

BIBLIOMETRIC ANALYSIS OF ARTIFICIAL INTELLIGENCE IN BUSINESS ECONOMICS

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Summary

Invention of artificial intelligence (AI) is certainly one of the most promising technological advancements in modern economy. General AI reaching singularity makes one imagine its disruptive influence. Once invented it is supposed to surpass all human cognitive capabilities. Nevertheless, narrow AI has already been widely applied encompassing many technologies. This paper aims to explore the research area of artificial intelligence with the emphasis on the business economics field. Data has been derived from the records extracted from the Web of Science which is one of the most relevant databases of scientific publications. Total number of extracted records published in the period from 1963-2019 was 1369. Results provide systemic overview of the most influential authors, seminal papers and the most important sources for AI publication. Additionally, using MCA (multiple correspondence analysis) results display the intellectual map of the research field.

Keywords: *artificial intelligence, business economics, content analysis, bibliometrics, HOMALS.*

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1. INTRODUCTION

Similar to previous technological revolutions artificial intelligence is expected to fundamentally change the way of doing business (Makridakis, 2017). Idea of harvesting a system that could properly understand available data, learn from it and accomplish predefined goals has been a topic of many boardrooms and business forums. Experience from industry, governments and universities have already demonstrated some positive effects of artificial intelligence application (Kaplan & Haenlein, 2019). Digital transformation fueled with development of mobile and Internet technologies have created a new economic environment branded with streamline operations and improved customer experience (Warner & Wäger, 2019). In search for more efficiency businesses have started to open cloud operations. Even some governments have followed this business trend and developed their online platforms. Terms such as e-commerce, e-banking, e-citizens and e-signature have nowadays created entirely new level of efficiency in private and business environment (Dirican, 2015). Implementation of AI may bring many rewards however to avoid negative consequences like job insecurity and rising inequality Nam (2019) has suggested gradual and supervised transition.

This paper aims to derive a systemic view of the AI application in business and economics. Results of the research reveal the most influential authors, seminal papers and the most important sources for AI publication. Additionally, results reveal intellectual structure of the research field.

Remainder of the paper is organized in four sections. Second part of this paper is about previous research examining AI application. Third part of the paper is about methodological approach developed for mapping the research field. Fourth part of the paper demonstrates the results of the research. Conclusion of the paper follows up with short discussion of the relevant findings, limitations and potential future research avenues.

2. LITERATURE REVIEW

There are different types of AI technology and therefore expectations regarding its disruptive nature may considerably vary. According to Kaplan & Haenlein (2019) artificial intelligence may be analytical, human-inspired or even humanized. If mentioned properties are fully utilized its effect may be nothing less than disruptive. Nevertheless, industry leaders are left with little practical advice on how to harvest this potential. AI is typically implemented accompanying other digital technologies. These types of projects are commonly deployed aiming to support existing operations therefore demystifying

exaggerated claims about AI's unprecedented effect (Brock & Von Wangenheim, 2019). Nevertheless, Sremac et al. (2019) explain that highly complex problems with stochastic properties are not easily solved with traditional methods while AI successfully does the challenge. Corea (2019) highlights several areas with positive experience regarding artificial intelligence including speech recognition, financial industry and insurance. According to Fountain, McCarthy & Saleh (2019) AI is being applied in everything from agriculture to banking. Many other industries also place great expectation toward artificial intelligence. AI enhanced machinery is expected to eradicate boring jobs and make the remaining workforce more productive. Interplay of artificial intelligence, robots and human creativity is expected to achieve another level of proficiency (Holford, 2019). Artificial intelligence has enabled conceiving innovations ranging from autonomous vehicles manufacturing to the autonomous enterprise creation (Barro & Davenport, 2019). Velencei claims (2019) that artificial intelligence capabilities are expanding from mechanical and analytical toward thinking. Combination of some AI strands like machine vision, natural language processing, big data and robotics could be used to boost quality of decision making in almost any organization (Kliman & Arinze, 2019). Fountain, McCarthy & Saleh (2019) emphasized that in order to further increase the success of implementing AI organizations should abandon traditional mindset and intensively focus on education of the workforce, accounting for complexity, business readiness and innovation capacity. Intensive implementing of AI without considering its role in innovation of products, services, processes and business models may not necessarily give the best results. Organizational strategy for technological advancement should account for meaningful investments with specific emphasis on the workforce training and necessary skill development (Barro & Davenport, 2019). While the AI is being deeply incorporated into organizational activities importance of emotional intelligence of the workforce is growing and humans are settling with interpersonal skills and empathy. Human workforce has always been an integral part of any organization but since AI is mastering mechanics and analytics importance of emotional intelligence is rising (Huang, Rust & Maksimovic, 2019). This type of approach would make humans valid partners in technological transformation and it would nurture human-oriented organizations (Holford, 2019).

3. METHODOLOGY

Bibliometric data collection was carried out using the *Web of Science Core Collection citation database developed by Clarivate Analytics* including several indexes:

AHCI, BCI-S, BCI-SS&H, CPCI-S, CPCI-SS&H, CCR, ESCI, ESCI B, IC, SCIE and SCCI.

In order to collect the data following query was design: TS="artificial intelligence". First database result included a wide range of records from all research areas encompassing 37613 records. Largest research fields were: Computer science (16520), Engineering (11974), Automation control systems, Telecommunications (1670), Science technology other topics (1508) and Operations research management science (1506). Business economics was the sixth largest research area with 1369 records. Research areas are not mutually exclusive and therefore one record may fit in more than one research area. Nevertheless, in order to closely examine the AI business economics application further specification was given by extracting only those records. Since the field of artificial intelligence is rather dynamic this research includes information not only from academic journals but also proceedings, book reviews, editorials, book chapters, reviews, meeting abstracts, early access, discussions and books covering period from the first Web of science digital records of the topic in 1963 to the present of September 2019. On 17th of September 2019 total number of 1369 records was selected from the Web of Science Core Collection database.

Following the selection of records list of accompanying keywords chosen by authors were extracted from the database output (see Appendix 1). There was total of 3257 unique keywords. In order for the keyword to represent a topic it should appear at least twice in keywords and at least five times in records. List was further examined manually in order to filter general words and phrases not reflecting AI business and economics application. This process generated a total of 176 topics. These topics have been cross-referenced with content of each record containing title, abstract and keywords. Depending on if the topic was found in the content of the record binary value was given to each field connecting database record and selected topic (1 if the topic was found in the record and 0 otherwise). This process created a matrix ((number of topics) x (number of records); 176x1369)) with binary values imported to statistical software to conducted HOMALS procedure for multiple correspondence analysis (MCA). MCA was found very useful in analyzing content data aiming to create the intellectual map of the research field (Furrer et al, 2008; Marzi et al., 2017; Demiroz & Haase, 2019). Procedure derives coordinates for two-dimensional map aiming to visualize the research field of artificial intelligence in the realm of business and economics. Coordinates are based on the number of mutual appearances of the selected topics in the AI database records. Topics appearing closer together create clusters mirroring subfields of the research area (Bendixen, 1995). Based on the topic total number of appearances map of the field was divided in two dimensions: first showing popular topics and second showing emerging topics and

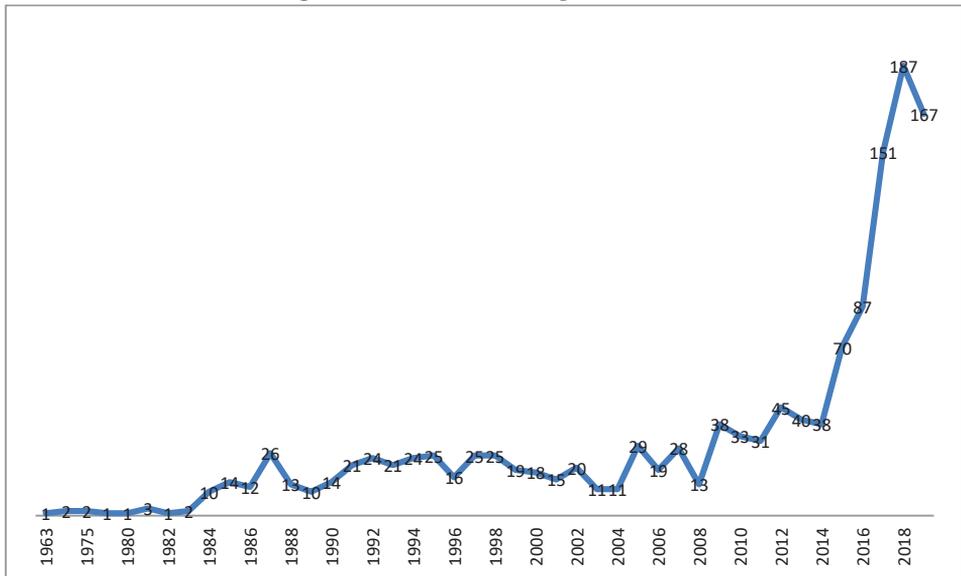
relevant literature gaps. Furthermore, the size of the keyword bubble reflects its relative importance (see the list of keywords in Appendix 1).

By applying this approach results offers stats which are not directly accessible from the database itself and offer insightful intellectual map of the research field body and bibliometric data analysis.

4. RESULTS AND DISCUSSION

Significant increase in the general number of scientific publication may be detected in two periods: one starting in 1990 and second in 2000 (Johnson, Watkinson & Mabe, 2018). Nevertheless, research area of artificial intelligence has proliferated not earlier then 2015 when the number of publication per year doubled reaching 70 records. Since then the number of publications was increasing and in 2017 there was 64 new records (see Figure 1). Total publication of artificial intelligence in the realm of business and economics in the period from 1963 to September 2019 in the Web of Science database has reached 1369 records. This information indicates the novelty of the research area producing intellectual map of the research field may help visualize its development.

Figure 1. Evolution of AI publications



Source: Web of Science, author calculation

Prior to intellectual map of the research field it is very useful to detect the most influential authors, seminal papers and the most important sources outlining the research field. The most cited author was the Tam K. Y. who published two papers. First paper was co-authored with Kiang, M.Y. tackling the use of neural networks for nonlinear discriminant analysis in predicting bank failure (cited 532 times). Tam & Kiang (1992) demonstrated promising properties of neural networks in evaluating bank crisis. Second paper was about genetic algorithms, function optimization, and facility layout design. Tam (1992) argued that genetic algorithms may be used for answering large scale layout difficulties (cited 104 times).

Kiang, M.Y. published two papers. One already mentioned and the other co-authored with Kulkarni, U.R. discussing dynamic grouping of parts in flexible manufacturing systems using a self-organizing neural networks approach (cited 26 times). Kulkarni and Kiang (1995) tested a special type of neural network designed for intelligent grouping of parts and machines. Tool has been proven useful and applicable in flexible manufacturing systems.

Other most cited authors have published only a single paper but nevertheless with highest impact in the research field. Sadeh, Smith, and Swaminathan (1998) explored modeling supply chain dynamics with multi-agent approach. They presented a contribution in methodology improvement for simulation and management decision in creating more effective supply chains systems (cited 405 times).

Jain & Meeran (1999) took a subset of job scheduling problems and provided a historical summary of applied approaches and scholars involved in deterministic job-shop scheduling (cited 385 times).

Chen & Das (2007) tried to perform sentiment extraction from Yahoo small talk. This being a hard semantic problem they used a combination of various classifiers combining with voting schemes. Due to similar accuracy of Bayesian method they recommend using approach for sentiment estimation regarding press release, board announcements, third party news and regulation change (cited 331 times).

Finally, Marco, Varetto, & Altman (1994) compared the results of linear discriminant and logit analyses with neural networks for detecting corporate distress. In the period 1982-1992 procedure was applied to thousand companies including high and low quality subjects. Accuracy was over 90% but authors emphasize the black-box problem and training overfitting with a negative impact on later prediction (cited 330 times) (see Table 2).

Table 1. List of 10 most influential authors

Author	Number of papers	Minimun citation	Max citation	Cumulative
Tam, KY	2	104	532	636
Kiang, MY	2	26	532	558
Sadeh, NM	1	405	405	405
Smith, SF	1	405	405	405
Swaminathan, JM	1	405	405	405
Meeran, S	1	385	385	385
Jain, AS	1	385	385	385
Chen, MY	1	331	331	331
Das, SR	1	331	331	331
Marco, G	1	330	330	330
Varetto, F	1	330	330	330
Altman, EI	1	330	330	330

Source: Web of Science, author calculation

Some of seminal papers are already mentioned as the work of the most influential authors and others are presented in the following section. LeBaron, Arthur & Palmer (1999) used computer simulated artificial stock market where bidding was done by the AI traders. Prices were given endogenously and goal was to clear the market. Aim of the research was to confirm the features found in the real stock markets. Prices followed fundamental and technical principles. Volatility hysteresis and leptokurtosis were also present. Furthermore, agents were able to acquire rational expectations equilibrium (cited 320 times).

Zhang et al. (1999) examined the general framework and cross-validation analysis of the artificial neural networks in bankruptcy prediction. They claim that neural networks give superior results against logistic regression (cited 272 times).

Storer, Wu & Vaccari (1992) explored new search spaces for sequencing problems applied to job shop scheduling. They suggest using the combination of problem specific search heuristics and artificial intelligence with novel definitions of solution space and their neighborhoods in order to solve the scheduling objective minimizing the necessary time (cited 260 times).

Using operational research and artificial intelligence Fethi & Pasiouras (2010) tried to assess bank efficiency and performance. They collected 196 papers examining

the bank soundness and performance. Envelopment data analysis was found to be the most often used operational research technique. Other usable techniques were support vector machines, neural networks and multi-criteria decision (cited 228 times).

Finally, the last top 10 list paper was examining the history and future of the workplace automation questioning why is there still so many jobs. David (2015) argued that some journalist and experts exaggerate replacement of labor input by automation claiming that machines and labor complement each other achieving higher efficiency, more earnings and require further employment. Nevertheless, technology has changed the structure of labor demand and amplified workers inequality, specifically between those with high and low level skills. Also he argues that this trend is not likely to continue and that recent development in AI and robotics may eradicate boring workforce assignments and increase demand for problem solving skills and creativity.

Table 2. List of 10 most cited papers

Author	Title	Journal name	Cit.	Year
Tam, KY; Kiang, MY	Managerial applications of neural networks - The case of bank failure predictions	Management Science	532	1992
Swaminathan, JM; Smith, SF; Sadeh, NM	Modeling supply chain dynamics: A multi-agent approach	Decision Sciences	405	1998
Jain, AS; Meeran, S	Deterministic job-shop scheduling: Past, present and future	European Journal of Operational research	385	1999
Das, SR; Chen, MY	Yahoo! for Amazon: Sentiment extraction from small talk on the web	Management Science	331	2007
Altman, EI; Marco, G; Varetto, F	Corporate distress diagnosis - comparisons using linear discriminant-analysis and neural networks (the Italian experience)	Journal of Banking & Finance	330	1994
LeBaron, B; Arthur, WB; Palmer, R	Time series properties of an artificial stock market	Journal of Economic Dynamics & Control	320	1999

Zhang, GQ; Hu, MY; Patuwo, BE; Indro, DC	Artificial neural networks in bankruptcy prediction: General framework and cross-validation analysis	European Journal of Operational Research	272	1999
Storer, RH; WU, SD; VACCARI, R	New search spaces for sequencing problems with application to job shop scheduling	Management Science	260	1992
Fethi, MD; Pasiouras, F	Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey	European Journal of Operational research	228	2010
David, H	Why Are There Still So Many Jobs? The History and Future of Workplace Automation	Journal of economic perspectives	211	2015

Source: Web of Science, author calculation

As the Figure 1 demonstrates, highest portion of literature in artificial intelligence in business economics was published recently. Moreover, since technology is continuously developing nature of the examined phenomenon implies that more recent publications may be more relevant part of the literature. Nevertheless, since not all new records bear the same importance following section further examines the papers with most impact within the last three years.

Grewal, Roggeveen & Nordfalt (2017) emphasized five important topics in retailing: analytics and profit, big data manipulation, customer preferences, visual display and inventory supply. They suggested additional examination of technologies such as AI (artificial intelligence), VR (virtual reality), AR (augmented reality), IoT (Internet of things), robots, drones and autonomous driving.

Makridakis (2017) explored forthcoming artificial Intelligence (AI) revolution and its impact on society and firms. He claimed that artificial intelligence may entirely transform the market. Customers will be able to access the global market while entrepreneurs who are willing to utilize innovative technologies and take the risk will benefit the most. He emphasizes that even though AI has the potential of society advancement it is important to avoid or at least minimize accompanying dangers such as consequential unemployment and rising wealth concentration.

Wirtz et al. (2018) examined the application of robots in the service industry. They have classified the properties of various progressive technologies used in service

industry and distinguish between activities that are expected to be dominated by the human workforce. Furthermore, they investigated the perception of technology users and therefore improved the service robot acceptance model. Finally, they discussed the ethical problems associated with robotics in the service industry. Huang & Rust (2018) distinguish among four levels of intelligence: mechanical task oriented, analytical, intuitive and empathic. They considered AI application to usually begin at the mechanical level replacing some part of human responsibilities. As it advances majority of the task oriented responsibilities are operated by the AI while replacement of analytics is on the horizon. Simultaneously importance of the human workforce skills is shifting from mechanical and analytical to intuitive and empathic. It is expected that AI will eventually reach the level of emotional intelligence encompassing necessary intuition and empathy therefore entirely replacing the need for human workforce.

Arntz, Gregory & Zierahn (2017) revisited the risk of job loss to automation. They reexamined the possibility of automation replacing the half of the human workforce in the next 10-20 years. Authors claim that the extent of job loss in automotive industry to robots is overstated. If accounting for heterogeneity of jobs and adaptiveness of the human workforce, job loss should not be higher than 9%.

Sagiyeval et al. (2018) researched the intellectual input of development in the knowledge-based economy and problems of measuring in countries with developing markets. High tech industries and services are growing twice as fast as manufacturing. If aiming to create knowledge based economy and utilize technological development intellectual security must be properly managed.

Kane (2017) examined the effect of social media in organizational knowledge management. He emphasized that social media is not monolithic and rather multidimensional technological infrastructure encompassing cloud computing, mobile communications and analytics. Each of these dimensions had an important transformative effect on the organizational knowledge management and technologies such as AI, VR, and AR are expected to drive this transformation even further.

Zhang, McBurney, Musial (2018) studied the convergence of trading strategies in continuous double auction markets with constrained rational networked traders. Trading simulation was conducted in social network artificial stock market with several canonical topologies. Participants learned from each other and portions of trading strategies became stable over time. Which strategy prevails depends on network topology, network connections and types of traders.

Dabirian & Kietzmann (2017) explored branding strategies that companies used to attract best employees. Using the IBM Watson authors analyze workplace reviews deriving several key points: balance between work and life, management role, salaries, advancement opportunities, meaningful application of employee skills, challenge and

social interaction. Importance of each dimension varies depending on the overall attractiveness of the company.

Ehret & Wirtz (2017) argued that existing business models are inadequate to utilize opportunities and manage threats arising from the recent technological development. Considering non-ownership approach they recommend developing business architecture with several properties: endowment of manufacturing assets, upkeep and repair, using big data and artificial intelligence while including the final customer in manufacturing process and supply chain system.

Table 3. List of most influential papers

Author	Title	Journal name	Cit.	Year
Grewal, D; Roggeveen, AL; Nordfalt, J	The Future of Retailing	Journal of Retailing	65	2017
Makridakis, S	The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms	Futures	25	2017
Huang, MH; Rust, RT	Artificial Intelligence in Service	Journal of Service Research	24	2018
Arntz, M; Gregory, T; Zierahn, U	Revisiting the risk of automation	Economics Letters	20	2017
Sagiyeval, R; Zhuparova, A; Ruzanov, R; Doszhan, R; Askerov, A	Intellectual input of development by knowledge-based economy: problems of measuring in countries with developing markets	Entrepreneurship and Sustainability Issues	18	2018
Wirtz, J; Patterson, PG; Kunz, WH; Gruber, T; Lu, VN; Paluch, S; Martins, A	Brave new world: service robots in the frontline	Journal of Service Management	14	2018
Kane, GC	The evolutionary implications of social media for organizational knowledge management	Information and Organization	13	2017

Zhang, JH; McBurney, P; Musial, K	Convergence of trading strategies in continuous double auction markets with boundedly-rational networked traders	Review of Quantitative Finance and Accounting	12	2018
Dabirian, A; Kietzmann, J; Diba, H	A great place to work!? Understanding crowdsourced employer branding	Business Horizons	12	2017
Ehret, M; Wirtz, J	Unlocking value from machines: business models and the industrial internet of things	Journal of Marketing Management	11	2017

Source: Web of Knowledge

Examining the seminal papers and the most cited papers in the last 3 years it is possible to extrapolate some relevant major topics giving the first outline of AI business economics research field. These topics include bankruptcy prediction, supply chain management, job-shop scheduling, stock market properties, trading strategies, workforce automation replacement, retailing technology advancement, robotics in services, knowledge based economy, social media and crowdsourced employer branding.

Furthermore, with interest in the field of AI it is beneficial to differentiate publication sources. European Journal of Operational Research was the most important source of publication with 120 AI papers reaching 3679 citations. Average number of citations was 28,5 and most cited paper published in the journal was titled "Deterministic job-shop scheduling: Past, present and future" (cited 385 times). Management Science was the second most important source with the highest number of total citations 1224 publishing 10 papers with an average citation 122,4. Most cited paper published in the journal was titled "Managerial applications of neural networks - The case of bank failure predictions" (cited 532 times). Journal of Banking & Finance was the source with the highest average citation (150) with total of 3 papers. Most cited paper in the journal was titled "Corporate distress diagnosis - comparisons using linear discriminant-analysis and neural networks (the Italian experience) (cited 330 times). Other most important sources were Decision Sciences (13 papers, 637 citations), Omega-International Journal of Management Science (42 papers, 600 citations), Journal of the Operational Research Society, International Journal of Forecasting (10 papers, 501 citations), Journal of Economic Dynamics & Control (6 papers, 450 citations), Journal of Forecasting (7

papers, 298 citations) and Interfaces (20 papers, 268 citations). For more details, see Table 4.

Table 4. Most influential sources

	No	Min	Max	Sum	Mean
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	129	1	385	3679	28,5
MANAGEMENT SCIENCE	10	1	532	1224	122,4
DECISION SCIENCES	13	1	405	637	49
OMEGA-INTERNATIONAL JOURNAL OF MANAGEMENT SCIENCE	20	1	182	600	30
JOURNAL OF THE OPERATIONAL RESEARCH SOCIETY	42	1	61	562	13,3
INTERNATIONAL JOURNAL OF FORECASTING	10	1	157	501	50,1
JOURNAL OF BANKING & FINANCE	3	2	330	450	150
JOURNAL OF ECONOMIC DYNAMICS & CONTROL	6	3	320	390	65
JOURNAL OF FORECASTING	7	1	192	298	42,5
INTERFACES	20	1	68	268	13,4

Following section of the paper illustrates intellectual map of the researched field. All topics are distributed in two maps. First map is showing popular topics and second map is showing emerging topics and relevant literature gaps. Topics are located in two-dimensional space according to sub-streams of research and their relative importance. In order to increase the readability of the map densest parts are augmented.

First map is showing popular topics with at least six sub-streams of research. First sub-stream of research is described with topics such as discriminant analysis, financial crisis, bankruptcy, support vector machine and credit risk. Second sub-stream of research is described with topics such as time series, pattern recognition and pricing. Third sub-stream of research is described with topics such as neural networks, forecast, simulation, optimization, agent based models, pricing, computational intelligence and hybrid modelling. Fourth sub-stream of research is described with topics such as genetic algorithm, multi agent system and clustering. Fifth sub-stream of research is described with topics such as distributed artificial intelligence, case based reasoning, knowledge based system, expert system and decision support. Sixth sub-stream of research is

described with topics such as operational research and scheduling. Other than mentioned sub-streams map includes topics such as manufacturing, data mining, big data, marketing, accounting, automation, virtual reality and robots (see Appendix 2 and Appendix 3).

Second map is showing emerging topics and relevant literature gaps with at least six sub-streams of research. First sub-stream of research is described with topics such as linear programming, swarm intelligence, vehicle routing, simulated annealing, dynamic programming, integer programming, tabu search. Second sub-stream of research is described with topics such as intuition, metaheuristics, influence diagrams, bounded rationality. Third sub-stream of research is described with topics such as particle swarm optimization, mathematical programming, operational risk, project management. Fourth sub-stream of research is described with topics such as operations management, probabilities, belief networks, knowledge representations, performance evaluation, complex systems. Fifth sub-stream of research is described with topics such as sensitivity analysis, fuzzy sets, ANFIS, rough sets, EVOLINO, technical analysis, neural nets, evolutionary algorithms, Bayesian network and classification accuracy. Sixth sub-stream of research is described with topics such as market microstructure, business failure, financial ratios, financial distress and exchange rate. Other than mentioned sub-streams map includes topics such as chatbots, augmented reality, autonomous systems, cyberspace, early warning, text mining, search engine, IBM Watson, ensemble, Industry 4.0., combinatorial optimization, particle swarm optimization, random forest, cognitive computing, evolutionary computation, soft computing, artificial general intelligence, singularity and consciousness (see Appendix 4 and Appendix 5).

5. CONCLUSION

Due to the high complexity of artificial intelligence development it is very difficult to establish clearly separated research fields. There are many tools of artificial intelligence and there are many industries in which these tools are utilized. Some tools are often used together and some industries use many different tools and therefore these connections are not always easily interpretable. Extensiveness of business economics utilization of AI bounds more detail insight into each of the selected application area. Future research efforts may be focused on individual tools or industries further examining specific circumstances accompanying selected area of AI application. Nevertheless, this research enables to identify the most influential authors, seminal papers and the most important sources dealing with the topic of artificial intelligence application in business and economics. Furthermore, intellectual map of the field offers some insights into

diversity of topics and systemic literature overview regarding the application of AI in business and economics.

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Appendix 1. List of topics sorted by the number of their appearance

Neural network	196
Forecast	132
Prediction	121
Simulation	113
Optimization	112
Decision making	104
Robot	103
Decision support	98
Expert system	90
Big data	87
Automation	60
Agent*based	59
Genetic algorithm	55
Marketing	55
Distribution	52
Manufacturing	52
Finance	46
Data mining	44
Time series	44
Scheduling	43
Heuristics	36
Accounting	32
Logistics	30
Case*based reasoning	26
Computer science	25
Supply chain	25
Support vector machine	25
Banking	24
Futures	23
Operations research	22
Pricing	22
Sustainability	21
Transportation	21
Bankruptcy	20
Decision analysis	20
Financial markets	20

Knowledge-based systems	20
Natural language processing	20
Social media	20
Traffic	20
Cloud computing	19
Discriminant analysis	19
Pattern recognition	19
Clustering	18
Computational intelligence	18
Game theory	18
Multi-agent system	18
Risk management	18
Credit risk	17
Operational research	17
Tourism	17
Psychology	16
Technological change	16
Blockchain	15
Data analytics	15
Distributed artificial intelligence	15
Knowledge acquisition	15
Business intelligence	14
Genetic programming	14
Intelligent systems	14
Military	14
Negotiation	14
Strategic planning	14
Auditing	13
Decision theory	13
Deep learning	13
E-commerce	13
Financial crisis	13
Hybrid model	13
Reinforcement learning	13
Virtual reality	13

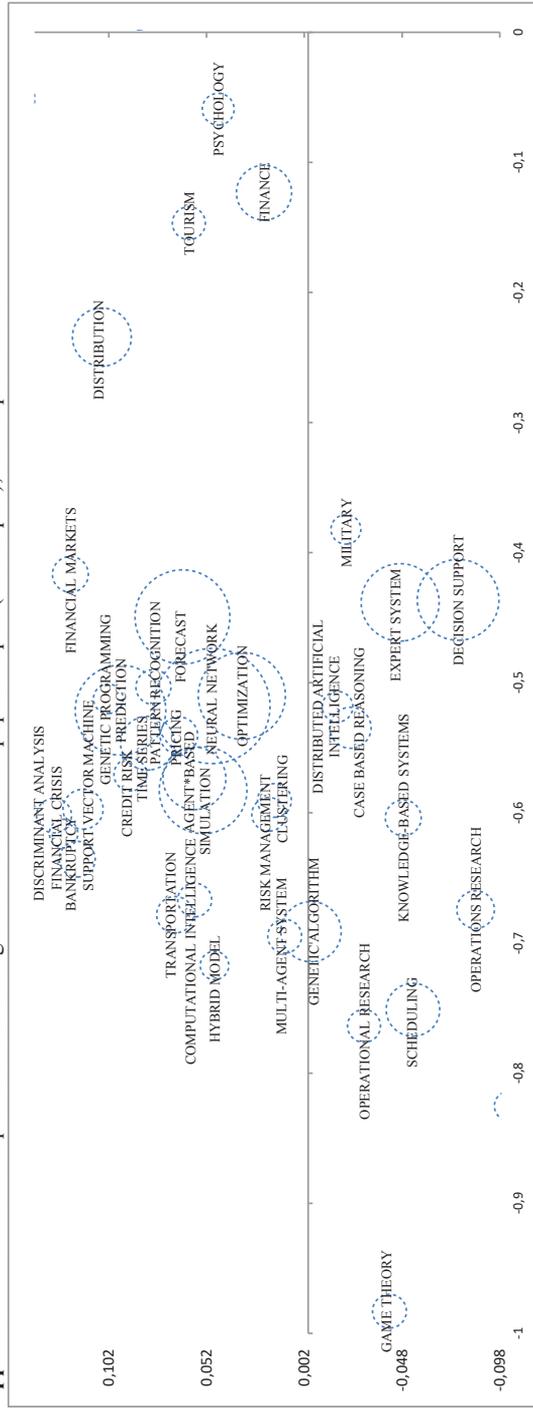
Bounded rationality	12
Consumer behavior	12
Entrepreneurship	12
Financial institutions	12
Intelligent agent	12
Linear programming	12
Probabilities	12
Credit scoring	11
Customer service	11
Ensemble	11
Industry 4.0	11
Knowledge discovery	11
Knowledge representation	11
Project management	11
Risk assessment	11
Singularity	11
Artificial stock market	10
Consciousness	10
Exchange rate	10
Financial ratios	10
Tabu search	10
Augmented reality	9
Bayesian network	9
Combinatorial optimization	9
Decision trees	9
Early warning	9
Health care	9
Mathematical programming	9
Risk analysis	9
Backpropagation	8
Belief networks	8
Classification accuracy	8
Classification problem	8
E-business	8
Foresight	8
Fourth industrial revolution	8
Future of work	8

Fuzzy sets	8
Market microstructure	8
Operations management	8
Particle swarm optimization	8
Personalization	8
Process management	8
Rough sets	8
Search engine	8
Sensitivity analysis	8
ANFIS	7
BPM	7
Complex system	7
Content analysis	7
Cyberspace	7
Evolutionary algorithms	7
Human-computer interaction	7
Intellectual capital	7
Intuition	7
Knowledge engineering	7
Neural nets	7
Organizational learning	7
Retailing	7
Simulated annealing	7
Strategic management	7
Tacit knowledge	7
Cluster analysis	6
Cognitive computing	6
Dynamic programming	6
Ecall	6
EVOLINO	6
Evolutionary computation	6
Financial distress	6
Fintech	6
Influence diagrams	6
Integer programming	6
Knowledge economy	6
Market research	6

Multivariate statistics	6
Q-learning	6
Real estate	6
Sentiment analysis	6
Social networks	6
Supervised learning	6
Technical analysis	6
Vehicle routing	6
Ant colony optimization	5
Artificial general intelligence	5
Autonomous systems	5
Business failure	5
Chatbot	5
Computational complexity	5
Control systems	5

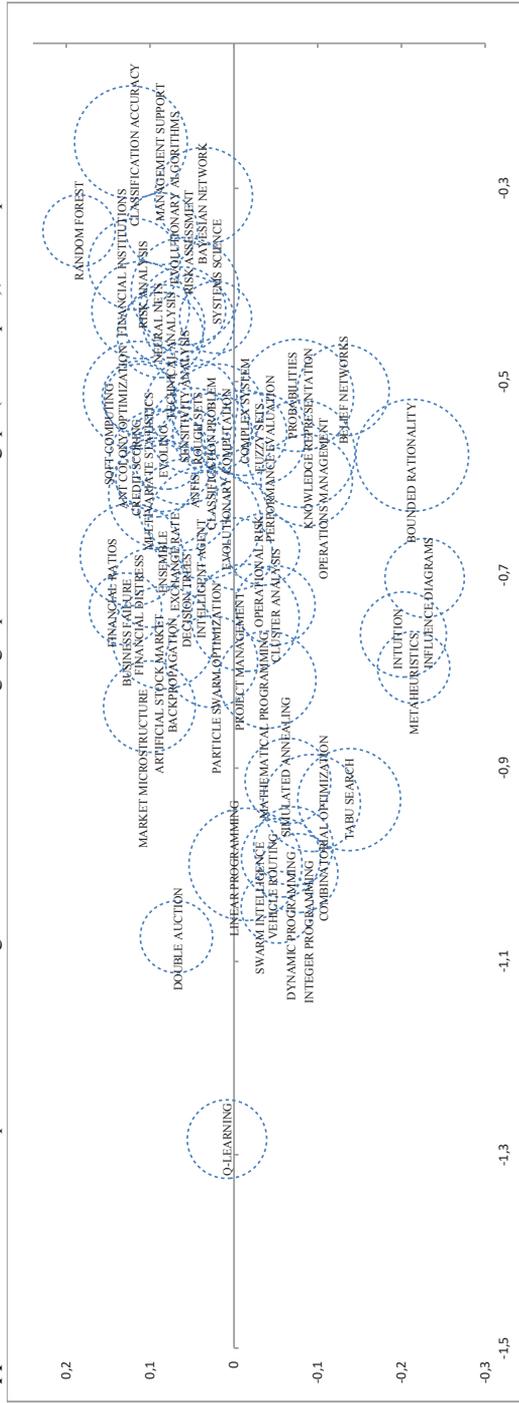
Corporate social responsibility	5
Double auction	5
IBM watson	5
Management support	5
Metaheuristics	5
Operational risk	5
Performance evaluation	5
Quality management	5
Random forest	5
Soft computing	5
Speculation	5
Swarm intelligence	5
System dynamics	5
Systems science	5
Telecommunications	5
Text mining	5

Appendix 2. Intellectual map of artificial intelligence research field - popular topics (central part), full map on demand



Source: Author's calculation

Appendix 3. Intellectual map of artificial intelligence research field – emerging topics and relevant gaps (central part), full map on demand



Source: Author's calculation

BIBLIOMETRIJSKA ANALIZA UMJETNE INTELIGENCIJE U POSLOVNOJ EKONOMIJI

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Sažetak

Otkriće umjetne inteligencije zasigurno predstavlja jednu od najvažniji tehnoloških inovacija moderne ekonomije. Opća umjetna inteligencija koja može dosegnuti singularitet ima potencijal kreirati novu tehnološku arenu. Jednom otkrivena smatra se da će nadmašiti sve ljudske kognitivne sposobnosti. Nadalje, specifična umjetna inteligencija već je otkrivena i primijenjena u brojnim sustavima. Ovaj rad nastoji istražiti područje umjetne inteligencije s naglaskom primjene u ekonomiji. Podaci su derivirani na osnovi zapisa Web of Science baze jednog od najrelevantnijih izvora znanstvenih radova. Ukupan broj ekstrahiranih zapisa u periodu 1963-2019 bio je 1369. Rezultati čine sustavan pregled najutjecajnijih autora, radova te izvora publikacija. Dodatno, koristeći MCA kreirana je intelektualna mapa istraživačkog područja.

ključne riječi: *umjetna inteligencija, poslovna ekonomija i ekonomija, analiza sadržaja, bibliometrija, HOMALS.*