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

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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.

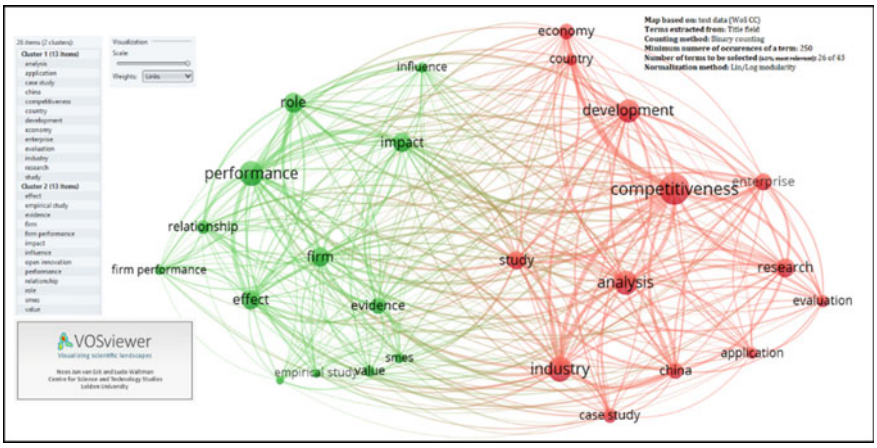


Fig. 1.1 Bibliometric map of keyword associations. *Source* Own elaboration

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

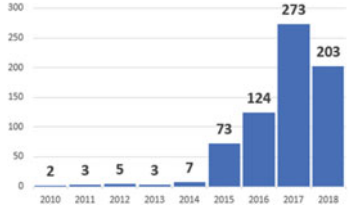
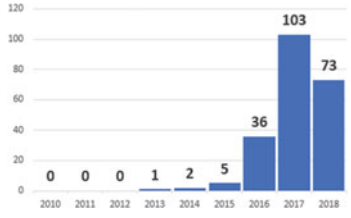
Keyword	Web of science core collection data				Publications by year: 2010–2018
Industry 4.0 (*filter: "topic"*)	Number of articles indexed in the Web of Science Core Collection database that contain a given keyword [N = number of articles/h—index for all articles/C = sum of times cited (without self-citations)/WoS 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)

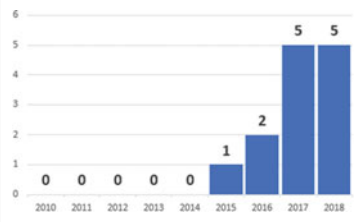
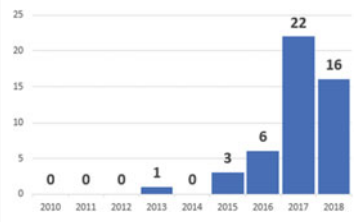
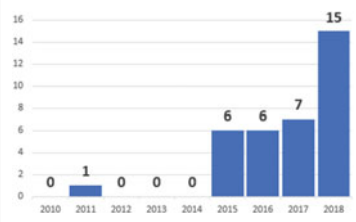
Keyword	Web of science core collection data				Publications by year: 2010–2018
Industry 4.0 and barriers (*filter: "title"*)		$n = 13$ h–index = 3 C, ART. 63 WoS C = 26 ACR = 4.85		1. England (3) 2. Germany (3) 3. Brazil (2) 4. USA (2) 5. Czech Republic (1) … 10. Poland (1)	
Industry 4.0 and competitiveness (*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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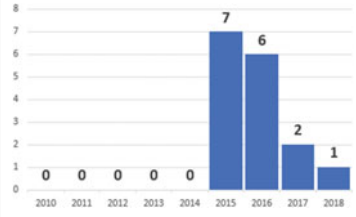
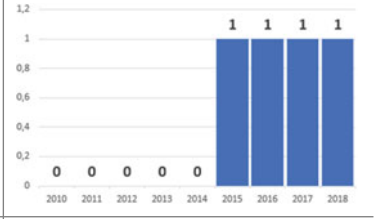
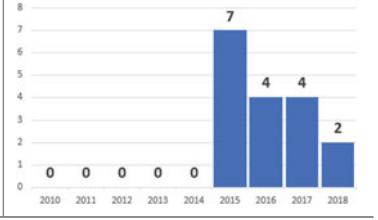
Table 1.1 (continued)

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

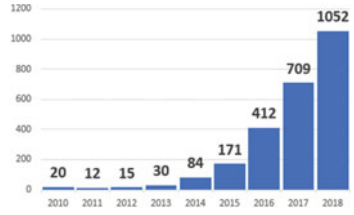
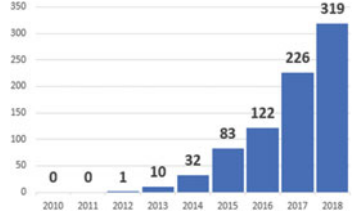
Keyword	Scopus data				Publications by year
Industry 4.0**	Number of articles indexed in the **Scopus** database that contain a given keyword [n = number of articles/C = sum of times cited/ HCV = highest citation value for an article/number of citations of article with highest citation value (descending 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%)	

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Table 1.2 (continued)

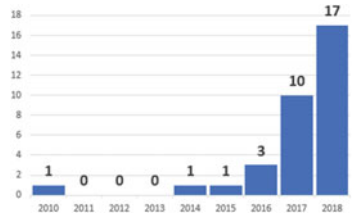
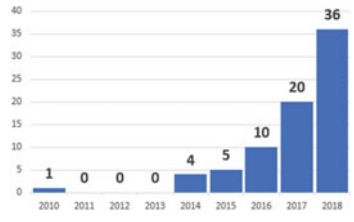
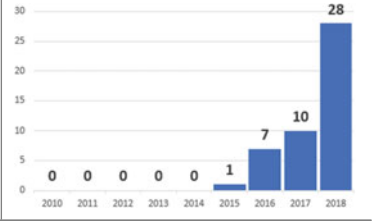
Keyword	Scopus data				Publications by year
Industry 4.0 and barriers		$n = 34$ C = 80 SCOP C = 33 2018: 26 2017: 6 2016: 1 FWCI = 5.72		1. Germany (8) 2. USA (7) 3. Italy (5) 4. Brazil (4) 5. UK (3) … 14. Poland (1)	
Industry 4.0 and competitiveness		$n = 77$ $C = 253$ SCOP D = 66 2018: 31 2017: 20 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)	

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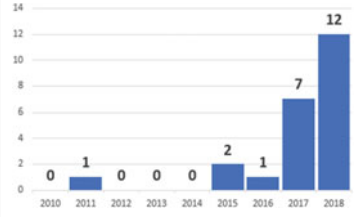
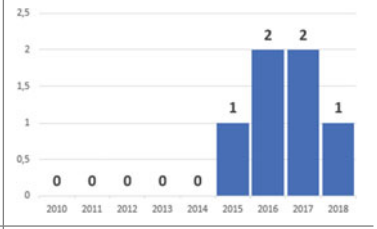
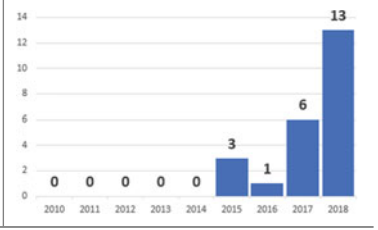
Table 1.2 (continued)

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"

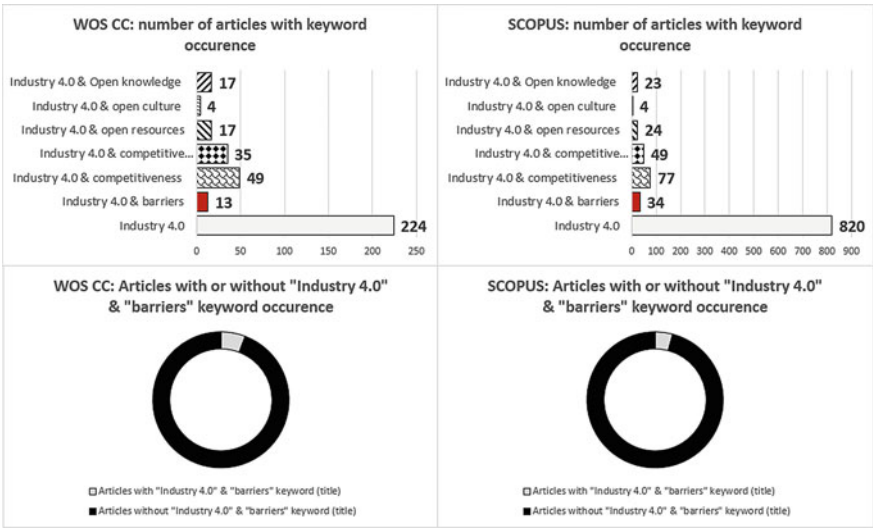


Fig. 1.2 WoS CC and Scopus data about disproportion between articles about Industry 4.0 and articles about barriers of Industry 4.0. *Source* Own elaboration

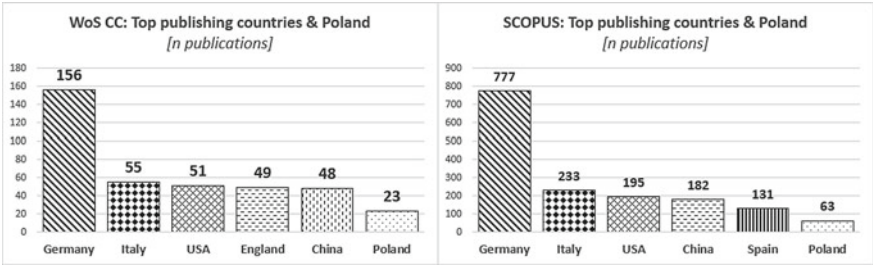


Fig. 1.3 Top publishing countries about Industry 4.0 (WoS CC and Scopus data). *Source* Own elaboration

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;

given barrier occurred, and it was scored based on that. Expert classification allowed to assign the identified symptom to one of 12 types of barriers separated in the empirical research of Black Points of CA IR 4.0. The database created this way was used to prepare the "Map of Black Points of Creating CA IR 4.0" and propose recommendations on how to overcome these barriers.

1.5 Results and Discussion

During the analyses, 64 Real Black Points of CA IR 4.0 were identified (see in Appendix Table 1.3). In the "Human Resource Platform" symptoms of 15 were diagnosed, in "Knowledge Platform" 23 and in "Technological Platform" 26. In each of them, the average rating of the diagnosed barriers was at average level. Relatively highest average = 3.2 points (out of 5) was diagnosed in the "HR Platform". For the "Knowledge Platform", the average rating of "Black Points" was at 3.1 points, and for "Technological Platform" was at 3.0. When preparing to compete, the tested enterprises therefore have relatively most difficulties with adjusting their human resources to the requirements of the age of Industry 4.0.

In the "**HR Platform**", the prevailing barriers were related to the areas of "**Leadership**" (6 symptoms), as well as "**Education**" (3) and "**Skills**" (3) that were unadjusted to the requirements of IR 4.0. Barriers related to the areas of "**other type**" were also noticed (3). The highest barrier in this platform (5/5) was the Black Point—Leadership resulting from incorrect management of human resources in the examined organisations, and especially the "Talents" necessary in the era of digital transformation. This problem was found in as many as 83% of the companies examined in 2017 by Deloitte and 69% respondents of McKinsey. It seems to be the strategic problem from which others stem, especially those related to "Lack of right workforce composition and the skill sets needed for the future" (Black Point—Skills, diagnosed in 75% of Deloitte's respondents) and "Retooling the capabilities of workers and educate them on new roles introduced through digital transformation" (Black Point—Education, diagnosed in 64% of KPMG's respondents).

In the "**Knowledge Platform**", the prevailing barriers were related to the areas of "**Management**" (10 symptoms) and "**Cooperation**" (5) that were unadjusted to the requirements of IR 4.0. Barriers related to the areas of "**other type**" were also noticed (8). The highest barriers in this platform were related to:

- Black Point in **Management** aspect:
  - **Planning and organisation**: Organisations are not highly capable of planning for and addressing the effects that technology-driven Industry 4.0 changes have on their organisational structures and employees (such issue was found in 93% of Deloitte's respondents). It generates "organisational inertia", which occurs as

- 80–100% of the tested sample = score 5 = barrier very high.

a group remains fixated on its past accomplishments to protect its current state, while unknowingly blind to changes taking place within the marketplace.
  - **Innovativeness**: Organisations are not ready to fully harness the opportunities associated with Industry 4.0 (86% of Deloitte's respondents have this issue). Many executives continue to focus on traditional business operations, as opposed to focusing on opportunities to create new value for their direct and indirect stakeholders.

- Black Point in **Cooperation** aspect:
  - **Interdependence**: The growth of global business networks changes the risk landscape and makes companies more vulnerable to external shocks. Companies are becoming more interdependent. The biggest barrier to extracting value from third parties is the difficulty of sharing data securely, so top-tier manufacturers are becoming more selective about which companies they partner with (this issue was diagnosed in 94% of KPMG's respondents).

When analysing the character of the remaining Black Points identified, similarly to the previously described platform, most of them seem to be caused by the above.

In the "**Technological Platform**", the most common were the barriers related to the abilities of effective implementing "**New Technologies**" (7 symptoms) and "**IT/ICT solutions**" (6). A large problem was also elements of "**Management**" (5). Barriers of "**other type**" were also noticed (8). Highest Black Points in this platform were related to gaps with regard to IT/ICT. In 80% of McKinsey's respondents a "Lack of setting up a data lake across network in more than 50% of their plants" was diagnosed, in 75% of them "Lack of use an advanced analytics platform at scale" and in 70% "Lack of adopting specific Digital Manufacturing rollout-relevant solutions company-wide". It seems, however, they are a consequence of Black Points for non-technology areas, such as:

- "**Knowledge**"→ Executives not ready for new delivery models or blurred lines between industries (75% of Deloitte's respondents);
- "**Time**" → Agility is the new currency of business if we're too slow, we will be bankrupt (70% of KPMG's respondents);
- "**Management**"→ Lack of ROI as a major obstacle when implementing Digital Manufacturing solutions at scale (61% of Mc Kinsey's respondents);
- "**Leadership**" → Manufacturing CEOs don't think they will need to improve the way that they monitor market disruption over the next 3 years (60% of KPMG's respondents).

The above observations confirm the correctness of the model's assumptions, in which it was indicated that unsolved Black Points from lower platforms of "Tree of Life CA IR 4.0" generate problems in the following, higher platforms, by which they make it difficult, or even block the READINESS TO CREATE CA IR 4.0 (PLANE 2). It is also a premise to positively verify the detailed hypotheses formulated in the last part of literature review section of the article:

- **H1**: Barriers and shortages occurring on Human Resource Platform [Black Points of Human Resource Platform] block the contemporary companies' readiness to effectively use the Knowledge Platform resources;
- **H2**: Barriers and shortages occurring on Knowledge Platform [Black Points of Knowledge Platform] block the contemporary companies' readiness to effectively use the Technological Platform resources;
- **H3**: Barriers and shortages occurring on Technological Platform [Black Points of 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;

and consequently, also the 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.

It is worth mentioning that systematic review of the literature (in-depth literature review/second part of desk research) also provided evidence for the validity of the hypotheses—other researchers included similar conclusions and observations in their papers.

For example, Saniuk and Saniuk [52] indicate that "*Implementing the concept of Industry 4.0 poses new challenges to companies, related to the need of building cyber-physical systems and use them to conduct network cooperation. This requires material investments in the area of automation, robotics, and computerisation […] the future also requires significant investments in the area of preparing engineers to apply (implement) those technologies […] an employee's knowledge and experience will definitely be of the highest importance, and this requires preparing new content and methods of professional training in the areas of production engineering, mechatronics, automation, robotics, information technology or logistics*".

Our observation is also consistent with the one of Basl [9], who researched enterprises operating in the Czech Republic in terms of readiness to implement technologies related to Industry 4.0. As he noticed "*Czech companies still lack own Industry 4.0 strategy and they don't have assigned responsible persons who would take care of further deepening of principles of Industry 4.0. […] The investigation has shown that there is a large space for improvement in terms of delivery of available information on Industry 4.0 to the employees. Most companies (56%) stated that their employees are not yet aware of what this new trend means. Only about 8% of companies reported that Industry 4.0"*.

Similar observations were noted by researchers dealing with the issue of Industry 4.0 barriers in the case of the *manufacturing sector in* Republic of China. Feng et al. [20] came to the conclusion that "*What Chinese manufacturing sector needs to do now is to overcome the problems and gradually move towards industrial 4.0 […] China's manufacturing sector can build the platform consist of government, industry, university, research unit, and customer to promote technological innovation in an all-round way […] The industry 4.0 era will make the relationship between countries*

and the world becoming more and more closely linked, and their inter-dependence is strengthening. Therefore, it is important to establish the manufacturing technological standards in line with the world's standards […] In industry 4.0 era, the requirement for the network is higher. So, China must build network infrastructure to meet the requirement […] Ultimately, all competition depends on the talent competition, so talent in manufacturing industry occupies an important position absolutely. China's manufacturing sector must build the Personnel-Training system to cultivate intelligences who meet the needs of industry 4.0".

Moreover, great inspiration in the creation of this article and the formulation of hypotheses were the results of research carried out by Kamblea et al. [32] which are published in "Computers in Industry" in article titled: "Analysis of the driving and dependence power of barriers to adopt industry 4.0 in Indian manufacturing industry". Scholars postulate that "*Industry 4.0 is a revolution in manufacturing, and it brings a whole new perspective to the industry on how manufacturing can be collaborated with the latest technologies to get maximum output with minimum resource utilization […] In this study, the '**Barriers to adoption of industry 4.0' (BTA)** is identified based on extant literature review and opinions of experts from industry and academia […] The present study identifies **twelve barriers** for Industry 4.0 adoption: **BTA1:** Employment Disruptions, **BTA2:** High Implementation Cost, **BTA3:** Organizational and Process Changes, **BTA4:** Need for Enhanced Skills, **BTA5:** Lack of knowledge management systems, **BTA6:** Lack of clear comprehension about IoT benefits, **BTA7:** Lack of Standards and Reference Architecture, **BTA8:** Lack of Internet coverage and IT facilities, **BTA9:** Security and Privacy Issues, **BTA10:** Seamless integration and compatibility issues, **BTA11:** Regulatory Compliance issues, **BTA12:** Legal and Contractual Uncertainty*".

In the above context, it is also worth quoting the conclusions of Pluciński and Mularczyk [47] regarding the situation in Poland. They indicate that "*Currently, Poland has no homogeneous ecosystem for introducing solutions resulting from the idea of Industry 4.0. Creating it will require a bottom-up initiative of the enterprises themselves […] requires on-going investments in automation, robotics, and human resources (operators and engineers) […] it will also be necessary to introduce changes in business models, methods of planning long-term strategies or human resources management*".

Lastly, Fonseca [21] also takes a similar position regarding the Industry 4.0 barriers, claiming that "*However, Industry 4.0 is still in the early stages for most companies and the digital transformation will require a strong leadership, the right human competences and to overcome the several barriers identified for its successful implementation. Although the literature indicates that the adoption of Industry 4.0 improves companies' performance, there are still many organizations that do not apply and don´t feel comfortable about doing it. This leads to opportunities to further investigate the areas where companies should prioritize the adoption of Industry 4.0 and to consider not only the technical aspects, but also the management, organizational and human dimensions, including what types of novel business models and people skills are required for the future, and what are the change processes to make it happen*".

Bearing in mind the fragments quoted above (selected from many of the analysed publications), it seems that the hypotheses put in this article fit fairly into the current research on the impact of Industry 4.0 barriers. In our opinion, an attempt to verify them provides valuable cognitive material that develops knowledge of management sciences.

1.6 Conclusion

The process of building competitive advantage of enterprises in IR 4.0 conditions should be detailed and considered throughout multiple layers. This is related to many requirements posed to modern organisations by the accompanying "digital transformation" and net economy. In order to be successful in the market, the grassroots work is necessary, i.e. preparing relevant structure and quality of the "Competitive Potential". For many organisations, this task brings significant barriers in the process of reaching "Readiness to CA IR 4.0", and in the bottom line to achieving the "Desired (high) level of competitiveness → CA IR 4.0". Although it might seem that the key to success are new technologies, the reality is slightly different. Much more is needed in order to be able to collect, implement and use such solutions. The complete view of the necessary actions is quite clearly shown in the "Tree of Life CA IR 4.0" (Fig. 1.4), and its details are provided in "The Map of Black Points of Creating CA IR 4.0"[30] (Appendix), and operationalised by the "**Pointer of Readiness to Competitiveness in IR 4.0**", which is a summary of the research described above (Fig. 1.5).

As the above tools suggest, the progress of works on developing and strengthening an organisation's ability to build and achieve CA IR 4.0 should be monitored in a specific way. Firstly, attention should be paid to "HR Platform" of organisational Competitive Potential. It is because it provides the key Black Points in the process of building CA IR 4.0. They are usually related to the issues related to Leadership (1), Education (2) and Skills (3). The absence of management competencies and talents required in IR 4.0 very often blocks the creation of the training system specific to IR 4.0 and the related incentive system, which in turn makes development difficult, or causes a backlog with regard to knowledge, skills and attitudes typical to IR 4.0, among employees and managers. Unfortunately, the effects of those gaps impact the next of those platforms Competitive Potential—"Knowledge Platform" and bring (cause) Black Points in processes of Management and Cooperation (both internal and external) which usually are a consequences of lack of efficiently implemented strategies, structures, or other tools typical to IR 4.0, as well as broadly understood network cooperation. Those barriers block the use of the resources of the "Technological Platform", resulting in having no significant ability to design, acquire, develop or implement not only new technologies, but also digitise their activities. What is important, those issues intensify when a given organisation fail to effectively

[30] See in Appendix Table 1.3.

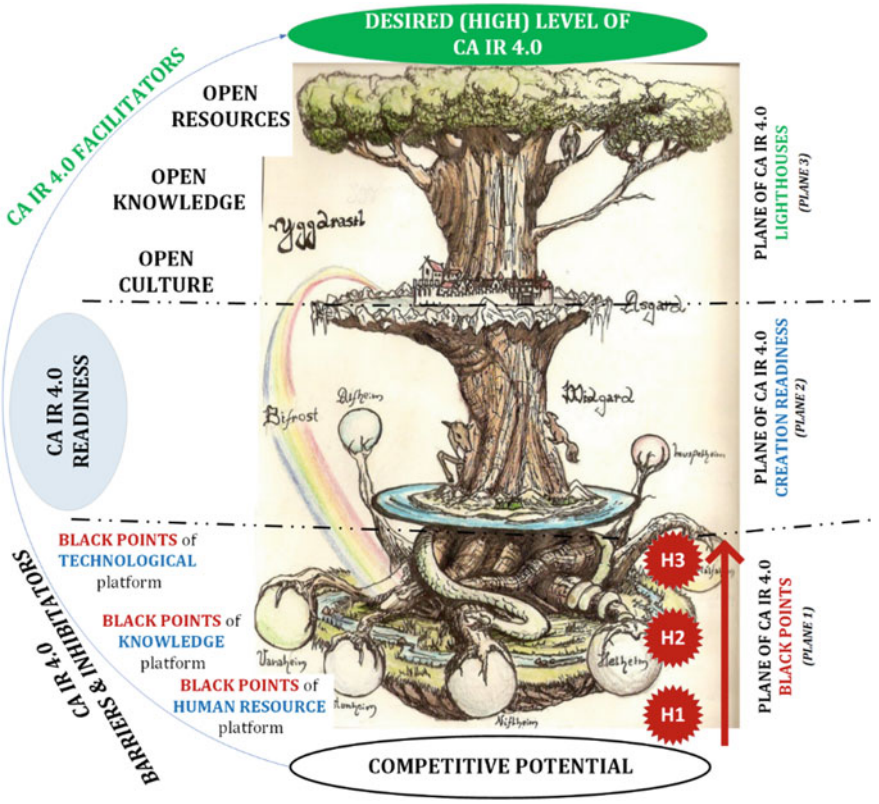


Fig. 1.4 Framework of conception of Tree of Life of CA IR 4.0. *Source* Own elaboration

overcome or even reduce the Black Points on "HR and Knowledge Platform". All of the above leads to "Lack of readiness to create CA IR 4.0".

The method to overcome the above deadlock is for enterprises to develop mechanisms to monitor and respond to the diagnosed Black Points. The most effective solution is a systematic work on developing the seven strategic factors listed in Fig. 1.4, with special focus on management competencies and talents necessary in IR 4.0. Case analysis clearly shows that actions aiming to prepare workers to navigate the age of Industry 4.0 by creating a culture of learning and collaboration and creating training opportunities—both within the organisation as well as in underserved communities should be a priority. Organisations need to invest in people and create an innovative mindset, involving training and enablement. These elements are more important than implementing the technologies. **If people don't get excited about transformation, it won't be successful**. Their knowledge can help to take a holistic approach to strategic planning, exploring how core capabilities can be enhanced by new ones to develop new products and services, and create new value for a broader range of stakeholders. It will also help to see that technology is the most powerful

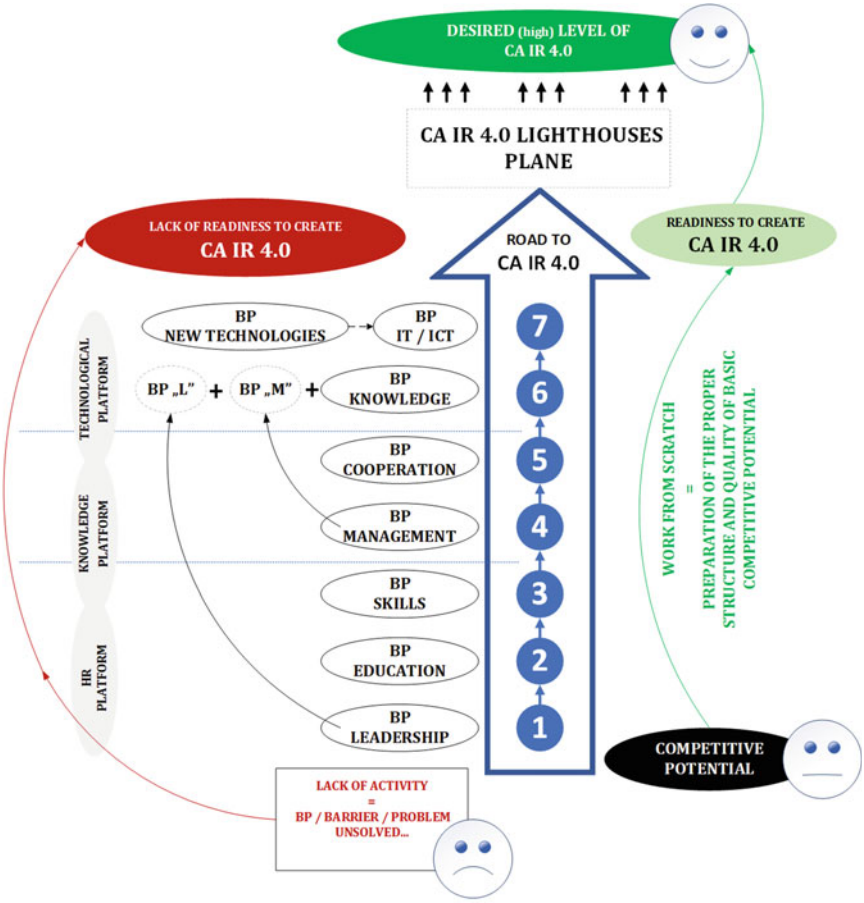


Fig. 1.5 Pointer of Readiness to Competitiveness in IR 4.0. *Source* Own elaboration

differentiator in an Industry 4.0 world, and it is valuable to invest in integrating new applications that can support new business models. And, most importantly, it should allow to understand that Industry 4.0 technologies shouldn't be limited to just one part of the organisation; **they should be integrated across the organisation** to better support a broad spectrum of responsibilities and stakeholders necessary to thrive in an Industry 4.0 world. Successful manufacturers will be those that blend artificial and human intelligence most effectively. The Black Points CA IR 4.0 eliminated this way will accelerate the "organisational readiness to create CA IR 4.0".

Appendix

See Table 1.3.

Table 1.3 The Map of Black Points of Creating CA IR 4.0

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
Technological platform)	• Operational quality and effectiveness • Development of production methods • Effective interorganizational cooperation • IT infrastructure and ICT technologies • Software integrations • Innovativeness Economies of scale of operation • *Digital transformation* • *Virtualization of organizational life* • Development and implementation of new technologies	IR 4.0 ICT technologies 1. Digitalisation 2. Simulation and forecasting techniques 3. Integrated software 4. Techniques of direct communication between the machines (M2M) 5. Innovative methods of collecting and processing large amounts of data (Big Data) 6. Operations in the cloud (Clouds) 7 Cyber-physical systems (CPS) 8. Internet of Things (IoT) 9. Internet of Services (IoS) 10. Cybersecurity *IR 4.0 modern technologies* 1. Augmented Reality (AR) 2. Virtual Reality (VR) 3. Digital twins 4. Artificial Intelligence (AI) 5. Neural Networks (NN) 6. Mass customization 7. Autonomic Robots (AR)	*KPMG (N = 300)*		
			Agility is "the new currency of business"; "if we're too slow, we will be bankrupt" (70%) Building digital connectivity is a must to improve transparency and better manage the ever-increasing complexity of global supply chains	Time	4
			Struggling to keep pace with the high rate of technological innovation in manufacturing (more than 30%). You need to achieve a high level of industrial readiness before even having a conversation with a prime contractor. Organizations will be asked about their cyber readiness, ERP maturity and whether they have the systems in place to work in an integrated fashion. This level of maturity is not only required by the prime contractors, but is also being stipulated by governments	Technologies	2
			The most of technology investments are tactical. If CEOs choose the wrong technology, it can be costly from the perspective of both time and money (almost 50%)	Technologies	3

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Some of the technologies are essential components of modernization. IoT and augmented reality are among the top forces driving the digital transformation of manufacturing. Advances in operational technology create a 'sensor net of things' in which operational decisions can be made independently of humans. It generates Cyber security risk (37%)	Technologies	3
			Lack of preparedness to identify new cyber threats (51% manufacturing companies) Lack of preparedness to contain the impact of a cyberattack on our strategic operations (53% manufacturing companies)	IT/ICT	3
			Manufacturing CEOs don't think they will need to improve the way that they monitor market disruption over the next 3 years (60%)	Leadership	4
			Manufacturing CEOs don't plan to increase investment in processes to detect disruption and promote innovation (50%). With the incredible pace that business disruption is moving, to be caught it could be a death sentence	Leadership	3
			Deloitte (N = 1603)		
			Lack of internal alignment about which technologies to follow (43%)	Knowledge	3
			Lack of collaboration with external partners (38%)	Cooperation	2

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Lack of adequate technologies (36%)	Technologies	2
			Lack of rank-and-file adoption (32%)	Management	2
			Lack of technology know-how (29%)	Technologies	2
			Budgetary issues (29%)	Finance	2
			Executives don't ready for new delivery models or blurred lines between industries (75%)	Knowledge	4
			Mc Kinsey & Company (N = 700)		
			Lack of adopting specific Digital Manufacturing rollout-relevant solutions company-wide (70%) (adopting: connectivity 23%; intelligence 29%; flexible automation 24%)	Management	4
			Lack of ROI as a major obstacle when implementing Digital Manufacturing solutions at scale (61%)	Management	4
			IT deficiencies as a main challenge in successfully implementing digital transformation initiatives (44%)	IT/ICT	3
			Lack of set up a data lake across network in more than 50% of their plants (80%)	IT/ICT	5
			Lack of use an advanced analytics platform at scale (75%)	IT/ICT	4
			Warwick, Crimson & Co, Pinsent Masons (N = 53)		
			Contracting processes are linear and unchanged (50%)	Management	3
			Self-optimisation processes are not in use (38%)	Management	2

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Autonomously guided workpieces are not in use (38%)	Technologies	2
			Cloud solutions not in use (35%)	IT/ICT	2
			Poor equipment readiness for Industry 4—Significant overhaul required to meet Industry 4.0 model (25%); Machines and systems have no M2M capability (22%); Few machines can be controlled through automation (22%)	Technologies	2
			Data-driven services account for an initial share of revenue (<2.5%) (42%)	IT/ICT	3
			Products show only physical value (38%)	Digitization	2

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
Knowledge platform	• Effective knowledge management • Employee skills development • Interorganizational knowledge partnering • Effective knowledge sharing *(Sharing Economy)* • Effective process approach to management • Effective competitive strategies • Competitive advantage • Organizational growth and development • Design management (design thinking) • Co-creation values	*IR 4.0 structural solutions leading solutions* Organic model of organisation; Cultural openness; Decentralization of power; Empowerment; flat, flexible organisational structures; work in creative task forces or project teams; mainly horizontal communication; fast decision-making process; Short communication channels, inter-department knowledge sharing; *IR 4.0 strategies* *key IR 4.0 resources* Employees, knowledge, relationships, dynamic abilities, modern technologies *Strategies for development and competitiveness* Eclectic, flexible, agile, dynamic, innovative, novel, proactive; *Strategies for building IR 4.0 advantage* Based on qualitative, dispersed, non-material, unreal, unstable, synergistic advantages; *Modern IR 4.0 functional strategies* ZZL, logistic, marketing, production, financial, etc.; *key IR 4.0 solutions* **– Relationship strategies** based on cooperation, alliances and coopetition, strategic partnership, network cooperation, sharing economy (C2C, B2C, B2B), co-creation, ambidexterity; **– Openness of management strategy**: Knowledge (Knowledge Partnering, Open Knowledge), innovations (Open Innovation), resources (Open Resources); **– Orientation to services;** **– Orientation to client;** **- Social responsibility of the organisation**	*KPMG (N = 300)*		
			Pressure from stakeholders to demonstrate the value of the investment quickly; the board of directors has an unreasonable expectation for a return on the investment in digital transformation (more than 50%)	Time	3
			Times on significant digital transformation projects often seem "overwhelming". A lot of CEOs struggle to maintain the course, often moving from strategic plans to tactical and limited execution (nearly 75%)	Time	4
			CEOs express scepticism about the ability of data analytics to forecast business trends; they won't be increasing use of predictive models or analytics (Almost 50%); CEOs have a low regard for the accuracy of predictive analytics (50%). CEOs often have no idea how to align a digitalized front office with the rest of the business	IT/ICT	3
			Strategic alliances are the most problematic strategy for achieving growth objectives over the next 3 years (More than 60%) The most critical elements will be creating digital supply chain networks based on complex strategic alliances	Cooperation	4

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			With connectivity comes risk. The growth of global business networks changes the risk landscape and makes companies more vulnerable to external shocks (94%). Companies are becoming more interdependent. The biggest barrier to extracting value from third parties is the difficulty of sharing data securely, so top-tier manufacturers are becoming more selective about which companies they partner with. Growth will be heavily reliant on strategic alliances, so determine which companies are important to work with. Only 6 percent have achieved full supply chain visibility, despite acknowledging its growing importance	Cooperation	5
			Deloitte (N = 1603)		
			Lack of internal alignment (43%)	Management	3
			Lack of collaboration with external partners (38%)	Cooperation	2
			Focus on the short-term investments, Short-termism (37%)	Management	2
			Lack of vision by the leaders (29%)	Management	2
			Organizations are not ready to fully harness the opportunities associated with Industry 4.0 (86%). Many executives continue to focus on traditional business operations, as opposed to focusing on opportunities to create new value for their direct and indirect stakeholders	Management	5

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Organizations are not highly capable of planning for and addressing the effects that technology-driven Industry 4.0 changes have on their organizational structures and employees (93%). It generates "organizational inertia", which occurs as a group remains fixated on its past accomplishments to protect its current state, while unknowingly blind to changes taking place within the marketplace	Management	5
			Mc Kinsey & Company (N = 700)		
			Lack of vision as a significant obstacle digital transformation (60%)	Management	4
			Lack of set up Digital Manufacturing integrated pilots as showcases to train and inspire the organization (75%)	Digitization	4
			Lack of robust road map for implementation digital transformation (clear definition of the size and nature of the business opportunity and a precise understanding of the IT and operational technology (OT) architecture and resourcing requirements) (42%)	Digitization	3
			Lack of a globally coordinated Digital Manufacturing strategy (75%)	Management	4
			No integration with suppliers or customers (35%), lack of supply chain visibility	Cooperation	2

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Warwick, Crimson & Co, Pinsent Masons (N = 53)		
			New risks not identified or assessed (50%)	Management	3
			No awareness 'As a service' business model (25%)	Management	2
			No sizeable Industry 4.0 investment (30%)	Finance	2
			Initial Industry 4.0 investments in only one business area (35%)	Finance	2
			KPIs are not focused around Industry 4.0 (55%)	Finance	3
			Industry 4.0 is recognised at departmental level but is not integrated into the strategy (40%)	Management	3
			Only basic communication and data sharing are required with suppliers and customers (35%)	Cooperation	2

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
Human resources platform	• Effective modern leadership • Trust and integrity • Effective interpersonal communications • Effective interpersonal relations • Effective motivation system • Effective structure and decision rights • Core values: values, believes, norms • Enthusiasm • Effective team work • Learning and development opportunities	*IR 4.0 competencies* 1. Subject-matter knowledge 2. Ability to learn 3. Teamwork 4. Ability to work in multicultural environment; 5. Ability to provide remote work 6. Knowledge of foreign languages 7. IT knowledge 8. Ability to share knowledge *IR 4.0 attitudes* 1. Will to constantly grow 2. Orientation to goals 3. Openness to new experiences 4. Creativity, flexible thinking, agility, high tolerance of uncertainty 5. Social responsibility	*KPMG (N = 300)*		
			Retooling the capabilities of workers and educate them on new roles introduced through digital transformation. Many organizations are struggling with it. 64%will create more jobs than it eliminates	Education	4
			The struggle for attract the talent need to accelerate organization digitalization strategies. Data scientists will be the most-needed type of worker for future growth (70%)	Motivation	4

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			CEOs aren't prepared to take charge of the process of reshaping the corporation and to set out a vision of what the organization should be aimin1g for. Personally, are not prepared to lead [their] organization through a radical transformation of its operating model to maintain competitiveness." (30%)	Leadership	2
			Workers will need extensive retraining, though, if they are to move into new jobs that robots cannot perform. 36% organizations will eliminate more jobs than it creates	Education	2
			CEOs don't feel that AI's focus should be in the reduction of operational costs (more than 70% don't feel it yet)	Education	4
			Deloitte (N = 1603)		
			Organizations' workforces will trend more toward contractual, temporary and/or ad hoc employees (More than 61%) This is supported by a larger economic trend that suggests one of the fastest- growing segments of the workforce is those engaged in alternative workforce arrangements with more workers working off campus and off-balance sheets	Time	4
			Lack of right workforce composition and the skill sets needed for the future (75%)	Skills	4

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Lack of believe that organizations hold significant influence over societal key factors such as education, sustainability and social mobility (75%)	Leadership	4
			Reformation strategies of Talent and HR are a relatively low priority during Digital transformation (83%)	Leadership	5
			Mc Kinsey & Company (N = 700)		
			Lack of appointed a C-level individual responsible for driving their Digital Manufacturing efforts (64%). Ensuring a sufficient pace and widespread adoption of Digital Manufacturing also requires the commitment of P&L owners	Leadership	4
			Talent issues are the main Digital Manufacturing challenge for 69% of manufacturers	Motivation	4

(continued)

Table 1.3 (continued)

Key parameters of readiness to CA IR 4.0		Potentially black points CA IR 4.0	Found/real black points CA IR 4.0 (%)	Type of barrier	Level of the barrier[a]
			Organizations don't see attraction, management, and the retention of top talent as the main challenge about Digital Manufacturing implementation (yet 30%)	Leadership	2
			Warwick, Crimson & Co, Pinsent Masons (N = 53)		
			Employees have little or no experience with digital technologies (20%)	Skills	2
			Technology focused areas of the business have employees with only some digital skills (35%)	Skills	2
			Leadership team are still investigating potential Industry 4.0 benefits (30%)	Leadership	2

Source Own elaboration

[a] 1: 0–19% of the tested sample—very low barrier; 2: 20–39% low barrier; 3: 40–59% average barrier; 4: 60–79% high barrier; 5: 80–100% very high barrier

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