-2022-0202.
25. Long, W., Gao, Y. (2022). Artificial Intelligence Education System Based on Differential Evolution Algorithm to Optimize SVM. *Scientific Programming,* doi: 10.1155/2022/5379646.
26. Lu, C.H. (2022). Artificial intelligence and human jobs. *Macroeconomic Dynamics, 26(5),* 1162-1201, doi: 10.1017/S1365100520000528.
27. Ma, R., Kareem, S.W., Kalra, A., Doewes, R.I., Kumar, P., Miah, S. (2022). Optimization of Electric Automation Control Model Based on Artificial Intelligence Algorithm. *Wireless Communications and Mobile Computing,* doi: 10.1155/2022/7762493.
28. Market and Markets (2022). *Artificial Intelligence*, https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-market-74851580.html, 28.04.2023.
29. Moranding, P., Maffia, F., Puggioni, F., Motta, F., Vecellio, M., Costanzo, A., ..., Selmi, C. (2022). *POS0294 Artificial intelligence to connect the use of biologics and small molecules in rheumatoid and psoriatic arthritis with a multidisciplinary evaluation: a real world evidence approach through natural-language processing*, doi: 10.1136/annrheumdis-2022-eular.3270.

30. Mutascu, M. (2021). Artificial intelligence and unemployment: New insights. *Economic Analysis and Policy, 69,* 653-667, doi: 10.1016/j.eap.2021.01.012.
31. Naudé, W. (2021). Artificial intelligence: neither Utopian nor apocalyptic impacts soon. *Economics of Innovation and New Technology, 30(1),* 1-23, doi: 10.1080/10438599.2020.1839173.
32. Nguyen, Q.P., Vo, D.H. (2022). Artificial intelligence and unemployment: An international evidence. *Structural Change and Economic Dynamics, 63*, 40-55, doi: 10.1016/j.strueco.2022.09.003.
33. Olugbade, S., Ojo, S., Imoize, A.L., Isabona, J., Alaba, M.O. (2022). A Review of Artificial Intelligence and Machine Learning for Incident Detectors in Road Transport Systems. *Mathematical and Computational Applications, 27(5),* 77, doi: 10.3390/mca27050077.
34. Raj, M., Seamans, R. (2019). Primer on artificial intelligence and robotics. *Journal of Organization Design, 8(1),* 1-14, doi: 10.1186/s41469-019-0050-0.
35. Santoni de Sio, F., Almeida, T., van den Hoven, J. (2021). The future of work: freedom, justice and capital in the age of artificial intelligence. *Critical Review of International Social and Political Philosophy,* 1-25, doi: 10.1080/13698230.2021.2008204.
36. Shaik, T., Tao, X., Li, Y., Dann, C., McDonald, J., Redmond, P., Galligan, L. (2022). A Review of the Trends and Challenges in Adopting Natural Language Processing Methods for Education Feedback Analysis. *IEEE Access*, doi: 10.1109/ACCESS.2022.3177752.
37. Shao, Y. (2022). Human-Computer Interaction Environment Monitoring and Collaborative Translation Mode Exploration Using Artificial Intelligence Technology. *Journal of Environmental and Public Health,* doi: 10.1155/2022/4702003.
38. Song, X., Fan, L. (2022). Pattern Recognition Characteristics and Neural Mechanism of Basketball Players' Dribbling Tactics Based on Artificial Intelligence and Deep Learning. *Mathematical Problems in Engineering,* doi: 10.1155/2022/1673969.
39. Thomas, M. (2022), *The Future of AI: How Artificial Intelligence Will Change the World,* https://builtin.com/artificial-intelligence/artificial-intelligence-future [28.04.2023].
40. Zhu, Z., Jiang, M. The Role of Artificial Intelligence Algorithms in Marine Scientific Research. *Frontiers in Marine Science, 781*, doi: 10.3389/fmars.2022.920994.