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AUGMENTED REALITY IN BUSINESS AND ECONOMICS: BIBLIOMETRIC AND TOPICS ANALYSIS

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ABSTRACT

Augmented reality enhances the sensory experience of the real world, often across multiple senses such as visual, hearing, tactile and sensorimotor, with technology using computer-generated sensory input. Current literature reviews of augmented reality mainly focus on its generic usage or specific topics, such as medicine or tourism. However, augmented reality has become one of the prevalent topics in business and economics since it is one of the main growth drivers of disruptive companies. Since many companies are considering its usage in their business models, there is a lack of literature review in business and economics. Therefore, this paper aims to present a literature review of the scientific research that investigates the broad range of usage of augmented reality in business and economics. Web of Knowledge has been searched with the keywords "augmented reality" within the research area of business and economics for 2017-2021. Bibliometric analysis has been conducted to investigate the main journals, conferences, authors and countries. Finally, text mining with VosViewer has been conducted to extract the main topics, which are: (i): Technologies; Education; (ii) e-Commerce; Retailing; (iii) Tourism; User Experience; (iv) Consumers; Purchase. The results indicate that the research of augmented reality in business and economics focused on various applications, among which education is one of the emerging ones.

KEY WORDS

augmented reality, bibliometric analysis, VosViewer, keyword analysis, text mining, topic mining, education

CLASSIFICATION

JEL: M21, O3

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INTRODUCTION

The transformation of virtually all industries and business models has been made possible by several separately developed but concurrently deployed digital technologies [1]. Information technology, computer science, communication, and networking technologies are all combined in digital technologies [2].

Digital technologies can be categorised into infrastructure (primary), mature (secondary), and emerging (tertiary) technologies. Furthermore, mature technologies are present as they are "old enough" to understand their benefits and drawbacks, although they might not be widespread globally. Telephone and farming are among them [3], [4]. Mobile and communication technologies, social networks, cloud computing, sensors, and the Internet of Things (IoT) are considered infrastructure technologies because every industry will inevitably employ them. For instance, practically all businesses rent and pay for cloud computing services to store content, eliminating the need for capital expenditure on their servers.

A mature technology has been in use for a sufficient time for most of its initial flaws and inherent difficulties to be eliminated or mitigated. In some instances, it may also apply to technologies whose scientific basis is well-understood but has not yet achieved general use [5]. Mature digital technologies include the omnipresent applications in society and business, such as enterprise resource planning (ERP), databases, and data warehouses [6].

Emerging digital technologies may not yet have reached their full potential and typically contain the following items: robotics (e.g. robot process automation), 3D printers, blockchain, drones, advanced and virtual reality, etc. Businesses may be aware of the benefits of applying emerging digital technologies but do not fully deploy them in their day-to-day business [7]. The simultaneous and integrated application of emerging digital technologies allows for disruptive innovations and reinvention of the overall business model [8]. An example of such a model could be extracting the information from physical devices (data on sensors and IoT devices), disseminating it via mobile technologies like 5G, storing it in the cloud, and performing real-time analysis using big data and advanced data analytics.

Augmented reality (AR) refers to technologies that allow a real-time connection between the virtual and physical worlds [9]. In AR applications, a real-world environment is brought to life by computer-generated perceptual information, sometimes across many sensory modalities, including visual, aural, haptic, somatosensory, and olfactory [10]. Hence, AR alters how one perceives the physical environment. Unlike virtual reality (VR), which captivates the user completely in a virtual world, AR enables the person to interact with virtual elements seamlessly using real-world objects [11]. Both technologies have a significant role in the development of Web 3.0.

The first AR interface was developed in the 1960s [12]. Since then, AR has experienced relatively slow growth, until the development of smartphones, due to which AR technologies have a strong potential to be omnipresent. A typical smartphone has standard hardware, a 4G/5G high-speed network, a built-in camera, and a relatively large screen [13], [14], which is sufficient for running most AR applications. Because of affordable technologies that allow its widespread usage, the AR market forecasted growth is from $6,27 billion in 2021 to $10,37 billion in 2022 and has a strong potential for even considerable progress [15].

Due to its strong potential to impact various aspects of science, business and education, AR literature reviews are relevant for academics and practitioners. Literature reviews about AR technologies and applications range from the general ones that cover the broad area of AR deployment (e.g. [16]-[18]) to those focusing on either AR relevant technologies or AR specific applications. In addition, taxonomy, methods and patterns of various AR techniques are

developed to provide a common vocabulary for AR researchers and practitioners [19]. A brief overview of examples of specific applications using AR technologies is as follows. Most of the applications focus on medical displays [20], educational environment [21], [22], tourism [23], and manufacturing applications [24], [25].

There is still a lack of bibliometric analyses of AR in business and economics; when they do exist, they tend to be less informative and capture only a segment of business and economics, such as manufacturing or tourism. Considering that AR has a significant role in disruptive technologies that drive most business growth, this paper aims to develop a literature review of AR covering the broader area of business and economics. Web of Knowledge has been searched to discover AR research in business and economics. The research goals were to: (i) detect the most prominent authors, institutions, journals, conferences, and most cited papers and (ii) detect the main topics of the research and research groups based on countries. For that purpose, bibliometric analysis and text mining has been used. This article aims to provide a broad literature review of AR usage in business and economics.

The outline of the article is as follows. After the introduction, the methodology is presented. The third part discloses the article's findings while the conclusion and future implications are discussed lastly.

METHODOLOGY

Specific methods are used to provide a broad literature review of AR usage in business and economics. Furthermore, the paper comprehends the main research topics and groups using the linkages between keywords and countries of author origin [26]. This part of the research paper consists of Data representation followed by the Analysis methods used. The Data part consists of the Web of knowledge search strategy explanation. Searched keywords, filtered fields and indices are shown. Analysis methods used part briefly explains the two methods used in this research paper, bibliometric analysis and text mining analysis.

DATA

The Web of Knowledge (WoK) database has been used for AR scientific papers. The following search strategy has been applied (Table 1). Firstly, the primary search was conducted in WoK, using the keywords "augmented reality" as the research topic, which resulted in many research papers, including the period from 1982 to 2021. Secondly, the search was refined by the WoK Research area of Business Economics and focused on 2017-2021, which resulted in 488 papers. Additionally, the research is focused only on English-language peer-reviewed literature. Science Citation Index Expanded (SCI-EXPAND), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI), and Emerging Sources Citation Index (ESCI) are WoK indices included in the search strategy, Table 1.

Table 1. Web of the knowledge search strategy.

Search strategy	Research papers	Period	Indices
"augmented reality" (Topic)	23 152	1982-2021	A&HCI, BKCI-SSH, BKCI-S, CCR-EXPANDED, ESCI, IC, CPCI-SSH, CPCI-S, SCI-EXPANDED, SSCI
Refined by: Business Economics (Research Areas)	488	2017-2021	SCI-EXPANDED, SSCI, A&HCI, ESCI

The following subsection displays the analysis methods of this research. To represent the researched topic, bibliometric and text-mining analyses are used.

ANALYSIS METHODS

The analysis is conducted in two phases.

Firstly, bibliometric analysis has been conducted using the WoK interface, focusing on the research area, document type, type of open access, journal and conferences of the paper publication. Furthermore, the most frequent countries, funding agencies, authors and institutions are also examined.

Secondly, full data about each paper has been extracted from WoK, including the bibliometric data, abstract, keywords, and references for each paper. This data has been used as input for the text mining analysis using the VOSviewer tool [27]. Two advanced functions of VOSviewer are used.

First, VOSviewer's text mining functionality for constructing co-occurrence networks of terms extracted from English-language textual data, for instance, from keywords (both authors and assigned), is deployed. This process utilises the Apache OpenNLP library, an open-source Java library for processing Natural Language text [28]. Tokenisation, sentence segmentation, part-of-speech tagging, named entity extraction, chunking, parsing, and co-reference resolution are some of the services provided by OpenNLP.

VOSviewer envisions bibliometric linkage using a distance-based principle, with the ability to visualise various types of items in a network, e.g. those based on the keywords, authors or countries. Firstly, items are grouped in nodes, and secondly, the distance between nodes is normalised [29]. Thirdly, nodes are located in a two-dimensional space following the principle that strongly related nodes are located close to each other, using the VOS mapping technique. Finally, nodes are allocated to clusters using the smart local moving algorithm [30], [31].

This approach allows the co-occurrence analysis to discover the most researched topics and research groups of AR in business and economics. The focus is on the keywords and countries' co-occurrence for that purpose, using the full-counting extraction algorithm.

A total of 2295 keywords were assigned to papers in WoK (both Author Keywords and Keywords Plus). In addition, the threshold of 10 keywords occurrence was used for the analysis, indicating that only those keywords that occur in a minimum of 10 papers are retained in the analysis. This approach resulted in the 55 keywords used in text mining analysis.

The total number of countries of authors in the analysed papers was 72. The threshold of 5 countries was used for the analysis, indicating that only those countries that occur in a minimum of 5 papers are retained. This approach resulted in the 32 countries used in the co-occurrence analysis.

BIBLIOMETRIC ANALYSIS

Table 2 presents the allocation of papers according to research areas since the search strategy was oriented mainly to indicate that researchers from the 488 publications that were extracted concentrate their work primarily on business and economics (100 %). Papers are, in some cases, assigned to more than one research area. Most of the papers that are assigned to another research area besides business and economics are allocated to Social Science Other topics (12,3 %) and Computer science (8,2 %), followed by Engineering (5,3 %), Public Administration (4,9 %), Communication (3,5 %) along with the rest. Other areas include Telecommunications, Agriculture, Geography, International Relations, Forestry, and Medical Informatics.

Table 3 presents the distribution of papers according to the document type, journals and conferences. Most of the research has been published as research articles (352 papers, 72,1 %), followed by papers published in conference proceedings (105 papers, 21,5 %) and book chapters (31 papers, 6,4 %).

Table 2. Distribution of papers according to the research areas. Note that the sum of the research papers differs from the number of papers (488) since the paper can be assigned to more than one research area.

Research Area	No. of papers	percentage of 488
Business Economics	488	100,0
Social Sciences Other Topics	60	12,3
Computer Science	40	8,2
Engineering	26	5,3
Public Administration	24	4,9
Communication	17	3,5
Operations Research Management Science	17	3,5
Information Science Library Science	14	2,9
Environmental Sciences Ecology	12	2,5
Psychology	12	2,5
Education Educational Research	11	2,3
Other areas	43	8,8

Journals and conferences that publish AR papers are highly diversified. Some of the top-performing article titles are Journal of retailing and consumer services (30 articles), AR and VR empowering human place and business (22 articles), Journal of business research (22 articles), Progress in IS (22 articles), Technological forecasting and social change (19 articles), International journal of retail distribution management (13 articles) and Psychology marketing (10 articles). Other papers (214) are published in other articles, indicating the field's heterogeneity. Some of these journals are Harvard business review (6 articles), Tourism Management (6

Table 3. Distribution of papers according to the document type, journals and conferences.

Document Type	No. of papers	Journal title	No. of papers	Conference title	No. of papers
Article	352 (72,1 %)	Journal of retailing and consumer services	30	International conference on augmented reality and virtual reality	25
Proceeding. Paper	105 (21,5 %)	Augmented reality and virtual reality empower human place and business	22	Conference of the international business information management association	10
Book Chapters	31 (6,4 %)	Journal of business research	22	Other	70
Total	**488 (100 %)**	Progress in IS	22	**Total**	**105**
		Technological forecasting and social change	19		
		International journal of retail distribution management	13		
		Psychology marketing	10		
		Other	214		
		Total	**352**		

articles), Journal of the academy of marketing science (5 articles), International journal of advertising (4 articles) and International journal of consumer studies (4 articles). The selection of the journals that publish the AR papers indicates that the focus is growing on marketing, tourism and consumer studies. This shows that AR is a technology that will be involved in many fields, as it is useful for both the consumer and producer.

Among the conferences, the most papers are published in the International Conference on AR and VR (25 papers), followed by the conference of the international business information management association IBIMA (10 papers). Most of the papers (70 papers) are published at other conferences. However, these are only two conferences that publish more than 10 papers on AR, indicating that currently, no conference focuses solely on the AR domain.

Table 4. presents the distribution of papers according to country. The majority of papers are published in the USA (93 papers), England (81 papers), Germany (44 papers), Australia (35 papers) and the People's Republic of China (33 papers).

The leading funding agency in the area of AR research is the European Commission (25 papers), followed by the Ministry of Science and Technology Taiwan (9 papers), the National Natural Science Foundation of China (7 papers), the Ministry of Science and Higher Education Poland (3 papers and lastly UK Research Innovation Programme (3 papers). The results indicate that more developed countries are funding more research in the AR field.

Table 4. Countries of the authors (with 20 or more papers) and funding agencies (with 3 or papers). The sum should not be 488 since the focus is here only on countries which occur in more than 20 papers and on funding agencies which occur in more than 3 papers.

Country	**No. of papers**	**Funding Agency**	**No. of papers**
USA	93	European Commission	25
England	81	Ministry of Science and Technology Taiwan	9
Germany	44	National Natural Science Foundation of China	7
Australia	35	Ministry of the Education Republic & National Research Foundation of Korea	6
People's Republic of China	33	Ministry of Science and Higher Education Poland	3
France	29	UK Research Innovation Programme	3
India	24		
Netherlands	24		
Italy	23		
Russia	20		

Table 5 presents the most frequent authors and institutions of AR papers. The top three affiliations/institutions are the University of London (18 papers), Manchester Metropolitan University (14 papers) and the University of New South Wales Sydney (13 papers), indicating that most research is based in the United Kingdom and Australia. The most frequent authors are also listed in the table, indicating that 12 published more than 5 AR papers indexed in WoK.

Figure 1 shows the citations of the papers investigating the AR topic in 2017-2021. A total of 488 papers generated 6 180 citations, indicating an average number of citations is 12,1 per paper. The number of publications has been steadily growing, from 55 publications in 2017 to 156 in 2021. The number of citations increased even further, from 17 in 2017 to 3 537 in 2021, indicating the strong impact of AR papers resulting more from their practical implications than from their theoretical implications.

Table 5. Most frequent authors and institutions (with 5 or more papers). This table presents only those affiliations and authors which occur in more than 5 papers.

Affiliations	No. of papers	Author	No. of papers
University of London	18	De Ruyter, K.	12
Manchester Metropolitan University	14	Keeling, D.I.	12
University of New South Wales Sydney	13	Chylinski, M.	11
King's College London	12	Mahr, D.	10
Maastricht University	11	Heller, J.	9
State University System of Florida	11	Hilken, T.	9
University of Sussex	11	Dieck, M.C.T.	8
University of Texas System	9	Huang, T.L.	8
Bucharest University of Economic Studies	7	Rauschnabel, P.A.	8
Yuan Ze University	7	Jung, T.	6
California State University System	6	Hassan, A.	5
Indian Institute of Management	6		
University of Central Florida	6		
University of Texas Rio Grande Valley	6		
Griffith University	5		
Hong Kong Polytechnic University	5		
King Abdulaziz University	5		
Tallinn University	5		
University of Bristol	5		
University of Michigan	5		

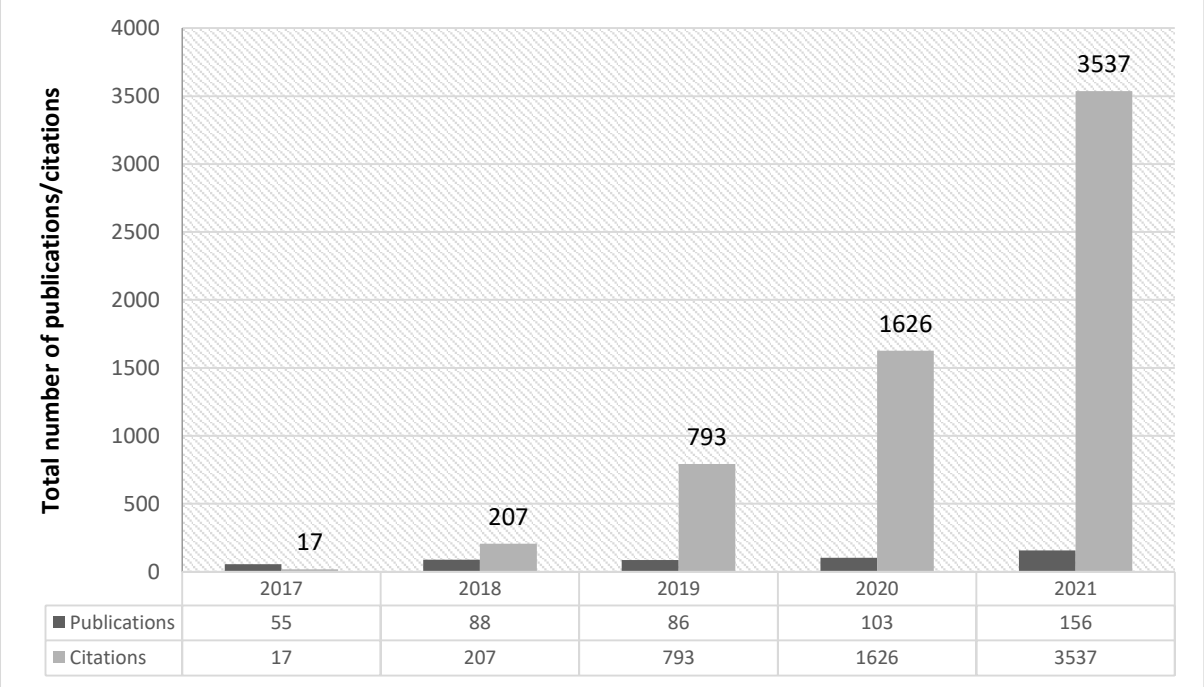

Figure 1. Number of publications and citations of papers about AR (2017-2021).

Appendix 1 presents the 10 papers investigating AR in business and economics that generated the highest number of citations from 2017 to 2021. The two most cited publications investigate AR applications in retailing [32] and manufacturing [33] as one of the most important

technologies relevant for their future development in digital transformation. Other papers investigate more specific topics, such as customer experience [34], e-commerce [35], shopping apps [36], tourism and hospitality [37], online service experience [38], construction [39], marketing [40], and retail [41]. The scope of the most cited papers indicates the most significant areas of AR applications in business and economics, which will be investigated in the next chapter of this article.

TEXT MINING

In this part, keywords and country co-occurrence with citation analysis are described.

Keywords co-occurrence analysis

The software VOSviewer analysed 488 articles to extract the most researched AR-related topics. The most frequent keywords are AR, technology, VR, AI and e-commerce. All keywords with at least 15 occurrences are categorised into four logical groups (Figure 2). The node's size indicates the keywords' frequency: the larger the node, the more frequent the keywords. The proximity of the links between the two phrases affects the line's thickness [42]. The study discovered 1858 links for 55 items, giving the co-occurrence an average link strength of 33,8 (across all keywords).

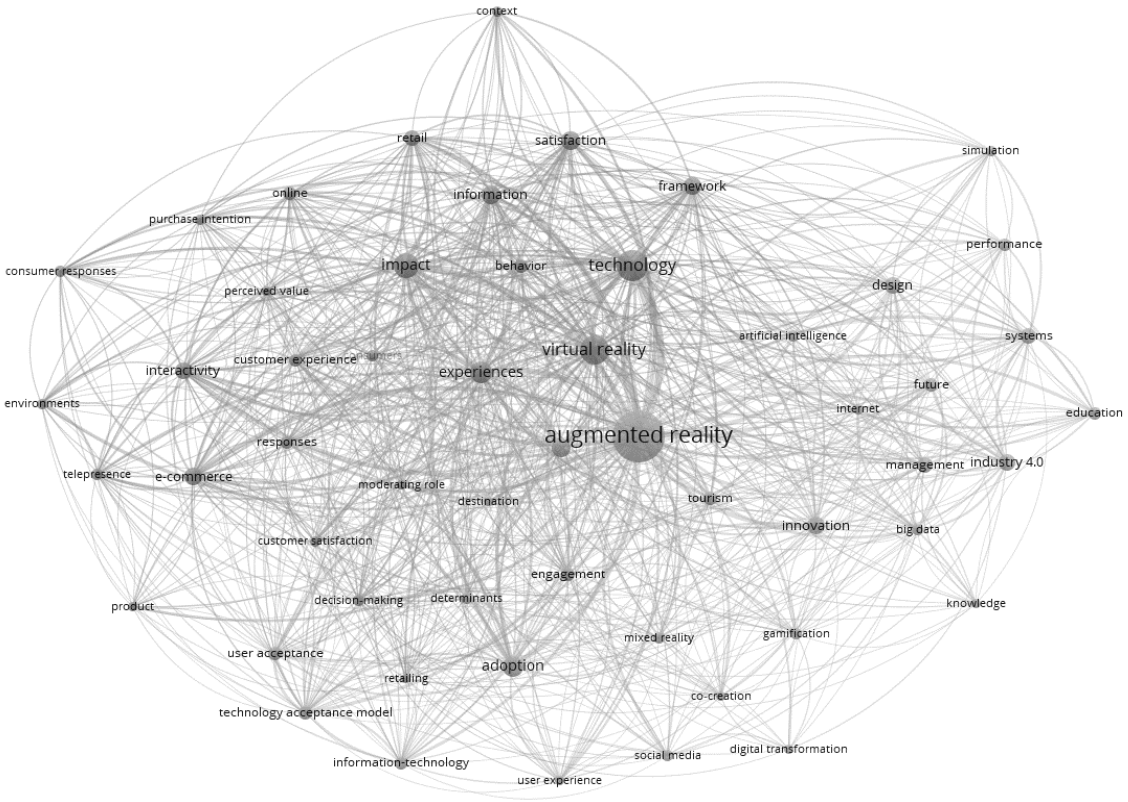

Figure 2. VosViewer cluster analysis (keywords with 10 or more documents).

Figure 3. presents the keywords heat map. The brightness around the most frequent keywords indicates their high occurrence (e.g. AR, VR, technology, experiences and impact).

Table 6 presents the clusters extracted by VosViewer. Cluster keywords are presented in the second column, and the third column defines the cluster topic and example papers that represent the specific cluster most.

Further cluster systematising and explanation are denoted in this research following part. As shown in Table 6, there are four Clusters on which this research will focus.

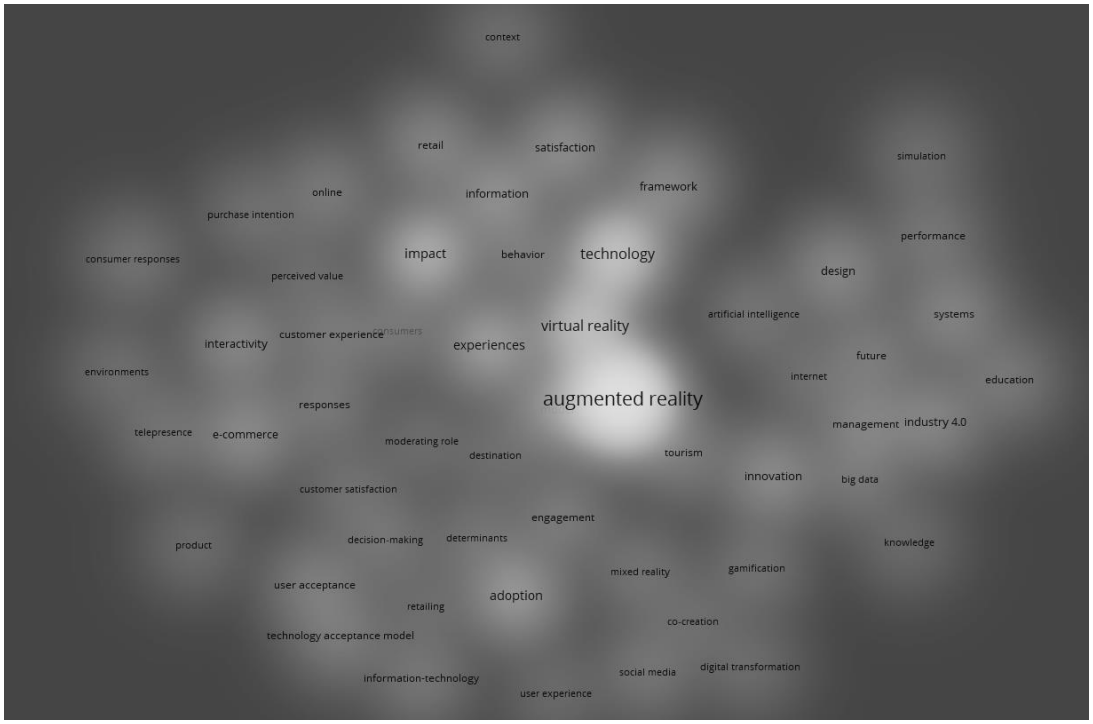

Figure 3. VosViewer keywords heatmap (keywords with 10 or more documents).

Table 6. Cluster keywords and cluster topics (keywords with 10 or more documents).

Cluster	Cluster keywords	Cluster topic / Example papers
Cluster 1	artificial intelligence; AR; big data; co-creation; design; digital transformation; education; future; gamification; industry 4.0; innovation; internet; knowledge; management; performance; simulation; social media; systems.	Technologies; Education [43], [44], [45], [46], [47], [48], 0, [51], [52], [53],[54], [55], [56], [57], [58], [59]
Cluster 2	behavior; consumers; context; customer experience; decision-making; e-commerce; experiences; framework; impact; information; online; responses; retail; retailing; satisfaction; technology;	e-Commerce; Retailing [60], [61], [62], [63], [64]
Cluster 3	adoption; destination; determinants; engagement; information-technology; mixed reality; model; technology acceptance model; tourism; user acceptance; user experience;	Tourism; User Experience [65], [66], [67], [68]
Cluster 4	consumer responses; customer satisfaction; environments; interactivity; moderating role; perceived value; product; purchase intention; telepresence; VR	Consumers; Purchase [69], [70], 0

Cluster 1 – Technologies; Education includes artificial intelligence (AI), AR, big data, co-creation, design, digital transformation, education, future, gamification, industry 4.0, innovation, knowledge, management, performance, simulation, social media and systems. Due to the scope of the papers, the topic of this cluster was called Technologies, Education. The research presented in this cluster indicates that AR could strongly support improvement in business and education, often complemented by AI.

[43] discusses that AR is one of those innovations that can help companies in their digitalisation, enabling them to position their products innovatively, create value for the customer and potentially increase sales. The authors conducted a survey where they presented AR apps to the graduate students for their opinion. The findings indicated that the most important factors in developing such an app are the explicit purpose of the application, ease of use and learning, smooth operation, imaginative information presentation, and interactivity.

[44] stresses that AR and VR technologies are needed in training, such as nursing training. They point out that this should be compulsory for any nursing education. Furthermore, they are promoting their application with arguments that it can reduce inexperienced nursing students' anxiety and make them more familiar with the ward environment and fundamental nursing skills, which can minimise medical errors in their real practicum.

[45] indicates that location-based AR navigation systems are becoming available; therefore, proper optimisation of consumer satisfaction and purchase intention is needed. Their findings show that consumers' intentions to purchase location-based AR navigation systems were found to be significantly influenced by three user perceptions of AR (AR): spatial ability (sensory domain), sense of presence (feeling domain), and conceptual understanding (cognitive domain). Furthermore, experiences mediated these consumer intentions in education, entertainment, aesthetics, and escape, such as make-up AR app [46].

Other papers in this cluster complement the role of AR in education. They are presented further in the text.

[47] researched how school classrooms could be shaped and equipped with innovative technologies such as AR, AI and smart material for a futuristic classroom open shape. They called them vignettes in their research. After experimenting with the Six Pillar method, the researchers concluded that it has the potential to prepare teaching staff for this new environment which could become a much better connection between school, further education or practical environment.

[48] uses the Unified Theory of Acceptance and Technology 2 (UTATU2) model to predict the consumers' behavioural intention toward AR adoption among companies in the Middle East based on education and gender. They confirm that all the UTATU2 model variables correlate statistically to AR adoption, especially in more educated users.

0 research imagines the usage of AR in an innovative higher education institution (HEI). The classroom of the future, as they call it, is a design thinking lab, which consists of AR technology with interactive detachable workstations, shareable smartboards and interactive video display walls. The AI complements AR with additional functionalities. Future graduates of such HEIs will have a smooth transit from education to a desired job or entrepreneurship practice due to the enhanced real-life experience, which is more relevant to business practice than classical education.

[50] focuses on attaining students' feedback on AR implementation in HEI in the Russian Federation, finding out that students were particularly interested in reviving textbooks with illustrative material based on AR to make them more appealing to the reader. [51] shows that AR with AI can help show practical and real-life examples in higher education during serious crises and pandemics such as COVID-19, enabling a more community-orientated approach to the study and practice of entrepreneurship.

The potential of "visual thinking", a concept that is underdeveloped in many HEIs' curricula but is essential to the design thinking process, is tapped into by AR's capacity to generate a visually rich environment [52]. Empathy and feelings of surprise and delight are frequently experienced during in-person design work, and they are often key to immersion and

engagement, which also consider our nonverbal senses [53]. In addition to generally promoting visual thinking, AR can assist students in practising the kind of covert observation frequently essential to the empathising and testing phases of the design thinking process [54]. Such observation is unquestionably an important aspect of fieldwork. However, if such possibilities are not offered, AR can offer an alternative that goes beyond a purely cognitive comprehension of the usefulness of this technique.

AR implementation in the study curriculum depends on the subject itself. Numerical and natural science subjects have seen the most AR usage in the classroom. They are mainly accessed through a handheld display. Furthermore, the study shows the benefits of AR usage in Science, Technology, Engineering and Mathematics (STEM) education. Student benefits are evident and recorded. Lecturers are surprisingly getting well with new technology as well. Although the general outcome is positive, specific study outcomes may vary depending on learner type, subject, learning environment or style, duration of the intervention, and student's computer attitude [55]. [56] showed that lecturers perform well with the Photomath AR application regardless of their teaching or teaching experience stage. The research recommends that lecturers prepare their curricula in the AR way from the basic to secondary difficulty level.

[57] research showed that with AR implementation in HEIs, students engage and perform better, have a positive attitude toward learning and increase their independence. On the other hand, AR implementation might be expensive, some software might be of poor quality due to a lack of experience in development, and sometimes the user interface is not convenient.

An important aspect of this cluster is also gamification. Since our psychological emotions occasionally influence our decisions, gaming has always been at the forefront of technological advancement. The game industry was one of the first to use AR technologies, one of the first examples being "Pokemon Go" [43], [58] which indicated that the AR technology's momentum had started. As a result, adding the mobile gaming software "Pokemon Go" made "the game" more emotional and nostalgic [59]. The game offered something unique compared to other games available, such as the ability to play the game indoors or outside utilising a phone and camera. The audience had never previously before "Pokemon Go" experienced walking on the ground while inside a virtual world through your camera's lens. AR technology spread quickly when combined with nostalgia for the "Pokemon" series [60].

Cluster 2 – e-Commerce; Retailing contains the following keywords: behaviour, consumers, context, customer experience, decision-making, e-commerce, experiences, framework, impact, information, online, responses, retail, retailing, and satisfaction. Due to the scope of this research, it was called e-Commerce; Retailing.

[61] presents the typology of new technologies powered by AI and show a new framework for better customer journey understanding. Authors conclude that the internet of things, AR, VR, virtual assistants, chatbots, etc., will hugely impact consumer experience and decrease the time between purchase and delivery. However, they also denote that a potential downside of these technologies' usage is loss of control, privacy concerns and danger of overreliance on them.

[62] researches the eye tracking method for consumer visual attention in their shopping process. They argue that mobile eye tracking has several limitations in the sense of a heavy data coding process and limited control of some important variables. VR might help consumer eye tracking while AR can be of a hand to the consumer in their shopping process.

[63] theoretically reviews the AR contribution to the retail customer experience transformation. After a review of 141 articles, they found that nine digital value propositions, such as vividness, mobility, peer communication, personalisation, interactivity, connectivity, value co-creation, telepresence, and information availability, are the main mediators in this consumer experience transformation understanding.

[64] compares AR and web-based product presentations using the IKEA website and Place app research. The findings show that AR generates better immersion and enjoyment in the shopping process. Furthermore, reuse and purchase intention are influenced by enjoyment, immersion and media usefulness. Therefore, retailers should impose AR apps as they are more than certain to increase revenue and overtake the competition by offering something new and unique.

Cluster 3 – Tourism; User Experience contains keywords adoption, destination, determinants, engagement, information-technology, mixed reality, model, technology acceptance model, tourism, user acceptance and user experience. Due to the scope of the papers, this cluster's topic was Tourism; User Experience.

[65] investigates the application of AR in tourism. The findings show that tourists might be interested in AR apps with intuitive interface design and qualitative content. This topic is broadened by Loureiro et al. (2020) [66], who investigated the improvement of AR apps over the last few decades in a comprehensive study. The research used a full-text analysis of 56 journals and 325 conference proceedings for virtual and AR apps in tourism-related studies. Their findings indicate that AR and VR apps have a wide area of improvement for a better touristic experience. Some of the improvements are in the atmospheric design, cultural heritage and smart cities content, location-based information, experiential, telepresence and case study applications, among others mentioned. They also recommend further improvements in the field of physical and sensory simulations, enhanced longitudinal virtual experiences, well-being development and the use of AI.

[67] explores AR's perceived value in the tourism industry from the tourism development perspective. Research findings indicate AR app implementation use in tourism strategy development, AR implementation and tourist experience design.

[68] investigates the possibility of attracting tourists, especially millennials, with innovative technologies to complement the scattered hotel accommodation option. Through their case study, they tried to develop a combination between scattered hotel accommodation options and technological advances in Istria, Croatia. The findings indicate that infrastructure needs to be properly developed for other advancements. Most accommodation providers are not using applications for destination experience, a target market for AR apps. The research presented in this cluster denotes that AR apps are more than welcome in the tourism sector with few additions. Those additions are quality content, great and easy user interface and an overall quality app that can be a great asset to a particular destination's visiting tourists.

Cluster 4 – Consumers; Purchase consists of the following keywords: consumer responses, customer satisfaction, environments, interactivity, moderating role, perceived value, product, purchase intention, telepresence, and VR. Due to the scope of the papers, the topic of this cluster was called Consumers, Purchase.

[69] investigates a "try before you buy" online shopping experience. They focus on AR apps where consumers try products on their faces or surroundings. AR apps compared with other non-AR product presentations, this research results show greater customer perceived informativeness and enjoyment of their shopping experience with AR apps. Furthermore, when a consumer has increased perceived informativeness, this transforms into purchase intention, increasing brand recognition and potential revenue.

[70]describes that there have been obstacles between consumers and online products. Therefore, the authors mention that these obstacles can be overborne by AR app usage. Furthermore, their research shows that AR implementation reduces product quality and fit uncertainty, and reducing product uncertainty leads to a positive product attitude.

0 denotes that new technologies such as augmented and VR will significantly impact the future of e-retailing. Using the stimulus-organism-response (S-O-R) model, the study examines the AR consumer intention in e-retail. The study found that most of the sample University students have technophilia or a strong enthusiasm for nw technology usage and purchase intention.

Countries co-occurrence

Figure 4 represents the countries' co-occurrence analysis for at least 10 documents per country. The total number of countries detected is 32, with 244 linkages. Five clusters were discovered, among which the United States of America and England are represented with the highest number of papers.

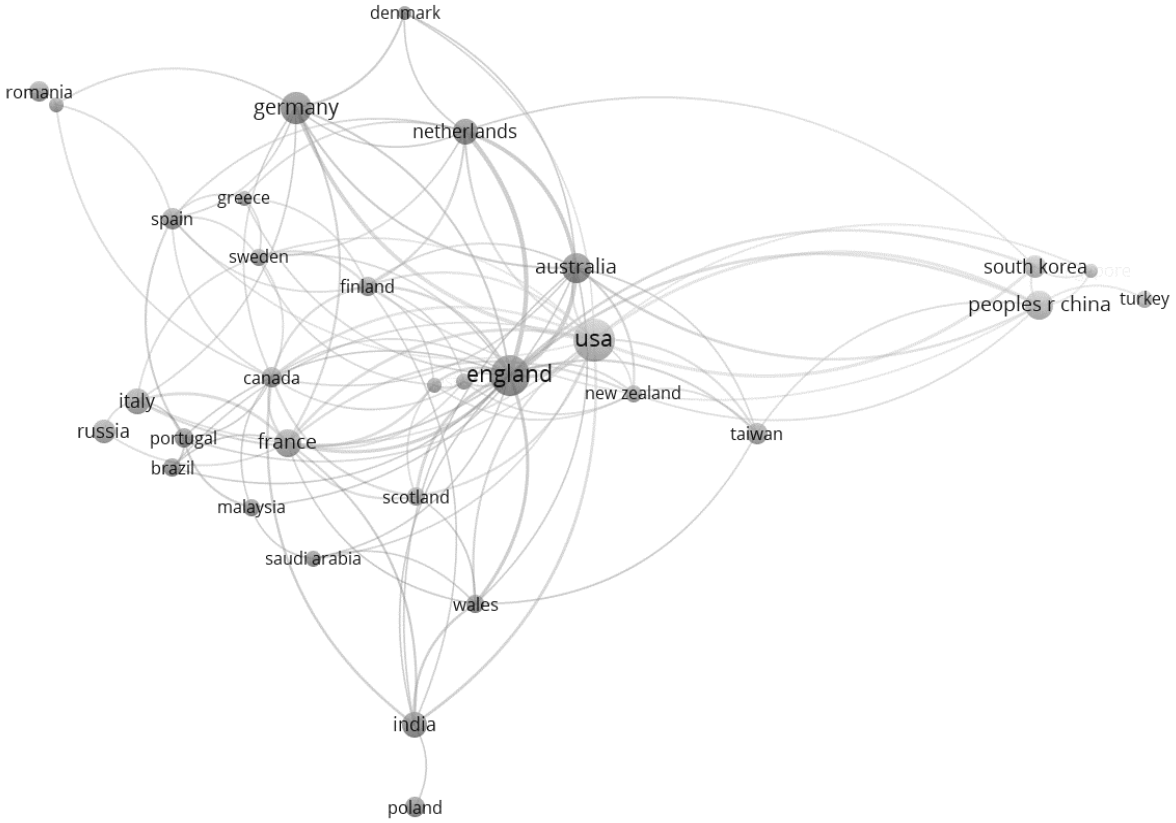

Figure 4. VosViewer cluster analysis (countries with 10 or more documents).

Figure 5 contains the country's heat map. It can be seen that the middle part of the map has the brightest yellow colour. This shows that the United States of America and England, with border countries such as Australia and New Zealand, indicate keywords with 10 or more documents per country.

Table 7 presents the cluster of the countries where the author's institution is situated. Cluster 1 contains mainly European countries except for Taiwan and New Zealand. Cluster 2 denotes a more diverse mix of European (Poland, Portugal and Wales), South Asia (India, Malaysia), South America (Brazil) and the Middle East (Saudi Arabia). Cluster 3 is formed mainly of European countries, except for Canada and Iran. Cluster 4 contains Northern European countries, except for Australia. Finally, Cluster 5 contains a mixture of regions such as North America (USA), South Asia (Singapore), Europe (Turkey) and the Far East (People's Republic of China and South Korea). As can be seen, most countries with a minimum of 10 documents per country are mainly from Europe. However, the cluster composition indicates strong international cooperation between authors from various countries.

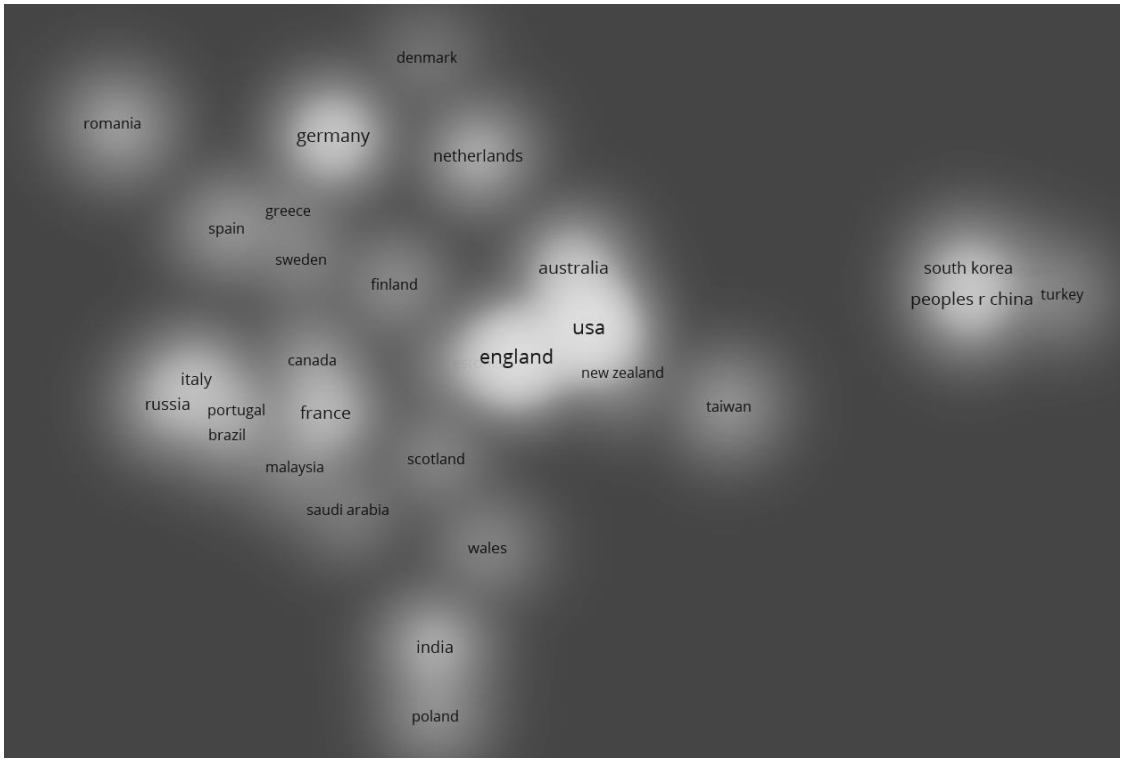

Figure 5. VosViewer countries heatmap (keywords with 10 or more documents).

Table 7. Cluster countries (countries with 10 or more documents).

Cluster	Cluster countries
Cluster 1	Estonia; France; Italy; New Zealand; Norway; Russia; Scotland; Taiwan;
Cluster 2	Brazil; India; Malaysia; Poland; Portugal; Saudi Arabia; Wales
Cluster 3	Canada; Finland; Greece; Iran; Romania; Spain; Sweden;
Cluster 4	Australia; Denmark; England; Germany; Netherlands;
Cluster 5	People's Republic of China; Singapore; South Korea; Turkey; USA

The following section consists of a discussion and conclusion. In that section comparison of these research findings with another peer, literature will be discussed. Furthermore, the research paper authors will conclude their final thoughts.

DISCUSSION AND CONCLUSION

SUMMARY OF THE RESEARCH

Technological innovations have become ubiquitous, and their omnipresence will increase even more. Therefore, companies must adapt to the constant market demands, which require constant technological innovation, with AR as one of the most prominent.

The purpose of this work was to provide a literature assessment of AR in business and economics research from 2017 to 2021. The research time frame for this study, which uses the Web of Knowledge database, spans from 2017 to 2021.

THEORETICAL IMPLICATIONS

The article aimed to conduct a literature review of AR in business and economics research in 2017-2021, thus complementing the more general literature reviews of AR research, e.g. [16], [17]-[19]. However, more importantly, this literature review focuses on the applications of AR in business and management, which is relevant, taking into account that previous research focused on specific applications using AR technologies, e.g. [20]-[25].

The first part of the research presents the bibliometric analysis to detect the most significant journals, conferences and countries. It is explained below.

Most of the research has been published as research articles, followed by papers published in conference proceedings. The AR topic is highly diversified based on the various journal areas that publish AR research, ranging from the Journal of retailing and consumer service to various journals in business research, retail distribution management, psychology, marketing science and tourism management, and others. Conferences are also diversified, with the only exception being International Conference on AR and VR is the most fruitful one. Yet, no single journal or conference is solely devoted to the publication of AR research.

Most of the papers were published in the USA, followed by England and Germany, indicating that most AR research has been conducted in developed countries. The same conclusion stems from the analysis of the funding agencies.

Citation analysis has, on the other hand, indicated a constant rise in publications and citations from 2017 to 2021. The number of citations grew much larger than the number of publications, indicating the demand for AR high-quality publications.

The second part of the research presents the text mining analysis using VOSviewer software, intending to conduct the keyword and country co-occurrence. The co-occurring keywords are structured in 4 clusters with main topics of technology & education (cluster 1), e-commerce & retail (cluster 2), tourism & consumer experience (cluster 3) and consumer & purchase (cluster 4). Most publications are interconnected with imposing AR app benefits and their impact on future business, e.g. consumer purchase intention, e-commerce, tourism and education.

The co-occurrence by countries has shown five clusters from which most publications are from the United States of America and England. Therefore, confirming the results of the bibliometric analysis also pointed out these two countries as the leading ones in the area of AR research.

PRACTICAL IMPLICATIONS

To provide clients with unique solutions, practitioners of AR will find this study helpful. In-depth analyses of current AR trends and prospective future uses for the improved experience in business, and economics are shown in this study.

Several concepts are constructed with AR technology for it to be more efficient in providing solutions. Visual thinking or AR's capacity to generate a visually rich environment with the ability to understand changes in personal behaviour is crucial for detecting nonverbal senses detection [52], [53]. The practical implication of such AR's ability could be in the fieldwork/practical application of various disciplines. Education, retail and gaming are the industries where AR technology might see the biggest impact.

The ARs in classroom usage help students, especially in STEM education, better understand numerical, visual or graphical equations and solving processes, for example [55], [56]. This kind of lecture innovation would not only be practical but would decrease the amount a student needs to spend understanding how to solve an exercise. Furthermore, it would deduct the time a lecturer must spend explaining tasks and could focus on other aspects.

Another industry where AR is already gaining full usage is the gaming industry. The innovation of an old game, such as "Pokemon", with new technologies, such as AR, can substantially increase the number of game users due to the combination of the new technology and nostalgia and user emotions [58]. Therefore, a game that uses AR technology might become more interesting to the user due to the higher level of engagement, as it involves a real-life environment through the mobile phone camera lens.

Another distinction is that this study provides a detailed explanation of each cluster's mapping results. This means the subjects that have received the most attention and use in AR research for the corresponding field can be identified.

Cluster 1 focuses on technology & education the most. Therefore, the papers in this cluster show innovations in these areas as the examinee's opinion of the research experiment. AR innovations are positively referenced by students, which included that the explicit purpose of the application, ease of use and learning, smooth operation, imaginative information presentation, and interactivity are the most important aspects of AR app development [43]. Furthermore, any education with a practical application should have AR technology as compulsory. It can reduce inexperienced students' anxiety and make them more familiar with the practical application environment and fundamental specific job skills, which can minimise errors in their real practicum [45].

Cluster 2 focuses on e-commerce and retailing. In this field, AR is just one of the few technologies, such as AI & VR, that are "working" together to create a more efficient consumer buying process [61]. Another great innovation in this area is the eye tracking method which could be tracked through the laptop/computer video camera or by using VR glasses, where the tracking would be easier. The AR, in this case, would only be used in the consumer part of the purchase process [62].

Cluster 3 is focused on tourism & user experience. This cluster is focused on one industry where AR implementation is of great importance due to its nature. AR technology might change the way tourists experience cities, same as with the retail purchasing process; tourism city exploration might change as well with new sightseeing AR apps [65][67], [68]. Those apps are already used in some Croatian touristic cities such as Split.

Cluster 4 is focused on consumers & purchases. This cluster can be slightly related to cluster 2, where AR is used in online purchasing to make purchasing for the consumer easier. The option of showing products in their environment makes a purchasing intention difference [69] 0.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Based on corresponding research, it can be said that, while being initiated early, the study of AR in business and economics is still in its infancy. Future investigation in this area will need to focus on expanding AR usage in particular industries and the consumer experience. Although these technologies can simplify for consumers to obtain their activities and potentially raise the calibre of doing traditional business, many industries still have not embraced them.

Article limitations stand from the focus on only one scientific research source indexed in WoK. Although this approach assures the inclusion of peer-review research, it also misses the emerging research, which is especially relevant for advanced technologies, such as AR. Therefore, future research directions for reviewing AR in business and economics are to increase the coverage of the research papers to white papers and case studies and include complementary technologies, such as VR. Furthermore, a combination of professional research papers and two or three additional research paper databases would contribute to a better and more concise AR in business and economics presentations.

APPENDIX

Table 8. Ten most cited augmented reality publications (2017-2021).

Title	Authors	Journal	Average per year	Total
The Future of Retailing	Grewal, D.; Roggeveen, A.L. and Nordfalt, J.	Journal of Retailing **93**(1), 1-6, 2017	68,33	410
The future of manufacturing industry: a strategic roadmap toward Industry 4.0	Ghobakhloo, M.	Journal of Manufacturing Technology Management **29**(6), 910-936, 2018	77	385
The impact of virtual augmented and mixed reality technologies on the customer experience	Flavián, C.; Ibáñez-Sánchez, S. and Orús, C.	Journal of Business Research **100**, 547-560, 2019	57,75	231
Is Augmented Reality Technolog y an Effective Tool for E-commerce? An Interactivity and Vividness Perspective	Yim, M.Y.C.; Chu, S.C. and Sauer, P.L.	Journal of Interactive Marketing **39**, 89-103, 2017	33,83	203
Enabling smart retail settings via mobile augmented reality shopping apps	Dacko, S.G.	Technological Forecasting and Social Change **124**, 243-256, 2017	27,33	164
Technological disruptions in services: lessons from tourism and hospitality	Buhalis, D.; Harwood, T.; Bogicevic, V.; Viglia, G.; Beldona, S. and Hofacker, C.	Journal of Service Management **30**(4), 484-506, 2019	38,5	154
Augmenting the eye of the beholder: exploring the strategic potential of augmented reality to enhance online service experiences	Hilken, T.; de Ruyter, K.; Chylinski, M.; Mahr, D. and Keeling, D.I.	Journal of the Academy of Marketing Science **45**(6), 884-905, 2017	25,67	154
Collaboration in BIM-based construction networks: A bibliometric-qualitative literature review	Oraee, M.; Hosseini, M.R.; Papadonikolaki, E.; Palliyaguru, R. and Arashpour, M.	International Journal of Project Management **35**(7), 1288-1301, 2017	25,17	151
Augmented reality marketing: How mobile AR apps can improve brands through inspiration	Rauschnabel, P.A.; Felix, R. and Hinsch, C.	Journal of Retailing and Consumer Services 49, 43-53, 2019	35,25	141
Discernible impact of augmented reality on retail customer's experience, satisfaction and willingness to buy	Poushneh, A. and Vasquez-Parraga, A.Z.	Journal of Retailing and Consumer Services **34**, 229-234, 2017	22,33	134

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