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ORIGINAL PAPER

INDUSTRY 4.0: STATE OF THE ART AND RESEARCH IMPLICATIONS

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ABSTRACT. **Background:** Over the last few years, the Industry 4.0 concept has attracted attention among both academics and practitioners. Industry 4.0 is a very broad domain including production processes, efficiency, data management, relationship with consumers, competitiveness, and much more. Therefore, the aim of the paper was to analyze the main contributions published on the topic of Industry 4.0.
Methods: The literature review method was used to verify current knowledge on the Industry 4.0 topic, with the use of developed methods for literature review research dedicated to it.
Results: On the basis of the literature review procedure, answers to the research questions were obtained: RQ1: Is the "Industry 4.0" topic still relevant for researchers? RQ2: Does the national policy on Industry 4.0 influence the research interest in Industry 4.0? RQ3: What are the key components of Industry 4.0? RQ4: What are the implications of Industry 4.0 for other research topics?
Conclusions: This paper contributes theoretically to the development of the literature on Industry 4.0. Results obtained from the research not only summarise the current research activities but also indicate existing potential research directions. The findings of this review can be used as the basis for future research on Industry 4.0 and related topics, as well as a guideline for making a literature review.

Key words: Industry 4.0; literature review; state of art.

INTRODUCTION

This paper draws attention to Industry 4.0 as it has been observed to be a considerable interest of the fourth industrial revolution as a research topic, which has concerned Academia, business, and governments, since 2011, when the German term "Industrie 4.0" was announced at the 2011 Hannover Fair. It was stated that Industry 4.0 has been one of the most frequently discussed topics among people, which may be confirmed e.g. by the analysis of trends in the Google Trends browser (Fig. 1).

Google Trends show the interest in terms of region or interest in terms of time for any searched keyword. Interest in terms of time estimates numbers representing individual interest towards the highest point in the chart printed in the browser. A value of 100 indicates the highest popularity of a particular term. In order to verify the worldwide potential in the aspect of Industry 4.0, checking of interest by time was sufficient, considering the English ("Industry 4.0") term and the German one ("Industrie 4.0") as Germany is the place of the concept's origin. Since the beginning, there has been much more interest in this topic in the German language, but the situation changed in 2017, where the total number of searches in English was higher. Moreover, this increasing trend in the number of searches has continued and in the authors' opinion, this situation will take place for the next few years.

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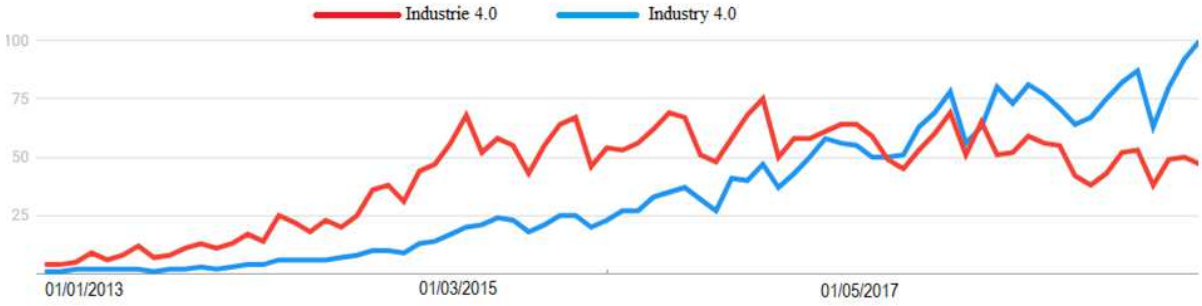

Source: own work

Fig. 1. Interest rate of "Industry 4.0" topic (between 01.01.2013-22.03.2019)

The high importance of Industry 4.0 has been caused by interest from the government. The German federal government has supported the idea by announcing that Industry 4.0 will be an integral part of the "High Technology Strategy for Germany 2020", an initiative aimed at leading the technological innovation. Consequently, Germany was closely followed by other countries which decided on an industrial revolution, including China, France, Japan, South Korea, the United Kingdom, and the United States. National proposals and policies have been created to drive the development of industry in the medium and long term, which was described in detail in [Lu,Weng 2018, Da Silva et al. 2019]. Considering the above, it was claimed that there is pressure to move towards Industry 4.0.

Table 1. Reviews on Industry 4.0 – state of art

Reference	Year	Time window	Database	Scope of the research
Liao et al., 2017	2017	Till 06.2016	WoS, Scopus, Science Direct	1) Journals and conferences including Industry 4.0 topic; 2) Enabling features of Industry 4.0; 3) Existing Industry 4.0 application fields; 4) The most frequently citied references; 5) Research objects and research goals in Industry 4.0; 6) Researchers working on Industry 4.0, countries, and represented institutions; 7) The list of standards, software and hardware appeared in Industry 4.0 implementations.
Lu, 2017	2017	2011-2016	WoS, Google Scholar	Research on Industry 4.0 categorization including following categories: Cyber-Physical Systems (CPS) based Industry 4.0, Interoperability of Industry 4.0, Concept and perspectives, Key technologies, Applications of Industry 4.0.
Oztemel, and Gursev, 2018	2018	Till 2017	CiteSeerX, ACM, AISeL, EBSCO host, Emerald Insight, Taylor Francis, Science Direct, Google Academic	1) National incentives for Industry 4.0 (Germany, USA, Japan, China, Taiwan, South Korea, Turkey); 2) A set of goals to achieve Industry 4.0; 3) Industry 4.0 components description (CPS, Cloud systems, IoT, machine to machine (M2M) communication, Smart factory, Data mining, big data, ERP and business intelligence, augmented reality, simulation, virtual manufacturing, robotics; 4) Description of particular Industry 4.0 research projects.
Kamble et al., 2018	2018	2012-2017	WoS	1) Research on Industry 4.0 categorization including: research categories (conceptual papers on Industry 4.0, human-machine interactions, machine-equipment interactions, technologies of Industry 4.0 and sustainability) research approach (conceptual, case study, simulation, experimental, survey, prototype); 2) Qualitative analysis of number of papers per year; 3) High contributing authors; 4) Contributions by publishers, journals and country; 5) Keywords in publication title statistics; 6) Co-citation map of top contributing authors.
Piccarozzi et al., 2018	2018	Till 06.2018	Scopus, WoS, Google Scholar	1) Qualitative analysis of number of papers per year; 2) Contributions by journals and country; 3) Research on Industry 4.0 categorization based on methodological aspect (conceptual, empirical); 4) Industry 4.0 definition divided by main domain in which they were found (technical components, value chain, smart factory, competitiveness, strategy, IoT); 5) Industry 4.0 domains

Source: own work

Industry 4.0 is a new concept, but it is not a completely new research area, as it has been based on previous research and has tied together recent advances in the areas of automation, artificial intelligence, production technology, information communication technology, and cloud technology [Lu, Weng 2018].

As a result of preliminary research on Industry 4.0, only five papers presenting a literature review of Industry 4.0 were identified (Table 1).

Despite the dynamic nature of the research on Industry 4.0, limited access to a systematic and extensive review of recent research on this topic has been identified. With reference to Table 1, researchers have done literature reviews on Industry 4.0 using various scientific databases. However, the most frequently used repositories were Scopus and Web of Science. Research on Industry 4.0 has been analyzed qualitatively (e.g. definition of Industry 4.0) and quantitatively (e.g. distribution of papers per year, contributions by journals or country, etc.). The most recent review was from the middle of 2018, but it was focused on the managerial context of Industry 4.0. In the authors' opinion, the most comprehensive paper was [Liao et al., 2017], but it presents the state of the industry up to the end of 2016.

Accordingly, this paper conducts a review on Industry 4.0 made up to 03.2019 to give a more recent look at the Industry 4.0 topic, considering aspects presented in research questions RQ1-RQ4, which have not been analyzed in any study so far (Table 2).

Table 2. Research questions

ID	Question	Objective
RQ1	Is the "Industry 4.0" topic is still relevant for researchers?	To justify conducting a research on Industry 4.0 topic
RQ2	Does the national policy on Industry 4.0 influence the research interest in the Industry 4.0?	To verify the relationship between national policy on the Industry 4.0 and research on this topic
RQ3	What are the key components of the Industry 4.0?	Identification the key components of Industry 4.0, considering the human and technological context
RQ4	What are the implications of Industry 4.0 on other research topics?	Identification of the scope and size of Industry 4.0 influence on research apart from manufacturing process

Source: own work

Consequently, the major objective of the paper was to obtain an overview of Industry 4.0 following a list of specified research questions (Table 2), which was required to achieve the following partial objectives:

- O1: A procedure for literature review development;
- O2: Carrying out a literature review.

In the paper a few research questions were presented that have taken up the issue of Industry 4.0 considering aspects which have not been discussed so far in the literature or that have not been updated. The presented results of the literature research are preliminary research on the state of Industry 4.0.

The remainder of this paper is structured as follows. The research methodology is introduced in Section 2. Section 3 presents the main findings of the literature analysis on the basis of research questions RQ1-RQ4. Based on the answers to those questions, Section 4 provides final conclusions with research limitations and future perspectives..

RESEARCH METHODOLOGY

A literature review is an essential part of any research work. The aim of this study was to obtain an overview of Industry 4.0 considering the relevance of the topic, the influence of national policies on the interest rate of Industry 4.0, key components of Industry 4.0 and research directions. To achieve the major objective of the paper, approaches developed by Kitchenham [2004]

and Denyer and Tranfield [2009] have been used to gain comprehensive insights into Industry 4.0. Owing to the fact that one common approach to the literature review has not been identified, the authors decided to prepare a procedure useful for the literature review on a specific topic which corresponds with the partial objective O1 (Fig. 2).

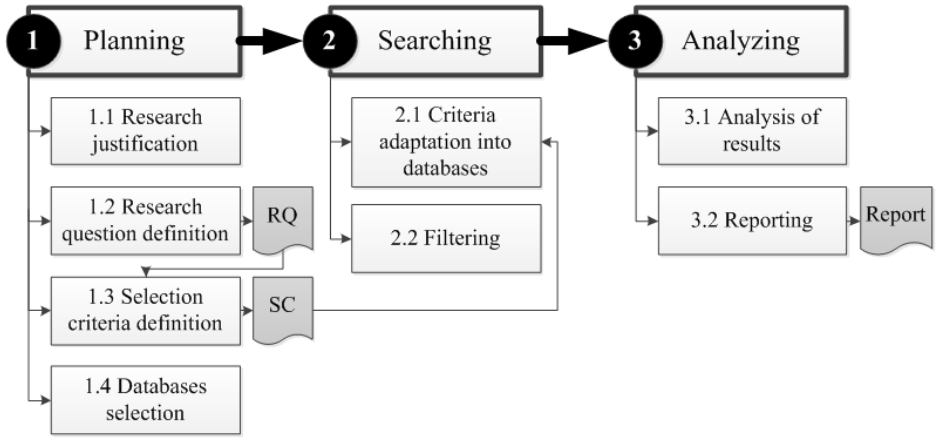

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Fig. 2. Review procedure

With reference to Fig. 2, the review procedure consists of three stages, including planning, searching and analysis of the obtained results. In the authors' opinion, the procedure for literature review should be simple to use and clear on how to analyze the results. The prepared procedure (Fig 2.) was used in the paper to verify this.

Considering the major objective of the paper, the literature research was justified. The research questions RQ1-RQ4, presented in the Introduction, were used in the literature research in order to define the selection criteria described in Table 3.

Table 3. Selection criteria

Criterion	Description
Keywords	"Industry 4.0" OR "4th industrial revolution" OR "fourth industrial revolution"
Search field	Title
Time window	2011 - 03.2019
Language	English
Publication type	Conference paper, book chapter, article
Inclusion criteria	I1: The whole content of the paper is written in English
	I2: The paper explicitly express research focus on Industry 4.0

Source: own work

Considering the efforts of previous research on the literature review of Industry 4.0 (Table 1) the following keywords have been searched among paper titles: "Industry 4.0", "4th industrial revolution", "fourth industrial revolution". Book chapters, articles and conference papers were included in the search to ensure the research originated from academic sources. In the research, papers published after 2011 and written in English were included (as the date of the concept's origin). In order to ensure the high quality of the research, two inclusion criteria were used, regarding the language of the whole content of the paper (I1) and the research focus on Industry 4.0 (I2). At the last step of the planning stage (Fig. 2), scientific databases were chosen, considering the use of repositories to which access is available for authors of the paper, using scientific databases with the highest coverage for the researched topic. For these reasons, the authors referred to

papers from the Web of Science (WoS) and Scopus databases, which contain a significant number of renowned publications on the Industry 4.0 topic, which corresponds to the information presented in Table 1.

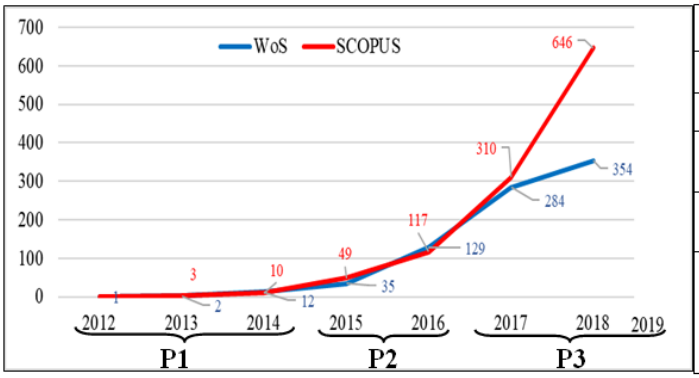
Regarding Fig.2, in the second stage of the review procedure, answers to the research questions were searched by selection criteria adapted into filtering for databases and papers.

The last stage of the conducted research included an analysis of the results and a report of them, which is described in detail in the next section.

RESEARCH FINDINGS

Is the "Industry 4.0" topic still relevant for researchers?

To present the current interest rate in the Industry 4.0 topic among researchers, an analysis of documents collected in scientific databases was carried out, including Web of Science (WoS) and Scopus, where particular selection criteria (Table 3) were adopted into databases. The results of publication filtering are presented in Fig. 3.



	WoS	Scopus
Total number of papers	857	1250
First paper date	2012	2013
Max. number of papers per year	354	646
% share of papers (2017-2018)	74%	76%

Trend lines:
$y = 14{,}429x^2 - 53{,}286x + 41{,}286$ (WoS)
$y = 31{,}583x^2 - 157{,}7x + 161{,}29$ (Scopus)

Source: own work

Fig. 3. Distribution of papers on Industry 4.0 per year (28.03.2019)

Although the term, Industry 4.0, was used for the first time in 2011, the first scientific paper was published in 2012 (WoS) and in SCOPUS it was dated in 2013. With reference to Fig. 3, the authors determined three phases of research on Industry 4.0 (P1-P3):

- P1: 2012-2014, the initial phase, where there was little interest in Industry 4.0 with a high conceptual character;
- P2: 2015-2016, the introduction phase, where there was increasing interest in Industry 4.0 as the concept had begun to be introduced into the national policies of particular countries;
- P3: 2017-2019 (till now), the growth phase, where a high level of interest has been identified in the Industry 4.0 topic, which has been a well-known and recognized concept from a theoretical perspective, resulting in works on the practical applications of Industry 4.0 solutions. Moreover, at this phase, the creation of new concepts based on Industry 4.0 may be observed, which go beyond industrial application e.g. Logistics 4.0.

According to Fig. 3, the distribution of papers in both the WoS and Scopus databases, rose significantly over the period from 2012 to 2018, achieving the maximum value in 2017 of 354 papers in WoS, and 646 papers in Scopus. Although there were differences in the number of papers in the compared databases, the trend was quite similar. It is noteworthy that there has been a rapid growth in the number of publications on Industry 4.0 since 2017, wherein both databases the total number of papers was around 300, while in 2016 it was almost three times less. Considering the percentage share of papers developed between 2017 and 2018 (around 75%), a multinomial trend analysis was carried out for each database, which confirmed that the level of interest in the Industry 4.0 topic is going to go

up (Fig. 3). On the basis of trend analysis, it was assumed that in 2019 there may be more than 920 papers in the SCOPUS database and around 540 publications in the WoS database, so the positive trend should continue. It was planned that these forecasts be verified in 2020.

To sum up, there was a clearly defined pattern on the graph (Fig. 3) that confirms a growing interest in research on the Industry 4.0 topic, which will be continued in the future. In the authors' opinion, this provides a justification for research on the fourth industrial revolution, in particular, that it was a relevant issue for Business and Academia in the past and it should be important in the future, too. It was claimed that the challenge is to describe existing Industry 4.0 solutions used in practice, because in the authors' opinion, the practice of Industry 4.0 is ahead of the theory of this concept. Taking the above into consideration, it was stated that the RQ1 was answered.

Does the national policy on Industry 4.0 influence the research interest in the Industry 4.0?

It was assumed that national policies and programs leading to Industry 4.0 should have an impact on the level of interest on this topic among researchers, expressed in number of papers. To verify this assumption, results were analyzed of the distribution of papers by country, presenting the top 5 countries, considering the number of papers (Table 4).

Table 1. Documents per country

Position	WoS			Scopus		
	Country	No of papers	% share	Country	No of papers	% share
1	Germany	167	13,36%	Germany	225	18,00%
2	China	77	6,16%	Italy	124	9,92%
3	Italy	67	5,36%	UK	90	7,20%
4	Spain	51	4,08%	USA	84	6,72%
5	UK	50	4,00%	China	82	6,56%
Total		412	32,96%	Total	605	48,4%

Source: own work

Regarding Table 4, in WoS almost one-third of all papers were written by researchers representing the top 5 countries, while this share was greater by almost 15% in the Scopus database. Despite the database type, Germany was a leader providing almost one-fifth of all papers in Scopus and around 14% of all works in WoS. Considering the above, the authors verified the assumption with respect to these top 5 countries, so information was sought on national policies and programs on Industry 4.0 to assess the level of commitment to Industry 4.0 at the national level according to a scale where:

- 0 - there is no national policy on the Industry 4.0;
- 1 – there is a national policy, there are undertaken some initiatives for Industry 4.0;
- 2 – there is a national policy, there are many valuable in the context of the whole country initiatives for Industry 4.0 promoted by business and government;
- 3– there is a national policy, there is a plenty of initiatives on Industry 4.0 promoted by business and government, and the policy has an influence on other countries initiatives.

With reference to Table 4, it was stated that, according to the number of papers on Industry 4.0, the most influential country has been Germany, and later were identified: China, UK, USA, Spain and Italy. In order to answer the RQ2, an analysis of literature and Internet sources on Industry 4.0 initiatives in selected countries was carried out, which was scored according to the accepted scale (0-3). The results of the analysis are shown in Table 5.

Table 5. Assessment of commitment in Industry 4.0 at national level

Country	Examples of initiatives	Score (0-3)
Germany	Platform Industrie 4.0, BDEW, BDI, Bitkon, VDA, VDMA, ZVEI	3
China	Made in China 2025, Smart Factory 1.0 Initiative, Internet Plus, Internet of Things Center Shanghai	3
Italy	The I4.0 National Plan	2
Spain	Connected Industry 4.0 (CI 4.0)	2
UK	Catapult centres, High Value Manufacturing, Satellite Applications	2
USA	Industrial Internet Consortium (IIC), National Network for Manufacturing Innovation (NNMI), AllSeen Alliance	3

Source: own work based on Kagermann et al. 2016

To sum up, it was stated that in the case of all the countries analyzed in this section, a positive relationship has been identified, confirming that the more initiatives on Industry 4.0 at the national level, the bigger the research interest in the topic. In the authors' opinion, this confirms that research follows practical achievements.

What are the key components of the Industry 4.0?

In the presented paper, the authors' claim that many approaches to the definition of Industry 4.0 have been identified in the literature, considering the following categories: technical components, value chain, smart factory, competitiveness, strategy or The Internet of Things, described in detail in [Piccarozzi et al , 2018, p.11]. One common thing for each definition has been a technological context, as technology plays an essential role as it is required for change. As a consequence, following Burritt and Christ [2016], in this study, Industry 4.0 was considered as "an umbrella term used to describe a group of connected technological advances that provide a foundation for increased digitization of the business". Considering the results of previous literature research on Industry 4.0 (Table 1), a list of key components of Industry 4.0 was prepared and verified by the authors of the paper (Table 6).

Table 6. Key components of the Industry 4.0

Keyword	% share (WoS)	% share (Scopus)
Internet of Things (IoT)	30,22%	47,12%
Big data	15,52%	33,92%
Cyber Physical System (CPS)	11,44%	43,20%
Smart Factory	8,52%	29,84%
Cloud computing	6,18%	15,92%
Data mining	1,05%	6,48%
Virtual reality	1,52%	6,00%
Augmented reality	3,03%	7,92%
Robots	5,60%	16,64%
Additive manufacturing	2,22%	5,60%

Source: own work

With reference to Table 6, it was stated that some of the components are more relevant, e.g. Internet of Things or Big Data, because they appear more often in the paper's topic (title, keywords, abstract), but it is essential that all elements define the meaning of Industry 4.0. In the authors' opinion, Industry 4.0 creates a smart factory which results in smart products being delivered to customers. It is noteworthy that in manufacturing, as well as in the whole value chain, innovative solutions are used combining the physical and virtual world (by CPS), where things and objects are linked through IoT. Moreover, in Industry 4.0, additive manufacturing (e.g. 3D printing), virtual reality, cloud computing, big data, and data mining are used as there is a huge amount of data resulting from the communication between objects.

To sum up, there are many components of Industry 4.0 which should be used in order to introduce Industry 4.0. In the author's opinion, this topic requires empirical research in the industry to verify theoretical data about the key technological components of Industry 4.0.

What are the implications of Industry 4.0 on other research topics?

In order to get the answer for the last research question (RQ4), publications with the term "4.0" in the publication title and published after 2011 were analyzed, excluding papers with the following terms in the title: "Industry 4.0", "Industrie 4.0" and "version 4.0".

It was assumed that the term "4.0" combined with other words had been used by researchers to determine new concepts which were defined by the authors of the paper as "Industry 4.0 secondary documents". As a result, a list of concepts based on Industry 4.0 was identified (Table 7).

Table 7. Concepts based on Industry 4.0

Concept	frequency	% share	cumulative % share	Concept	frequency	% share	cumulative % share
Education	25	12,76%	12,76%	Supply chain	3	1,53%	87,24%
Operator	16	8,16%	20,92%	Machine Tool	2	1,02%	88,27%
Health	16	8,16%	29,08%	Marketing	2	1,02%	89,29%
Logistic	16	8,16%	37,24%	Country (Thailand)	2	1,02%	90,31%
Management	14	7,14%	44,39%	city	2	1,02%	91,33%
Work	12	6,12%	50,51%	Mobility	2	1,02%	92,35%
Factory	9	4,59%	55,10%	Material	2	1,02%	93,37%
Agriculture	7	3,57%	58,67%	Audit	1	0,51%	93,88%
Resources (energy, water)	7	3,57%	62,24%	Engineering	1	0,51%	94,39%
Medicine	7	3,57%	65,82%	Remanufacturing	1	0,51%	94,90%
Leadership	5	2,55%	68,37%	Workforce	1	0,51%	95,41%
Organization	5	2,55%	70,92%	Transport infrastructure	1	0,51%	95,92%
Lean	4	2,04%	72,96%	Productivity	1	0,51%	96,43%
Maintenance	4	2,04%	75,00%	Insurance	1	0,51%	96,94%
Service	4	2,04%	77,04%	Everything	1	0,51%	97,45%
Quality	4	2,04%	79,08%	Cybercrime	1	0,51%	97,96%
Economy	4	2,04%	81,12%	Administration	1	0,51%	98,47%
Enterprise	3	1,53%	82,65%	Software	1	0,51%	98,98%
Safety	3	1,53%	84,18%	Government	1	0,51%	99,49%
Paint Shop	3	1,53%	85,71%	Tools	1	0,51%	100,00%

Source: own work

Based on the filtering scientific databases WoS and Scopus, 40 concepts were identified in the literature within the Industry 4.0 framework which could be categorized as e.g. considering human aspect, level of interest (country, city, enterprise, etc.), business activity (e.g. marketing, logistics, remanufacturing, management, etc.), resources context (including machines, tools, water, energy, etc.) and other unclassified aspects.

Firstly, papers available in the Scopus database (182 papers) were identified, and secondly, papers included in the WoS repository (67 papers). In the next step, all papers were included in the one spreadsheet, eliminating duplicates, which resulted in 196 papers, which were analyzed in detail. Each concept based on Industry 4.0 was examined in the publication title to identify the frequency of occurrence in the literature. It was stated that the identified concepts are not equally important for researchers (% share of use of a particular concept in the paper's title). Considering the Pareto Rule, it was claimed that 50 % of all concepts have been used in 80% of all Industry 4.0 secondary papers. The in-depth analysis resulted in the conclusion that the most relevant concepts (top five) based on Industry 4.0 are: Education 4.0, Operator 4.0, Health 4.0, Logistics 4.0 and Work 4.0. In the authors' opinion, a human context of Industry 4.0 appears very often in the research, considering issues related to working conditions, health and, most relevant of all, an education context. In the authors' opinion, the education aspect has become very relevant, because it is related to people's skills and qualifications who have to deal with revolution 4.0, not only in the Industry, but also in Services, Transport, Administration, etc. (Table 7). It is noteworthy that Logistics 4.0

has been an important issue, too. As a consequence some efforts may be observed on a description of maturity models for Industry 4.0 (in total, 13 papers on that topic have been identified in WoS and Scopus (e.g. [Schumacher et al., 2016; Ganzarain, Errasti, 2016]) and for Logistics 4.0 [e.g. Sternad et al. 2018, Oleśków-Szłapka, Stachowiak 2019]. To sum up, Industry 4.0 is a very influential research topic, which may be confirmed by data in the Table 7. In the authors' opinion, the level of interest in the concepts presented in this paper should increase because a research gap has been identified in the context of the Industry 4.0 topic.

CONCLUSIONS

In this paper, the authors have presented the results of a literature review on the Industry 4.0 topic focusing on a few aspects of the fourth industrial revolution, namely:

- Future potential for research on the Industry 4.0 topic, which corresponds to RQ1;
- The relationship between incentives for Industry 4.0 at the national level and research on Industry 4.0, which corresponds to RQ2;
- Identification of key elements of Industry 4.0, which corresponds to RQ3;
- Identification of new concepts based on Industry 4.0, which corresponds to RQ4.

Taking the above into consideration, it was stated that the partial objective, O2, was achieved, and, as a consequence, the major objective of the paper was achieved.

In this study, knowledge about the existing state of art papers on the Industry 4.0 topic was gathered to provide a guideline for future research on this topic. It should be kept in mind that literature review papers are always active for some period of time. Because the world is changing very fast, researchers have to follow changes and update their work. Consequently, the literature review should consider the results of previous research, to treat them as a guideline. In this paper, the authors have used existing literature review papers on the Industry 4.0 topic in order to obtain answers for specified research questions (RQ1-RQ4). Considering the previous literature on Industry 4.0 (Table 1), the authors have specified a list of questions which have not been included in the literature review so far.

Considering the results of the presented study, several limitations should be noted. Firstly, in the presented research, only a few research questions were included about the actual state of Industry 4.0 (up to March 31, 2019). It should be noted that the list of research questions has not been closed as the paper presents results of preliminary research on Industry 4.0. In the future, the authors are going to prepare a complex literature review that will summarize all information about Industry 4.0 in the scope of various dimensions, including those which have been presented in the papers in Table 1.

Secondly, academic sources (collected from the WoS and Scopus databases) were used in the research, so the future research should be extended to other repositories like Google Scholar or IEEE Xplore Digital Library and should take into account evidence from industry/practitioners. The next issue is the language limitation which has influenced the research, as existing Industry 4.0 research published in other languages (in particular, in German) was excluded.

Despite some limitations, as a result of the literature review, the current status of the research on Industry 4.0 was reported from the perspective of selected research questions. In the future, it is planned to expand this research by adding German language and additional databases in order to build our own database of all the papers on Industry 4.0 and to add to the analysis additional research questions which were used in previous research (Table 1).

It is noteworthy that the presented research was based on scientific papers, which in particular represent theoretical character. To define real key components of Industry 4.0, empirical research into companies should have been done to identify the practical solutions they use. To sum up, the authors of the paper stated that a research gap has been identified which indicates the direction of future research in which evidence from industry should be

included too. It was claimed that, in Industry 4.0, the rule that, „the Practice is one step before the Research" may be observed. The above implies the necessity of conducting empirical research in companies in order to make a full analysis of Industry 4.0 and, as a consequence, to determine Industry 4.0 paradigms based on theoretical foundations verified by industry achievements.

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PRZEMYSŁ 4.0: STAN OBECNY I WYTYCZNE W ZAKRESIE POTENCJALNYCH BADAŃ

STRESZCZENIE. **Wstęp:** W ciągu ostatnich lat, koncepcja Przemysłu 4.0 przyciąga uwagę zarówno przedstawicieli nauki jak i przemysłu. Przemysł 4.0 dotyczy procesów produkcji, wydajności, zarządzania danymi czy relacjami z klientami, kwestiami związanymi z konkurencyjnością oraz wiele innych zagadnień.
Metody: W pracy wykorzystano metodę analizy literatury celem weryfikacji aktualnego stanu wiedzy w zakresie koncepcji Przemysłu 4.0. W tym celu wykorzystano dedykowaną procedurę przeprowadzania badań literatury.
Wyniki: Na podstawie opracowanej procedury przeprowadzania studiów literatury, uzyskano odpowiedzi na wskazane pytania badawcze tj.: PB1:Czy pojęcie Przemysł 4.0 jest wciąż istotne dla badaczy? PB2: Czy programy prowadzone na szczeblu krajowym wpływają na zainteresowanie badaczy w zakresie Przemysłu 4.0? PB3: Jakie są kluczowe komponenty Przemysłu 4.0? PB4: Jakie Przemysł 4.0 wywołuje implikacje na inne tematy badawcze?
Wnioski: Zaprezentowany artykuł wnosi wkład w rozwój literatury nad koncepcją Przemysłu 4.0. Wyniki uzyskane z przeprowadzonej analizy literatury nie tylko stanowią podsumowanie dotychczasowej wiedzy na temat koncepcji Przemysłu 4.0, lecz również wskazują kierunki potencjalnych badań. Rezultaty z przeprowadzonych studiów literatury mogą zostać wykorzystane jako wskazówki do przeprowadzenia dalszych badań nad koncepcją Przemysłu 4.0 oraz tematów z nią związanych, jak również służyć mogą jako wytyczne do przeprowadzenia badań literatury w wskazanym obszarze.

Słowa kluczowe: Przemysł 4.0, przegląd literatury

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