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Agnieszka Zakrzewska-Bielawska
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Contemporary Challenges in Cooperation and Coopetition in the Age of Industry 4.0

10th Conference on Management of Organizations' Development (MOD)

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Preface

Industry 4.0 is a concept relating to the use of automation in industries, data processing and data exchange. The concept also encompasses artificial intelligence, the digitalization of the production process and introducing new technologies. Nowadays, workforce, digitally controlled machines connected to the Internet and information technology, is all integrated and this new setting poses new challenges for the management of organizations and for their development. One of these challenges involves the necessity of cooperation with many stakeholders and business partners. However, thanks to networking and data exchange, businesses are also able to make goods in a more economical way. What is more, they can adapt quickly to their clients' individual needs and integrate each other in the value networks which enable them to gain a competitive advantage. As a consequence, the conditions created by Industry 4.0 are both an opportunity and a threat to successful cooperation and coopetition.

The challenges posed by Industry 4.0 are the focus of this proceedings volume. They will be analysed in terms of their impact on present-day organizations and the changes that occur in cooperation and coopetition between companies. Other selected problems relating to the development of organizations based on new conditions will also be addressed. The approach the authors used when writing this proceeding volume was both theoretical and empirical. The work consists of three parts.

In Part I, general guidelines pertaining to Industry 4.0 are considered. To start with, Anna Adamik and Michał Nowicki offer their critical literature review on the subject and an account of the research in consulting firms. Based on their findings, they identified key barriers and potential pitfalls in the process of building a competitive advantage in the age of Industry 4.0. They also provided solutions to overcome them. Afterwards, Michał Młody and Adam Weinert also analysed the literature, but they provided an overview of the current knowledge level about Industry 4.0 in Poland and indicated the direction of further research in this field. Moreover, Edyta Gwarda-Gruszczyńska pointed out theoretical and research gaps in the 'Valleys of Death' concerning creating, commercializing and diffusion of Key Enabling Technologies (KETs). Another contributor, Edyta Bielińska-Dusza

identified the changes occurring in the functioning of organizations caused by ground-breaking technologies. Furthermore, Aleksandra Rudawska pointed out that the phenomenon of Industry 4.0 enables the transfer of knowledge between the workforce. It contributes to overall knowledge building in an organization and, as a consequence, positively influences the creativity of individual employees as well as the creativity of an organization as a whole. Despite this fact, the author argued that sharing knowledge is not a straightforward process. She explained that proactive and reactive knowledge sharing involves employing different mechanisms on an individual and organizational level. Finally, another contributor—Katarzyna Szymańska—identified the main directions of change in the organizational culture of companies that adapt to the new conditions of Industry 4.0.

Part II is devoted to analysing cooperation and coopetition between organizations in the light the challenges that Industry 4.0 brings. This section opens with an article by Jerzy Niemczyk and Rafał Trzaska. The authors studied the network approach in Industry 4.0 in the context of coopetition. According to them, the competitive advantage of an organization can be established by entering the network with certain coopetition features as these organizations will take advantage of all efficiency sources and therefore increase their competitiveness and market value. Next, Dagmara Lewicka and Agnieszka Zakrzewska-Bielawska analysed how trust impacts the cooperation and coopetition between various market stakeholders. According to their research, if the level of trust to a particular group of market partners (e.g. suppliers, customers and other non-competitive partners) increases, the partnership cooperation with particular group is greater, and similarly, if the level of trust in competitors increases, the inclination to coopetition is greater. The authors Łukasz Sułkowski, Robert Seliga and Andrzej Woźniak focused on the complexity of mergers and acquisitions in the specific context of tertiary education. They identified the process of coopetition, cooperation and consolidation of universities in Poland based on their qualitative research. Furthermore, Magdalena Grębosz-Krawczyk and Sławomir Milczarek dealt with the issue of communication between companies and Polish research institutions. The authors strived to establish what expectations the companies have from the research institutions. The results confirmed that interpersonal communication is the most sought-after form of contact between them. It is also demonstrated that the most convenient means of information exchange is electronic media. What is more, Iwona Staniec and Yochanan Shachmurove showed that opportunism is the key obstacle in establishing cooperation regardless of the type of business or the industry it operates in. The authors demonstrated how the perception of the risks influenced the opportunistic approach to cooperation with small- and medium-size technological companies. Meanwhile, Waldemar Glabiszewski, Agata Sudolska, Joanna Górka and Angelika Pańka assessed the extent to which absorption capacity had an impact on the level of innovation in financial companies in Poland. The research confirmed that the ability to make the use of external technologies and the ability to develop existing ones had a positive impact on the level of innovation of the financial companies. Another author, Patrycja Klimas, also highlighted the fact that the proximity in strategic management may be perceived as a significant factor

leveraging effectiveness and performance of both cooperating (or coopeting) organizations and inter-organizational networks. The author stressed the importance of close cooperation and networking and helped the reader appreciate various aspects of such close collaboration. In Part II, Dagmara Wójcik, Patrycja Klimas, Katarzyna Czernek-Marszałek and Patrycja Juszczyk also examined the impact of the development of the tourist sector on the cooperation between various other sectors. The authors pointed out that the rapid development of the tourist sector, due to the popularization of the sharing economy, had a positive effect overall. Furthermore, Aleksandra Hauke-Lopes, Krzysztof Fonfara and Milena Ratajczak-Mrozek postulated various causes of conflicts in foreign inter-organizational relationships of multinational enterprises and determined the impact of such conflicts on the functioning of these companies. The authors mentioned the formal and informal tactics that managers employed in order to deal with the conflicts and mitigate their adverse effects. Aleksandra Sus and Michał Organa took up the problem of how the strategy dynamics and the dynamism of inter-organizational network strategies influenced the general development of network systems. The authors conducted a detailed analysis of relations between the strategy dynamics of inter-organizational networks (centralized or decentralized) and network development in the sense of increasing the effectiveness of activities within the considered systems. The last article in Part II was written by Katarzyna Liczmańska-Kopcewicz and Maciej Zastempowski. The article is an analysis of the relationship between a proactive responding to client's needs and the creation of innovative products in the fast-moving consumer goods industry.

In Part III, the contributing authors proposed that the conditions brought by Industry 4.0 make up a specific work and development environment. Here, Cezary Suszyński focused on outlining the main trends in the evolution of a company from the perspective of industrial revolutions to date. He highlighted the challenges and the changes introduced in how the business is done due to Industry 4.0. Afterwards, Mariusz Bratnicki and Wojciech Dyduch described the way our irrational perception of reality has an effect on the strategic decision-making in companies, which in turn determines how the values in organizations are created and captured. Another author, Andrzej Lis, identified new research areas in the context of the management of the development of organizations. Later, Dagna Siuda described the issue of co-creating the value of a brand in social media, whereas Agnieszka Izabela Baruk focused her attention on selected aspects of how the image of an employer is created by employees who are also prosumers. Automation in the context of Industry 4.0 was dealt with by Andrzej Kamiński. The author described an original concept of cooperation between heterogenic information systems in production by means of the integrated platform. The authors, Aldona Glińska-Neweś, Paweł Brzustewicz, Iwona Escher, Yulia Fomina, Barbara Józefowicz, Irina Katunin, Joanna Petrykowska and Dawid Szostek, pointed out in their article that the idea of corporate social responsibility (CSR) is being questioned nowadays, mainly due to its doubtful significance and its alleged lack of implementation in companies. In the authors' view, the basic requirement that needs to be met in order to make CSR work is to engage the workforce in projects that promote sustainable development.

The authors pointed out that such projects have the potential to introduce a positive social change within the organization and bring about many other benefits. Finally, Monika Kulikowska-Pawlak discussed political will in strategic management. The author provided insight into the range of political motivations that support stakeholder management and proposed an integrative model offering the necessary political mechanism for an organization's value creation.

Papers included in this proceedings volume have been written by scientists, researchers and practitioners, and they were presented during the 10th Conference on Management of Organizations' Development (MOD) organized by Department of Management of Lodz University of Technology in Poland. This proceedings volume highlights the complexity and diversity problems of organizations' development in the age of Industry 4.0 and the underlying challenges. It will cover a wide range of key areas from essence, determinants and forms of cooperation and coopetition, to networks creating and organization managing, and also culture and social problems connected with conditions of Industry 4.0. Combining the newest theory and practice, the book will provide a realistic outlook on the network economy in the age of Industry 4.0 and interdependencies between sectors and within them. That is why the proceedings will be a valuable source of knowledge for researchers in universities and research institutions, graduate students and practitioners in management in both private and public institutions.

Łódź, Poland

Agnieszka Zakrzewska-Bielawska
Iwona Staniec

Contents

Part I
Challenges of Industry 4.0

Chapter 1
Barriers of Creating Competitive Advantage in the Age of Industry 4.0: Conclusions from International Experience

Anna Adamik and Michał Nowicki

Abstract Industry Revolution 4.0 generate significant issues to still a large group of enterprises and often even barriers to the processes of their further growth or improving market competitiveness. Unfortunately, awareness among the businesses regarding their specificity, prevalence and real consequences is limited. This is why identification of major problems of effective shaping of enterprises' competitiveness in the Industry 4.0 era is the research problem. Consequently, the main goal of the paper is to identify and map the key barriers and potential sources of failure in processes of building competitive advantage of enterprises operating in the age of Industry 4.0, the so-called Black Points and creation of a specific "Road Map", which is a path/algorithm of actions illustrating how organisations can better prepare themselves to overcome these key barriers. The research was based on a review of the literature on strategic management, competitiveness of businesses, theory on competitive advantage or describing requirements that organisations face in the age of IR 4.0. The collected data was compared with the empirical results of research by global management consultancies who assessed the problems and degree of implementation of IR 4.0 solutions and preparation of enterprises from various countries to the requirements of IR 4.0.

Keywords Organisation competitiveness · Competitive advantage · Company development · Industry 4.0 revolution · Black Points Industry 4.0

JEL L29 · O31 · O32 · O33

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1.1 Introduction

Industry Revolution 4.0, IR 4.0, brings not only chances and opportunities to contemporary organisations,[1] but also difficult challenges.[2] Many of those challenges generate significant issues to still a large group of enterprises and often even barriers to the processes of their further growth or creating market competitiveness.[3] Unfortunately, the awareness among the businesses regarding their prevalence and real consequences is limited. This brings surprises, discouragement and resistance in relation to the changes required on the path to building competitive advantage typical to the age of IR 4.0, changes and the accompanying investment/implementation processes. Seemingly, the occurrence of such situations can be limited. Support may be given by promoting, among businesses, academic lecturers and students the so-called good business practices for the discussed subject and signalling the key, most common issues, called "Black Points". Regrettably, the latter ones are rarely described in the literature on the subject, even though they may act as significant "warning signs" in the organisational transition processes that are currently conducted in practice.

The **research problem** of the article is identification and help in reducing major problems of effective shaping of enterprises' competitiveness in the Industry 4.0 era. That is why the **main goal** of the paper is to identify and map the key barriers and potential sources of failure in processes of building competitive advantage of enterprises operating in the age of Industry 4.0., the so-called Black Points (Black Points of Competitive Advantages IR 4.0—BPCA 4.0), and propose a specific "Road Map", which is a path/algorithm for actions that will make it possible to avoid them or prepare for them.

In the theoretical part (Sect. 1.2) of the paper, research was based on a systematic review of world literature on strategic management, competitiveness of businesses, theory on competitive advantage and describing requirements and organisational issues in the age of IR 4.0. The bibliometric analyses were conducted on **Web of Science Core Collection** and **Scopus** databases. The research resulted in collecting the data showing the current state and growth in the interest in the problems of Industry 4.0, which also allows for indicating some theoretical/empirical gaps. Given the above, in Sect. 1.3, the authors focused on presenting a (prototype) of a model concept for the process of achieving competitive advantage in the age of Industry 4.0. The key CA IR 4.0 barriers and inhibitors, as well as catalysts and accelerators for this process, were separately presented in blocks.

After methodical Sect. 1.4, in the empirical part of the paper (Sect. 1.5, Results and Discussion), the model presentation was compared to results of research published in various scientific articles about "Industry 4.0" (see the references), as well as published by global management consultancies attempting to assess the degree of implementation of IR 4.0 solutions in various industries and the degree to which businesses from various countries are prepared for the requirements of IR 4.0. The

[1] See, i.e. [9, 21, 22, 47].

[2] See, i.e. [32, 40, 42, 58].

[3] See, i.e. [2, 3, 4, 7, 8, 12, 33, 49].

following reports were analysed: [16, 31, 41, 55]. Empirical research showing and verifying the validity of the proposed model was carried out. Verification of the hypotheses formulated in the paper and an attempt to assess how commonly in the economic practice the key "Barriers of CA IR 4.0" occur using the individual platforms then acted as a basis for formulating the "Map of Black Points of CA IR 4.0 creation" and proposing the recommendation on how to circumvent or defeat those barriers. The study is summarised with the conclusions from the conducted research.

1.2 Literature Review

In order to identify the key drivers for the processes of building competitive advantage of enterprises operating in the age of Industry 4.0, the literature on the subject was researched. Bibliometric research is the first part of conducted desk research. It aimed to confirm the existence and assess the size of identified research gap related to the problems and barriers of building a competitive advantage of enterprises in the Industry 4.0 era. In-depth (systematic) literature review is the second part of conducted desk research. Its purpose was to systematise and prioritise negative determinants (barriers) of effective building a competitive advantage in the Industry 4.0 era.

The bibliometric research was conducted using the method of a systematic review of the literature on "Industry 4.0" available in two international databases—WoS CC and Scopus. It was supported with in-depth bibliometric research.

The analytical work was focused on studying the **selected data sets**, taking account of "type of publication"[4] and "scientific field/research area".[5] Such approach is a certain novelty as compared to the bibliometric analyses of the subject of "Industry 4.0" performed by other researchers.[6] Secondary research of the selected papers showed that in most of such publications, reviews and comparisons used full aggregation, i.e. selection of data was knowingly given up, i.e. the research field/specialisation was disregarded. Therefore, the results obtained in the above cases may be considered to be low reliability and not fully valid if the objective is to recognise and analyse the output of the literature on "Industry 4.0" within the discipline of management and related sciences.

[4]Only the following types of publications were taken into account: articles, proceedings, reports, book chapters. Therefore, publications excluded included, e.g. reviews, news items/notes, or editorial materials, etc.

[5]In the case of analyses based on WoS CC resources, only the publications indexed in at least one of the following Web of Science Categories were taken into account: business/business finance/economics/management/operations research management science/planning development/engineering manufacturing. When selecting the data sets to be obtained from Scopus database, filters were used, which caused further analyses to be conducted on publications indexed in at least one of the following categories (Scopus): Business, Management and Accounting/Computer Science/Decision Sciences/Economics, Econometrics and Finance/Engineering/Environmental Science/Social Sciences.

[6]See: [6, 30, 43].

The work started by preparing the bibliometric map. To do that, **VOSviewer** software was used,[7] to which the data obtained from WoS CC database was input (obviously, taking account of only the literature in the field/discipline of management and related sciences) reflecting the volume of indexed publications containing in the title the keywords {*Industry 4.0*,[8] *competitiveness*,[9] *competitive advantage*,[10] *open resources*,[11] *open culture*,[12] *open knowledge*[13]}.

In the era of Industry 4.0 "open culture", "open knowledge" and "open resources" are the basic sources of enterprises competitive advantage. If they are successfully developed in a conscious and long-term manner, they have a chance to generate their

[7] It is a software tool for constructing and visualizing bibliometric networks.

[8] **Industry 4.0** → The concept of Industry 4.0 appeared in the literature in the year 2011 [27, 50]. It helped entrepreneurs to realise key developmental directions for the near future that determine the possibilities of gaining and maintaining competitive advantages. The Industry 4.0 challenges encompassed several areas such as: Autonomous Robots, Simulations, Vertical/Horizontal Software Integration, Machine-to-Machine Communication (M2M), Industrial Internet of Things, Internet of Services, Big Data and Analytics, Clouds, Additive Manufacturing, Augmented Reality, Virtual Reality, Cyber-Physical Systems, Digital Twin, Artificial Intelligence, Neural Networks, Cybersecurity and Mass Customisation. At the same time, considerations accompanying the concept pointed to a need to respect six key principles of effective competition under the conditions of Industry 4.0. These principles are: (1) inter-organisational cooperation, (2) virtualisation of business activities, (3) decentralisation of management processes, (4) real-time assessment of all kinds of organisational capabilities (e.g. production, sales, transport, warehousing capabilities, etc.), (5) service orientation, and (6) modularity of the proposed products, services and other types of solutions Hermann et al. (2015).

[9] **Competitiveness** → The organisation's competitiveness is the state of the organisation's dynamic balance, developed due to its strategic fit. It is a relatively permanent system of relations between the organisation and its environment, as well as within the organisation itself, which allows it to comply with the requirements of the organisation's environment and members (in the material and technical, as well as political and social sense).

[10] **Competitive advantage** → It is the ability of a given organisation to consciously identify, implement, develop, protect and obtain benefits of unique resources and skills (encompassing all the organisation's value chain links) which, being desired and valued by the market, are not available to the same extent to other competitors. Such an advantage appears when resources are configured and exploited in a proper manner. It leads to a situation in which a company has something that distinguishes it in the market out of the ranks of its competitors, i.e. special assets that allow it to do something better or differently from its competitors, and consequently achieves better results that lead to a specific superiority over other.

[11] **Open resources** → This openness should apply to an enterprise's resources as well as resources of its customers, suppliers and competitors. In fact, it should encompass entities that have complementary skills and do not hesitate to use them in relationships of co-creation with other sectors.

[12] **Open culture** → It is the type of culture characterized by the so-called openness to space, which means openness to change, openness to uncertainty and openness to flexibility. Such culture should be characterized by openness to learning as well as promoting and encouraging flexibility and creativity.

[13] **Open knowledge** → It is a common good from which everyone can benefit, a staff member and an organization itself or its business partners. Moreover, everyone can participate in its development. Knowledge is open if everyone has free access to it, can use, modify and share it with others, subject to the requirements of, at most, the determination of the sources of its origin or maintaining its openness.

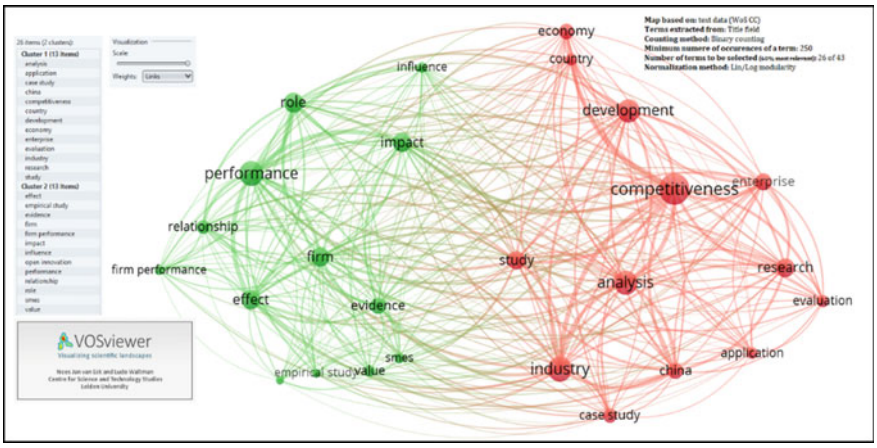


Fig. 1.1 Bibliometric map of keyword associations. *Source* Own elaboration

high competitiveness. The reason "why it is as it is" is quite simple. Due to enterprises' openness in different areas of their business activity, they can dynamically respond to changes in a volatile environment and reduce its complexity. Therefore, openness of enterprises should be seen as a key factor in raising the competitiveness of the European economy [5].

The map in Fig. 1.1 shows the subject of Industry 4.0 is closely related to competitiveness (cluster: "competitiveness"), development (cluster: "development"), enterprises/entrepreneurship (cluster: "enterprise" and "SMEs") and performance (cluster: "performance"). Contrary to the expectations, there was no statistically significant connection between the subjects: "Industry 4.0" and "barriers of creating competitive advantage in the age of industry 4.0".

This result encouraged us to explore the case closer. To that goal, detailed analyses were performed, consisting of several stages, using the principle "from the general to the specific". Working on WoS CC database, first we prepared a comparison of bibliometric data including publications containing the keyword "Industry 4.0", which described the character of the article (filter: "topic"), then limiting them to those containing the keyword "Industry 4.0" in the title (filter: "title"). To achieve a deeper analysis, then data sets were created containing publications containing in their titles the combination of keywords: "Industry 4.0 and barriers", "Industry 4.0 and competitiveness", "Industry 4.0 and competitive advantage", "Industry 4.0 and open resources", "Industry 4.0 and open culture" and "Industry 4.0 and open knowledge". A similar approach was applied to the analyses of Scopus database. First, for the keyword "Industry 4.0", a set was filtered using "article title, abstract, keywords",[14] and then using the filter "article title".[15] The deepened analyses used the filter which allowed us to pick up the articles with given subjects (again filter

[14]Equivalent of filter "topic" used with WoS CC.

[15]Equivalent of filter "title" used with WoS CC.

"article title, abstract, keywords"). The achieved data was then subjected to detailed analyses.[16]

Next, a ranking of "**Top publishing**" **countries** was created, and **histograms** showing the increments in publishing articles containing a given keyword/keywords in the title (or specifying the subject matter). The results of the above work are presented in Table 1.1 (WoS CC database bibliometric data), Table 1.2 (Scopus database bibliometric data) and Fig. 1.2 (WoS CC and Scopus data about disproportion between articles about Industry 4.0 and articles about barriers of Industry 4.0) and Fig. 1.3 (WoS CC and Scopus data about top publishing countries).

After analysis of the data shown in Table 1.1 (WoS CC database bibliometric data) and 2 (Scopus database bibliometric data) and those shown in Fig. 1.2 (WoS CC and Scopus data about disproportion between articles about Industry 4.0 and articles about barriers of Industry 4.0) and 3 (WoS CC and Scopus data about top publishing countries), it can be concluded that:

1. The subject of Industry 4.0 is relatively often discussed in articles representing the subject matter (discipline) of management and related sciences. The database WoS CC indexed $n = 711$ and 224 (filter: "topic" and "title") articles containing keyword "Industry 4.0". For Scopus database, it was, respectively, $n = 2732$ and 820 publications.
2. **There is a high disproportion between the volume of articles** "**generally**" **discussing the subject matter of Industry 4.0** ($n = 711$ and 224 for WoS CC and $n = 2732$ and 820 for Scopus), **and the volume of articles focusing on the specialised aspects, i.e.** "**the barriers for implementing solutions related to Industry 4.0**" ($n = 13$ and 34—see Fig. 1.1), "competitiveness" ($n = 49$ and 77) and "creating competitive advantages" (35 and 49) in the reality of Industry 4.0 revolution, or relations to the use of "open resources" ($n = 17$ and 24), "open culture" (4 and 4) and "open knowledge" planes (17 and 23).
3. The most often cited publications related to Industry 4.0 are cited much more often than others—those with "average" citations (WoS CC: h-index = 23 and

[16] Based on the data obtained from **WoS CC, the following were determined**:

1. n = number of articles indexed in the Web of Science Core Collection database that contain a given keyword;
2. h = h – index for all articles;
3. C = sum of times cited (without self-citations);
4. WoS "X" = highest citation value;
5. ACR = average citations per item;

Based on the data obtained from **Scopus, the following were determined**:

1. n = number of articles indexed in the Scopus database that contain a given keyword;
2. C = sum of times cited;
3. HCV = highest citation value for an article;
4. "*X*/*Y*/*Z*/…" = number of citations of article with highest citation value (descending order);
5. FWCI = Field-Weighted Citation Impact.

Table 1.1 WoS CC database bibliometric data

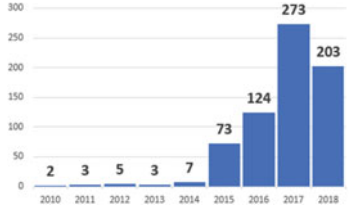
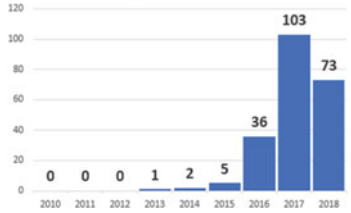
Keyword	Web of science core collection data				Publications by year: 2010–2018
Industry 4.0 (*filter: "topic"*)	Number of articles indexed in the Web of Science Core Collection database that contain a given keyword [N = number of articles/h—index for all articles/C = sum of times cited (without self-citations)/WoS X = highest citation value/ACR = average citations per item]	$n = 711$ h–index = 23 $C = 2063$ WoS A = 192 ACR = 338	Countries with the largest number of publications indexed in the Web of Science Core Collection database that contains a given keyword	1. Germany (156/21.94%) 2. Italy (55/7.74%) 3. USA (51/7.17%) 4. England (49/6.89%) 5. China (48/6.75%) … 13. Poland (23/3.23%)	
Industry 4.0 (*filter: "title"*)		$n = 224$ h–index = 11 $C = 623$ WoS B = 60 ACR = 3.29		1. Germany (41/18.30%) 2. Czech Republic (24/10.71%) 3. England (18/8.04%) 4. Brazil (15/6.70%) 5. Italy (15/6.70%) … 10. Poland (11/4.91%)	

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Table 1.1 (continued)

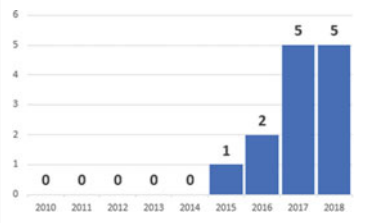
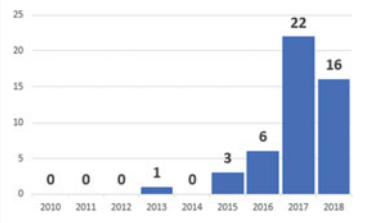
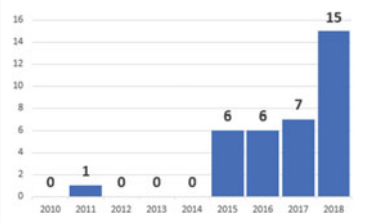
Keyword	Web of science core collection data				Publications by year: 2010–2018
Industry 4.0 and barriers (*filter: "title"*)		$n = 13$ h–index = 3 C, ART. 63 WoS C = 26 ACR = 4.85		1. England (3) 2. Germany (3) 3. Brazil (2) 4. USA (2) 5. Czech Republic (1) … 10. Poland (1)	
Industry 4.0 and competitiveness (*filter: "title"*)		$n = 49$ h–index = 6 $C = 99$ WoS D = 25 ACR = 2.08		1. Czech Republic (8) 2. Germany (6) 3. England (4) 4. Poland (4) 5. Lithuania (3)	
Industry 4.0 and competitive advantage (*filter: "title"*)		$n = 35$ h–index = 4 $C = 66$ WoS E = 13 ACR = 1.89		1. Malaysia (7) 2. Germany (4) 3. Czech Republic (3) 4. Denmark (3) 5. Turkey (3) … 9. Poland (2)	

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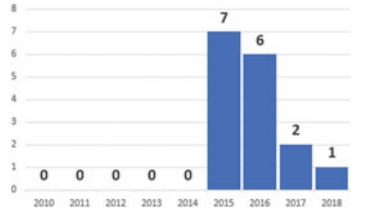
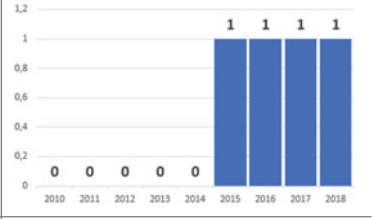
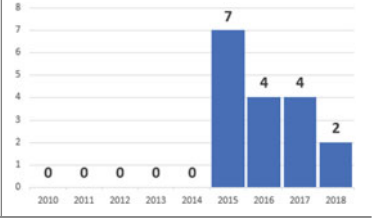
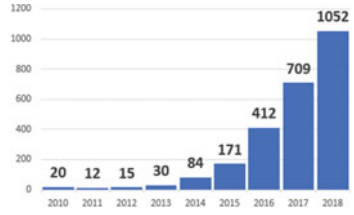
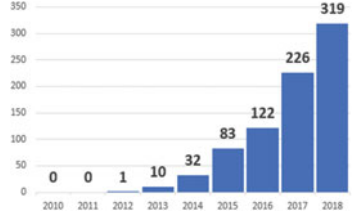
Table 1.1 (continued)

Keyword	Web of science core collection data				Publications by year: 2010–2018
Industry 4.0 and open resources (*filter: "title"*)		$n = 17$ h–index = 5 $C = 68$ WoS F = 19 ACR = 4		1. USA (4) 2. Germany (3) 3. Malaysia (3) 4. England (2) 5. Russia (2) … X. Poland (0)	
Industry 4.0 and open culture (*filter: "title"*)		$n = 4$ h–index = 2 $C = 10$ WoS G = 6 ACR = 2.50		1. England (1) 2. Malaysia (1) 3. Russia (1) 4. South Africa (1) 5. USA (1) … X. Poland (0)	
Industry 4.0 and open knowledge (*filter: "title"*)		$n = 17$ h–index = 6 $C = 95$ WoS H = 29 ACR = 5.59		1. England (3) 2. Germany (3) 3. Spain (3) 4. Italy (2) 5. Sweden (2) … X. Poland (0)	

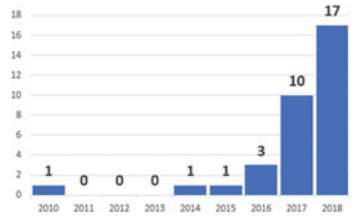
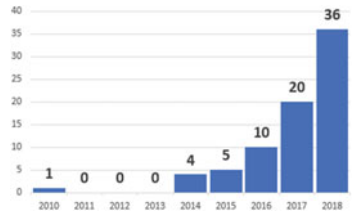
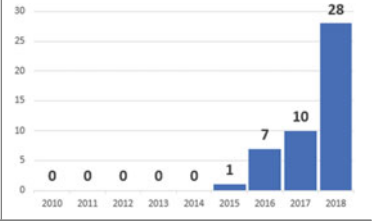
Source Own elaboration

Table 1.2 Scopus database bibliometric data

Keyword	Scopus data				Publications by year
Industry 4.0**	Number of articles indexed in the **Scopus** database that contain a given keyword [n = number of articles/C = sum of times cited/ HCV = highest citation value for an article/number of citations of article with highest citation value (descending order: 2018–2015) FWCI = Field-Weighted Citation Impact]	$n = 2732$ $C =$ - NA - SCOP A = 692 2018: 335 2017: 222 2016: 116 2015: 19 FWCI = 8697	Countries with the largest number of publications indexed in the **Scopus** database that contain a given keyword	1. GER (777/28.44%) 2. Italy (233/8.53%) 3. USA (195/7.14%) 4. CHPR (182/6.66%) 5. Spain (131/4.80%) … 14. Poland (63/2.31%)	
Industry 4.0*		$n = 820$ $C = 3049$ SCOP B = 692 2018: 335 2017: 222 2016: 116 2015: 19 FWCI = 8697		1. GER (285/34.76%) 2. Italy (66/8.05%) 3. UK (42/5.12%) 4. Spain (40/4.88%) 5. USA (37/4.51%) … 12. Poland (23/2.80%)	

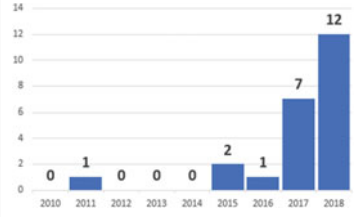
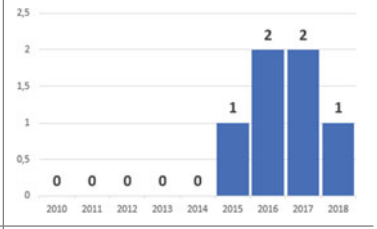
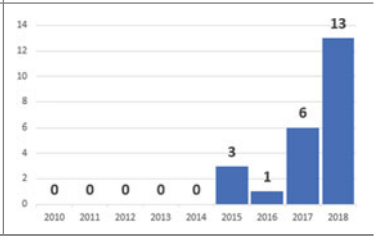
(continued)

Table 1.2 (continued)

Keyword	Scopus data				Publications by year
Industry 4.0 and barriers		$n = 34$ C = 80 SCOP C = 33 2018: 26 2017: 6 2016: 1 FWCI = 5.72		1. Germany (8) 2. USA (7) 3. Italy (5) 4. Brazil (4) 5. UK (3) … 14. Poland (1)	
Industry 4.0 and competitiveness		$n = 77$ $C = 253$ SCOP D = 66 2018: 31 2017: 20 2016: 11 2015: 3 FWCI = 22.52		1. Germany (20) 2. Italy (10) 3. UK (7) 4. Spain (6) 5. USA (6) … 33. Poland (1)	
Industry 4.0 and competitive advantage*		$n = 49$ $C = 49$ SCOP E = 8 2018: 6 2017: 2 FWCI = 2.14		1. Germany (6) 2. UK (4) 3. Denmark (3) 4. Italy (3) 5. Austria (2) … 10. Poland (2)	

(continued)

Table 1.2 (continued)

Keyword	Scopus data				Publications by year
Industry 4.0 and open resources*		$n = 24$ $C = 29$ SCOP F = 10 2018: 10 FWCI = 3.02		1. Italy (5) 2. USA (4) 3. China (3) 4. Austria (2) 5. Germany (2) … X. Poland (0)	
Industry 4.0 and open culture *		$n = 4$ $C = 0$ SCOP G = 0 FWCI = - NA -		1. China (2) 2. Austria (1) 3. Bangladesh (1) 4. Ethiopia (1) 5. Greece (1) … X. Poland (0)	
Industry 4.0 and open knowledge*		$n = 23$ $C = 32$ SCOP H = 17 2018: 16 2017: 1 FWCI = 6.49		1. China (3) 2. Germany (3) 3. Spain (3) 4. Norway (2) 5. UK (2) … X. Poland (0)	

Source *Own elaboration*

* query in the Scopus database with parameter "topic"

** query in the Scopus database with parameter "title"

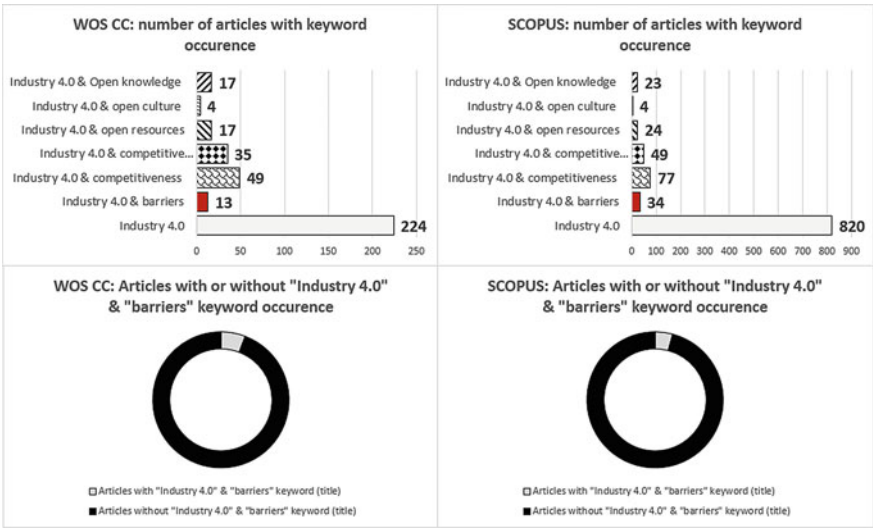


Fig. 1.2 WoS CC and Scopus data about disproportion between articles about Industry 4.0 and articles about barriers of Industry 4.0. *Source* Own elaboration

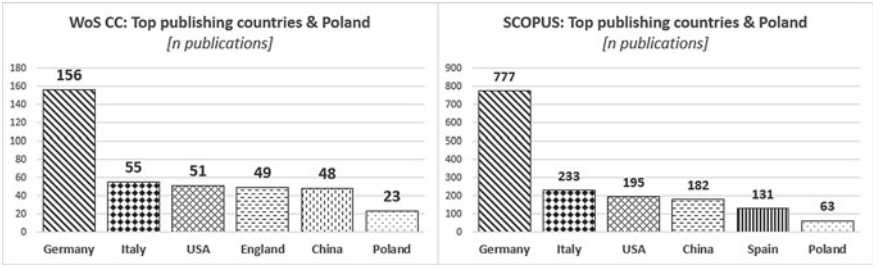


Fig. 1.3 Top publishing countries about Industry 4.0 (WoS CC and Scopus data). *Source* Own elaboration

ACR = 3.38 and h-index = 11 and ACR = 3.29; Scopus: FWCI for the most often cited article = 6.97!).

4. In terms of publications, the top centres are from Germany, Italy, and the USA, given the number of publications indexed in WoS CC/Scopus, for which the keyword "Industry 4.0" described the subject matter (filter "topic"). It is respectively $n = 156$ and 777 for publications from Germany, $n = 55$ and 233 for publications from Italy and $n = 51$ and 195 for publications from the USA.
5. In terms of the volume of articles published, for which the keyword "Industry 4.0" is included in the title, the most publications are from centres in Germany, Czech Republic, England (WoS CC: $n = 41/24/18$) or Germany, Italy and England (Scopus: $n = 285/66/42$).

6. Both databases indexed publications from Poland, however, their share at best ranks "us" at the end of the top ten most active publication "centres".
7. The three (3) articles generally dealing with the subject matter of Industry 4.0 with highest number of citations containing a given keyword/keywords:
   - WOS CC[17]: [37]/(Times Cited = 226)]; [35], (Times Cited = 197)]; [56]/(Times Cited = 122)];
   - Scopus[18]: [36]/Citations in Scopus = 709; FWCI = 86.97]; [37]/Citations in Scopus = 328; FWCI = 113.95]; [35]/Citations in Scopus = 310; FWCI = 21.26].
8. The three (3) most often cited articles dealing with the subject of the benefits (advantages) of implementing Industry 4.0 are:
   - WOS CC: [34]/(Times Cited = 8)]; [54]/(Times Cited = 3)]; [21]/(Times Cited = 1)];
   - Scopus: [34]/Citations in Scopus = 17; FWCI = 7.51]; [19]/Citations in Scopus = 5; FWCI = 0.79]; [22]/Citations in Scopus = 3; FWCI = 0.38].
9. The three (3) most often cited articles dealing with the subject of barriers and issues in implementing Industry 4.0 are[19]:
   - WOS CC: [29]/Times Cited = 3]; [11]/Times Cited = 2]; [58]/Times Cited = 2];
   - Scopus: [42]/Citations in Scopus = 2; FWCI = 1]; [40]/Citations in Scopus = 1; FWCI = 1,12]; [32]/Citations in Scopus = 0; FWCI = 0.00].

The general and detailed bibliometric analyses conducted clearly showed that even though the subject of barriers to building competitive advantage in the age of Industry 4.0 is developing, the publication volume on that subject[20] is relatively low as compared to the publication volume of articles on the general subject of "Industry 4.0"[21] (see Tables 1.1 and 1.2). Due to the fact that the essence of IR 4.0 is most often considered in practice to be skilful implementation of a combination of new IT technologies, Internet of things mainly and new production, transport and handling technologies plus new materials and related processes, contemporary organisations must learn to live and function in networks of various types of relationships not only in the real but also in the virtual/cyber plane of activity (in the virtual reality). In order to meet this challenge, they unfortunately must undergo changes related to:

(1) technologies they use,
(2) their organisational solutions, but also the
(3) relationships they use and develop and their social competencies.

[17] The search used the filter "title".

[18] The search used the filter "article title" (equivalent of "title" in WoS CC).

[19] As an exception, filter "topic" was used, as the filter "title" yielded very little valuable results.

[20] During the last 5 years for WoS CC:0/1/2/5/5 and for Scopus: 1/1/3/10/17.

[21] During the last 5 years for WoS CC:2/5/36/103/73) and for Scopus: 32/83/122/226/319.

New technologies [23, 48] must be supported by concepts and models that are appropriate for IR 4.0 [10], as well as appropriate strategies of both development and competition of businesses [2, 1], functional strategies [13], structural solutions [15, 44] and their supporting relationships, competencies and social attitudes of employees and managers [39]. Due to the fact that such solutions concern so many different areas, business practitioners often find it difficult to formulate consistent, well-directed and highly effective programs that prepare their companies to the age of Industry 4.0.

This observation inspired us to work on "Determinants of achieving competitive advantage in the age of Industry 4.0 → CA IR 4.0" (stimulating and blocking factors), on three special blocks/platforms: **Technological Platform, Knowledge Platform and Human Resource Platform**.

It should be noted that the in-depth literature review has provided convincing evidence that when describing the **most important CA IR 4.0 barriers one should focus on: Technological Platform, Knowledge Platform and Human Resource Platform** [1–4, 11, 13, 15, 23, 29, 32, 40, 39, 42, 44, 48]. That is why authors decided to define and try to validate the following main hypothesis:

- **MH**: Barriers of creating Competitive Advantage in the age of Industry 4.0 (Black Points CA IR 4.0) are present on many related to each other planes (platforms) of competitive potential of contemporary organisations.

In order to be able to better verify the above main hypothesis, detailed hypotheses were formulated:

- **H1**: Barriers and shortages occurring on Human Resource Platform block the contemporary companies' readiness to effectively use the Knowledge Platform resources;
- **H2**: Barriers and shortages occurring on Knowledge Platform block the contemporary companies' readiness to effectively use the Technological Platform resources;
- **H3**: Barriers and shortages occurring on Technological Platform block the contemporary companies' readiness to obtain various Competitive Advantages associated with Industry Revolution 4.0. (CA IR 4.0) and thus build strong (high) competitiveness.

1.3 Determinants of Achieving Competitive Advantage in the Age of Industry 4.0—Framework of Conception

The performed review of the literature allowed us to identify two problem areas that are a key for the processes of building advantage: the plane of factors blocking the readiness companies to creating CA IR 4.0 (Black Points) and the plane of stimulating factors, fostering the real creation of CA IR 4.0 (Lighthouses). Those planes are interconnected and compatible. They are connected by the plane of transitory and adjustment actions to IR 4.0. Research showed that similarly to the mythical "tree

of life",[22] or the model cycle of organisation's life by Greiner[23] [25] organisations reach readiness to creating CA IR 4.0 by skilfully coping with crisis situations typical to IR 4.0. They do this by overcoming Black Points generated by their competitive potential [17, 28, 53]. It is only the knowledge and experience acquired in these actions that give them the skills necessary to create, stimulate and utilise the sources of competitive advantage effective in IR 4.0 (Lighthouses), as shown in the research, currently mainly inherent in the ability to create the so-called: Open Culture, Open Knowledge and Open Resources [4, 5, 46, 57]. These observations were shown in the original concept of the model "Tree of Life of CA IR 4.0".

The model shows the role of quick and effective identification and elimination of key Black Points that may occur in each of the three, hierarchically interconnected platforms (HR/Knowledge/Technological Platform). By eliminating the Black Points, organisations gradually increase the level of their readiness to create competitiveness in the conditions of IR 4.0 by which they get closer to "PLANE 2—READINESS TO CREATING CA IR 4.0". In order to go further and transit to PLANE 3, they must be able to effectively implement and use methods, techniques, tools, strategies and other solutions that are key to the age of IR 4.0, which should support efficient creation of Open Culture, Open Knowledge and Open Resources that are present in IR 4.0.

Due to the objectives of the paper, further analyses focus on PLANE 1—Black Points of CA IR 4.0. Those barriers occur in many planes of the organisation (HG), however, most often in Human Resource Platform, Knowledge Platform and Technological Platform. What is important, the factors from the first platform are the source of multiplying Black Points, in the next two platforms. At the same time, the barriers occurring in the second one (Knowledge Platform) initiate new issues in the third (Technological Platform). This way, each of the platforms causes blocking of the READINESS OF MODERN ORGANISATIONS TO CREATE CA IR 4.0 (H1, H2, H3). Similarly, effective overcoming Black Points related to Human Resource Platform reduces issues in the Knowledge Platform and coping in that platform weakens barriers them may occur in the Technological Platform.

Therefore, the key to ensure effective competitiveness of enterprises in IR 4.0 seemed to be identifying the most common barriers to competitiveness on the base platforms listed above, therefore the real Black Points of CA IR 4.0. This was attempted in the empirical part of the paper.

[22]The Tree of Life perceived as a cultural pattern, symbolised the perpetual rebirth of nature and had the gift of giving immortality (in Jewish, Christian, Muslim, Buddhist traditions, the Greek myth of Heracles); it is also a bridge between two worlds—the lower, problematic one (roots, earth) and the ideal, dream one (crown, heaven) [24, 38].

[23]History shows that the same organizational practices are not maintained throughout a long-life span. This demonstrates a most basic point: management problems and principles are rooted in time.

1.4 Methodology

In order to identify the key real Black Points of CA IR 4.0 for the three base platforms in the concept of platforms described above, breakdowns of[24] "Key Parameters of Readiness to CA IR 4.0" and the resulting "Potentially Black Points of CA IR 4.0" were prepared based on the in-depth (systematic) review of the literature. "Key Parameters" constituted certain benchmarks, meaning reference points for further analyses, and even example sources of CA IR 4.0, i.e. the so-called Lighthouses. Specific operating activities, related to them, which are the most difficult and the most problematic for the contemporary enterprises, and the tools, competencies and attitudes necessary to deliver them were considered to be "Potentially Black Points". Their elements or symptoms were looked for in the reports with up-to-date results of research by global management consultancies attempting to assess the degree of implementation of IR 4.0 solutions in various industries and the degree to which businesses from various countries are prepared for the requirements of IR 4.0. The following reports were analysed: [31],[25] [16][26]; [41][27]; [55].[28] The identified barriers were assessed and classified. The assessment took account of how commonly[29] a

[24] See, i.e. [3, 14, 18, 26, 45, 51].

[25] The report is based on data from 300 manufacturing industry CEOs. This data was part of the 2018 CEO Outlook, a survey of 1300 CEOs in 11 countries, conducted in early 2018 by Forbes Insights on behalf of KPMG International. To support the data, KPMG International conducted a series of interviews with executives at manufacturers around the world. Their experience, combined with the views of KPMG professionals and sector leaders, provides valuable insights for today's manufacturers.

[26] This research is based on a survey of 1603 global executives conducted by Forbes Insights in the second half of 2017. Survey respondents represented 19 countries from the Americas, Asia and Europe and came from all major industry sectors. All survey respondents were C-level executives, including CEOs/presidents (16%), with the rest evenly divided among COOs, CFOs, CMOs, CIOs and CTOs. All executives represented organizations with revenue of $1 billion or more, with more than half (53%) coming from organisations with more than $5 billion in revenue. Additionally, Forbes Insights and Deloitte conducted one-on-one interviews with global industry leaders and academics.

[27] The report is based on data from over 700 qualified respondents from companies with more than 50 employees and over USD 10 million in revenues, spanning a range of industry sectors from automotive to chemicals to transport and logistics for seven key markets (Brazil, China, France, Germany, India, Japan and the USA).

[28] Report gives expertise in developing supply chain maturity assessment tools, and the assessment is designed around four readiness levels (beginner, intermediate, experienced and expert). They have explicit statements of what needs to be achieved to reach that particular level of readiness for each sub-dimension. This report has been designed to enable complete a self-assessment of your company's current Industry 4.0 readiness, providing a benchmark across a group of 53 companies from 22 countries—74% of respondents were senior management or executives.

[29] A barrier was identified in:

- 0–19% of the tested sample = score 1 = barrier very low;
- 20–39% of the tested sample = score 2 = barrier low;
- 40–59% of the tested sample = score 3 = barrier average;
- 60–79% of the tested sample = score 4 = barrier high;