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Creating a Competitive Advantage in the Age of Industry 4.0

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The paper highlights the role of and the need for the targeted, informed creation and the systematic enhancement of modern organisations' capacity, as well as the strengthening of their competitive advantages and competitiveness. The 21st century seems to have brought a need for radical changes in these processes. The fourth industrial revolution, also known as the digital revolution, forces companies to face specific competence-related, technological and organisational challenges. They are reflected in resources and skills needed by enterprises, as well as ways (methods, techniques, tools, or strategies) of creating a competitive advantage under the conditions of Industry 4.0. The aim of this study is to identify of key requirements of the process of creating a competitive advantage in the course of the development of Industry 4.0. and an initial attempt to determine the degree of their implementation, as well as their practical suitability for building a competitive advantage in selected enterprises of various sizes. The paper provides a synthetic description of the evolution in approaches to creating competitive advantages of enterprises over the period of four industrial revolutions and presents the characteristics of the so-called Competitive Advantage 4.0. A pilot study regarding the determination of the degree of development/implementation of tools specific to Industry 4.0 and their impact on the dynamization of competitive advantages of selected enterprises is described. This is a literature review and research paper.

Keywords: competitive advantage, methods of creating a competitive advantage, Industry 4.0, Competitive Advantage 4.0.

Budowa przewagi konkurencyjnej przedsiębiorstw w erze Przemysłu 4.0

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W artykule podkreślono rolę i konieczność ukierunkowanej, świadomej budowy oraz systematycznego wzmacniania potencjału, przewagi konkurencyjnej, a także konkurencyjności współczesnych organizacji. Zauważono, że XXI wiek niesie wymagania radykalnych zmian w tych procesach. Czwarta rewolucja przemysłowa, zwana też informatyczną, stawia przedsiębiorstwom konkretne wyzwania m.in. kompetencyjne, technologiczne i organizacyjne. Mają one swe odzwierciedlenie w niezbędnych przedsiębiorstwom zasobach i umiejętnościach, a także sposobach (metodach, technikach, narzędziach czy strategiach) budowy przewagi konkurencyjnej w warunkach Przemysłu 4.0. Celem opracowania jest zidentyfikowanie kluczowych wymagań procesu budowy przewagi konkurencyjnej w warunkach rozwoju Przemysłu 4.0 oraz próba

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wstępnego ustalenia stopnia ich realizacji i praktycznej przydatności dla budowy przewagi w wybranych przedsiębiorstwach różnej wielkości. W opracowaniu podjęto próbę identyfikacji kierunków, metod i narzędzi ułatwiających budowę budowy przewagi konkurencyjnej w warunkach rozwoju Przemysłu 4.0. Poza tym zawarto syntetyczny opis ewolucji w podejściach do budowy przewagi konkurencyjnej przedsiębiorstw na przestrzeni czterech rewolucji przemysłowych oraz charakterystykę tzw. przewagi konkurencyjnej 4.0. Zobrazowano powyższe opisem pilotażowych badań dotyczących identyfikacji stopnia rozwoju/wdrożenia oraz wpływu narzędzi charakterystycznych dla Przemysłu 4.0 na dynamizację przewagi konkurencyjnej wybranych przedsiębiorstw.

Słowa kluczowe: przewaga konkurencyjna, metody budowy przewagi konkurencyjnej, przewaga konkurencyjna w erze Przemysłu 4.0., era Przemysłu 4.0.

JEL: L29, O31, O32, O33

1. Introduction

The global economy is constantly changing. It has already undergone three revolutions (Tofler, 1997) and is in the process of the fourth industrial revolution. Each of these revolutions has left its mark on resource potentials and ways of functioning of contemporary enterprises. Also, enterprises have changed their approach to the process of developing their competitiveness, in particular to the type and nature of the underlying key advantages and mechanisms of their creation. The fourth revolution related to the development of the so-called Industry 4.0 brings specific challenges in this respect. Its specificity has been described in the literature since the beginning of the 21st century (e.g.: Lee, 2008; Żmijewski, 2014; Hermann, Pentek & Otto, 2015; Weyer, Schmitt, Ohmer & Goreck, 2015; Dmowski, Jędrzejewski, Libucha, Owerczuk, Suffczyńska-Hałabuz, Pławik, Iwasieczko & Kowalska, 2016; Qin, Liu & Grosvenor, 2016; Trappey, Trappey, Govindarajan, Chuang & Sun, 2016). Unfortunately, this specificity has been rarely referred to the possibility of building a competitive advantage of companies operating under these conditions.

In view of the above, the **theoretical aim of the paper** was to identify and present the key requirements of the process of building a competitive advantage in the course of the development of Industry 4.0., while the **empirical aim** was to determine the degree of their implementation and practical usefulness for creating a competitive advantage in selected enterprises. Theoretical considerations are illustrated with the results of a pilot study of several industrial enterprises of various sizes operating in Poland. The selection of companies for the study was dictated by the desire to determine differences in their preparedness for the age of Industry 4.0 and in their perception of the role of related activities, especially those associated with processes of creation of competitive advantages of medium-sized and large manufacturing enterprises.

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2. The specificity of the phenomenon of competitiveness and a competitive advantage of enterprises

The subject of business competitiveness development can be found within a wide field of issues related to strategic management. Although it continues to evolve, it is a distinct, problem-oriented and mature research speciality among the disciplines of management sciences. Research focuses mainly on long-term success of a business entity, and therefore on the issues of planning development and organisational restructuring, crisis management, and the creation of tools that rationalise these processes. Enterprises and their clusters are the research objects. Analyses regarding competitiveness not only describe and help to learn about regularities in organisational management practices, but they can also affect the practice of business management through streamlining it, especially through the formulation of normative rationalising models and determining conditions for their smooth implementation.

In accordance with the theoretical foundations of the analysed issue, **competitive organisations** are those that are capable of developing their own specific system of "strategic fit" to the environment. This fit (also called congruency or appropriateness) allows the organisation to effectively adjust its competences to the needs and requirements of the environment, so that the organisation goes through systematic positive selection and retention, receives the necessary resources to operate, and gains long-term social legitimacy (a high market position). Consequently, not only do such organisations ensures their own survival, but also generate profits and earn a good reputation. In this approach, 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 its members (in the material and technical, as well as political and social sense) (Adamik, 2015, p. 29).

Therefore, the **competitiveness of enterprises** in the market is a result of the effectiveness of the system which builds their long-term position within the environment, purposefully designed by their management. The system takes into account the impact of many mechanisms and factors, both internal (*inherent in a given enterprise, its resources and skills*) and external (*existing in the environment*). At the same time, it is a system **implementing smoothly three primary stages of activity** (Mann & Chan, 2002). The first stage is associated with the creation of a competitive area of activities for a given company, for example, through the search for a suitable way to stand out in the market, technological uniqueness, market attractiveness, development of new products and services, generation of market demand, or the choice of competitive concentration of the organisation's activities (the development

based on the exploitation of knowledge about the company's resources and skills, as well as the needs of the environment, that is, the exploitation of market opportunities). The second stage is related to concentration on the company's internal capabilities and generating the following on their basis: innovation, quality, cost effectiveness, flexibility of the structure and organisational systems (the development based on exploiting the company's internal potential). The third stage leads to a unique combination of the internal potential of the company with the external environment in which it operates. The company can be called competitive when this combination is so effective that, in a given environment, the said company will have "the ability to develop, obtain benefits, generate profits, and have the capacity to gain a competitive advantage" (Dobiegała-Korona & Kasiewicz, 2002).

Resources and skills inherent in a particular organisation, making up its so-called strategic capacity and **competitive advantage** developed on their basis, form the foundations of the above-presented processes. This advantage is the ability of a given organisation to consciously identify, implement, develop, protect and obtain benefits from 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 (Adamik 2003; 2008). This advantage requires resources to be 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 differently or better than its competitors, and consequently achieves better results that lead to a specific superiority over others (Aaker 1989; So what is competitive advantage… 2013; Catch me if you can!… 2016).

Studies have shown that, today, the ability to combine different types of resources and skills, i.e. the deliberate use of different primary sources of a competitive advantage, is increasingly a source of a competitive advantage. Creating unique and competitive combinations in this regard increases the chances of long-term market success (Ferrier & Wiltbank, 2010). In the light of the above, the ability to identify, shape and develop exceptional competences within the company is important along with the ability to mobilise the necessary resources and skills located outside the company (Adamik, 2016). For this purpose, the mastery of three essential activities is necessary; these are: dynamic specialisation[1], connectivity[2], and the creation of business potential in clusters of several entities[3]. The greatest results are achieved by the deliberate use (Kiron & Shockley, 2011) of global business and technological structures that may go beyond the boundaries of one enterprise and reach the potential of companies throughout the world (Hagel & Brown, 2006).

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3. Requirements of the age of Industry 4.0 towards modern enterprises. Competitive Advantage 4.0 (CA 4.0) – a framework approach

The world and the global economy are systematically going through various transformations that affect the functioning of enterprises in various ways. Macro conditions (such as state policies, laws, as well as socio-economic, technological, cultural, and natural/environmental conditions), as well as micro economic factors (e.g.: goods and services, suppliers, competitors, customers, stakeholders) have changed and continue to change. Also, customers' needs and enterprises' capabilities have evolved and continue to do so. From time to time, changes are revolutionary: they introduce into the public life unprecedented requirements and solutions. The three previous revolutions, agrarian, industrial, and post-industrial, as well as the ongoing fourth industrial revolution called Industry 4.0., seem particularly important. Their basic requirements, effects, and strategic solutions are summarised in Table 1. The list shows a kind of evolution which has taken place in the approach to creating competitiveness and competitive advantages of enterprises. It also summarises information that can help modern companies in the process of adjusting to currently occurring changes.

Given the aim of the paper and the topicality of the issue, we should pay special attention to the last of these revolutions. The concept of Industry 4.0 first appeared in literature in 2011 (Hermann, Pentek & Otto, 2015; Qin, Liu & Grosvenor, 2016). It helped entrepreneurs to realise key developmental directions for the near future that determine the possibility of gaining and maintaining competitive advantages. 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 (Dmowski, Jędrzejewski, Libucha, Owerczuk, Suffczyńska-Hałabuz, Pławik, Iwasieczko & Kowalska, 2016; Adamik & Nowicki, 2018). At the same time, the need to respect six key principles of effective competition under the conditions of Industry 4.0 were pointed out. 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, Pentek & Otto, 2015).

The analysis of the above-presented requirements, in association with basic competitiveness strategy theories and classifications (Adamik & Nowicki, 2012), allows us to conclude that, in the near future, the most effective methods of creating a competitive advantage will be differentiation-based qualitative advantages related in a special way to cyber-physical resources and skills (Competitive Advantage 4.0 – CA 4.0). The exploitation of new technologies, e.g.: ICT, digitalisation, or robotics, will allow enterprises to create resource-based, time or information advantages. The use of Virtual Reality solutions will offer a unique location advantage (based on the virtual location) (Nowicki, 2015a; Nowicki 2015b), while knowledge partnering (Adamik & Flaszewska, 2015) may lead to a management or relational advantage (Adamik, 2016). Smart networks, machines, processes, systems, products, supply chains, or factories can generate a multidimensional offer advantage evidenced, for example, by the advantage of flexibility, availability, and customisation (Gaub, 2016). Through well-thought-out combinations of these advantages, organisations managed in a modern manner will be able to develop unique and extremely valuable groups of qualitative advantages based on the following resources:

- intangible assets,
- assets dispersed over many areas of the organisation,
- unreal assets, often generated as a result of virtual activities in cyberspace,
- hidden assets, the origins of which the recipients will not be entirely aware of,
- synergistic resources, complementary towards each other, and even enhancing their mutual effectiveness.

Importantly, due to high dynamics of change in the environment (the age of "high velocity" environment), these advantages are often not only intangible, but temporary, quickly "overcome" by competitors. The Competitive Advantage 4.0 will be more of a "system" of highly advanced technologically and organisationally competitive advantages than a clearly identifiable, singular activity distinguishing a given company. Compared to the specificity of the competitive advantage of the 3.0 age, it will be based on far more developed understanding of customer needs and on meeting them with the use of state-of-the-art technologies and virtual reality. These solutions will create the so-called "post-reality"[4] modern humans will not be able to do without.

 DOI 10.7172/1644-9584.82.1

Revolutions	Advantage environment	Key resources and breakthrough applications	Ways of creating a competitive advantage	Key advantages	Nature of dominant advantages
1.0 (2nd half of 18th c. – 1st half of 19th c.) (agrarian revolution)	Physical world	Tangible: tangible assets, finance; **Mechanisation of production;** Substitution of charcoal with coke; development of metallurgy; generator, mechanisation, e.g.: mechanical loom; steam engine, steam locomotive.	Division of labour and exploitation of material resources, i.e. machinery parks, human resources; modern raw materials, financial resources.	**Cost leadership** **Advantage of specialisation/** market concentration **Differentiation**, including: – resource-based advantage – natural advantage – manufacturing advantage.	**Advantages:** – quantitative – concentrated – tangible – real – manifested – permanent – duplicated – clear – internal – exclusive – effective
2.0 (2nd half of 19th c.-. 1st half of 20th c.) (industrial revolution)	Physical world	Tangible: tangible assets, finance, supplies; **Mass production, electrification;** Internal combustion engine; car, radio, telephone, electricity; light bulb; assembly line; new means of transport; mass communication.	Development of tangible and intangible resources that generate, among others, the scale of operation; standardisation; specialisation, synchronisation, new materials; technological and sales effectiveness; employees' qualifications; customer service system; promotion and advertising.		
3.0 (2nd half of 20th c.) (post-industrial revolution)	Physical world + Elements of digital world	Intangible: competences, relations; **Automation**; Computers; the Internet; information technology; microprocessors, programmable controllers; new payment techniques; automation of production processes; unlimited access to information; customised manufacturing, renewable energy, remote communication, globalisation, network organisations.	Independent and joint implementation of: modern management methods; strategic analysis; active marketing; alliances and agreements; computerisation of management in the area of: brand, quality, logistics, knowledge; implementation of modern manufacturing technologies; development of unique product features; better fulfilment	**Differentiation,** including: – relational advantage – information advantage – time advantage – offer advantage.	**Advantages:** – qualitative – dispersed – concentrated – tangible and intangible – real – manifested – temporary – duplicated – clear – internal

continued Table 1

Revolutions	Advantage environment	Key resources and breakthrough applications	Ways of creating a competitive advantage	Key advantages	Nature of dominant advantages
3.0 (2nd half of 20th c.) (post-industrial revolution)	Physical world + Elements of digital world		of customers' needs; development of social capital; CSR, internationalisation of operations.		– commercial and exclusive – synergistic – effective
4.0 (since the beginning of the 21st c.) (fourth industrial revolution, Industry 4.0)	Digital world smoothly and fluidly permeating Physical world	Intangible: competences, functional systems, attitudes, capabilities **Cyber-physical systems; robotisation** Digitalisation; computerisation of manufacturing; dynamic data processing, new technologies, Smart Factories, through: Autonomous Robots; Simulations; Vertical/ Horizontal Software Integrations; Industrial Internet of Things (IoT); Machine-to-Machine Communication (M2M); Internet of Services (IOS), Big Data and Analytics; innovative methods of collecting and processing massive amounts of data, including	**Comprehensive and optimal use of operations,** i.e.: ICT, interoperability; dynamic capabilities, system partnering, knowledge partnering, virtualisation; robotisation, modularity; decentralisation; real-time assessment of capabilities; service orientation; network cooperation; smart: networks, machines, processes, systems, products, supply chains, factories (post-reality); sharing economy (C2C, B2C, B2B)	**Differentiation,** including: – resource-based advantage – management advantage – information advantage – relational advantage – time advantage – location advantage	**Advantages:** – qualitative – dispersed – intangible – unreal – hidden – temporary – impermanent – unique – unclear – internal and external – commercial – synergistic – potential

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Revolutions	Advantage environment	Key resources and breakthrough applications	Ways of creating a competitive advantage	Key advantages	Nature of dominant advantages
4.0 (since the beginning of the 21st c.) (fourth industrial revolution, Industry 4.0)	Digital world smoothly and fluidly permeating Physical world	Clouds; Augmented Reality (AR); Virtual Reality(VR); Cyber-Physical Systems (CPS),Digital Twins, Artificial Intelligence, and Neural Networks; Cybersecurity; Mass Customisation.		**Offer advantage**, including: – advantage of flexibility – advantage of availability – advantage of digital servilisation – advantage of digital integration – advantage of customisation.	
		Competitive Advantage 4.0 (CA 4.0)			
1	2	3	4	5	

Tab. 1. Evolution in mechanisms of construction of a competitive advantage and foundations of CA 4.0. Source: Own elaboration.

4. Pilot study methodology

Given that, according to worldwide studies, relatively the largest number of solutions specific to Industry 4.0 are implemented in the sphere of production (Trappey & al. 2016, see Table 2), manufacturing companies were included in the test sample. In order to conduct a pilot study of key differences in preparedness for operating in the age of Industry 4.0, one large, global-scale enterprise, as an example of the highest development possibilities, and three medium-sized companies, illustrating capabilities more typical of the Polish economy, were purposefully chosen.

Technology	**Application**		
	Energy	**Production**	**Supply chain**
Perception layer			
Sensors	30	211	11
Circuits	26	404	5
Actuators	10	43	3
Controllers	57	890	7
RFID	5	104	14
Imaging	1	27	2
Transmission layer			
Multiplexing methods	0	139	0
Topology management	5	118	1
Baseband processing	0	18	0
Protocols	8	531	2
Computation layer			
Hardware	10	255	10
Software	25	409	10
Algorithms	17	126	1
Cloud platforms	5	50	3
Encryption	22	211	6
Memory management	2	131	0
Power management	3	75	0
Resource management	3	97	0

Tab. 2. Technology application matrix (TAM). Source: Trappey, 2016, p.14.

 DOI 10.7172/1644-9584.82.1

In order to attain the objectives of the research process (pilot study), a diagnostic questionnaire was used in four selected enterprises (see Table 3). It was a tool supporting direct interviews and case studies. The questionnaire can be adapted to test larger samples. The questionnaire included queries about the surveyed companies' commitment to solutions specific to Industry 4.0 in 11 areas. Respondents also assessed the impact of this commitment on the processes of dynamisation of their competitive advantages. They were representatives of the management of the surveyed organisations and had extensive knowledge about their operations.

The large enterprise (A) is a global leader in the building materials industry. It has been on the market for more than 100 years and, today, has its subsidiaries in more than 50 countries throughout the world. The company owns 40 manufacturing plants. They are computer-controlled, which allows to minimise the impact of the "human factor" on manufactured products. In addition, they have appropriate facilities, e.g.: silos, storage tanks, containers, dispensing systems, etc. that enable such storage and handling of materials so as not to change their properties due to weather conditions, mixing or contamination. Thanks to special heating installations, which heat water and aggregates, production is carried out also during the winter season.

The first medium-sized enterprise (B) is one of the largest European Union manufacturers of sports fan accessories. It cooperates with licensed entities eligible to distribute gadgets of Europa League and Champions League, as well as Major League Soccer in the US and in Canada. The company is virtually self-sufficient in its manufacturing processes, since it has a team of experienced graphic designers, as well as a modern machine park consisting of embroidery, knitting, printing, screen printing and sewing rooms. It employs sales representatives able to reach every corner of the country to present the finished product and to initiate cooperation with new clients.

The second medium-sized enterprise (C) is a Polish cosmetics factory with more than 25 years of experience in the domestic and foreign markets. Its range of products includes a few hundred items and keeps growing. Each product is offered in several variants, for example, colours or fragrances. Products have the documentation (i.e. safety reports, biological or dermatological application research) legally required in Poland and internationally and are registered in the CPNP. The company's quality management system certificate ISO 9001 and its successive positive audits carried out by the certification body TUV NORD testify to the high level of its manufacturing processes.

The third medium-sized enterprise (D) is a provider of comprehensive services in the field of electronics manufacturing, with a focus on the production of printed circuit board (PCB), surface-mount electronic and through-hole technology (SMD/THT), as well as the development of

prototypes and testing services. It is a family business that has operated on the market for more than 30 years.

Their location (Poland) and manner of functioning will lead to an initial (pilot) understanding of the awareness of the requirements of Industry 4.0 and their role, as well as the level of preparedness of enterprises operating in Poland for Industry 4.0.

5. Pilot study results

From the analysis of the collected pilot study data (Table 3) it transpires that, in terms of 36 parameters in 11 key areas essential for the functioning in the age of Industry 4.0, the examined companies are generally rather poorly prepared (1.9 average on a 0–5 scale, column 6, Table 3.). The large enterprise (A), with an average score of 3.1 (column 2, Table 3), seems best prepared for Industry 4.0, which means that its level of use of Industry 4.0. tools is slightly higher than the average. The respondents were the most efficient in implementing automated machines and production equipment, procedures related to current data backup, as well as computer systems, antivirus security and antispyware integrated internally at the company level. They also collect in their databases current data about processes (e.g. technological or sales), and use them to take decisions in real time. Unfortunately, many solutions specific to Industry 4.0 are yet to be applied by the respondents. Out of 36 analysed activities and tools, four have not been implemented in any of the surveyed companies. Other four have only been applied by the large enterprise A. The respondents do not use electronic "kanban cards", augmented reality tools, smart products, and smart supply chains, or robots, even though they are aware that the lack of these tools limits their ability to dynamise their competitive advantages.

When it comes to the impact of applied Industry 4.0 solutions on the dynamisation of building competitive advantages in the surveyed companies, respondents claim that the currently used solution shave a weak, but positive impact, even if some of them are not very well-developed tools(the bottom row of Table 3, columns 7–11). They are, in a way, catalysts of the process of dynamisation of the created advantage. The role of deployments of automated machines and production equipment, as well as computer software, especially related to product modelling and integrating production, storage and transport equipment used in the surveyed companies have been rated highest. The possibility to create modular products, support mass customisation, simulate processes, and have a "digital twin" is also important for the respondents. At the same time, lack of smart supply chains, smart robots, machines autonomously adjustable to variable production, and autonomous systems that make their own decisions depending on the signals received are perceived as the greatest barriers to creating a competitive advantage (details in column 11, Table 3).

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	Type of activity/tool	Degree of tool implementation					Impact on the construction of a competitive advantage				
		Assessment scale: 0-5[a]				Σ N = 4	Assessment scale: from -2 to +2[b]				Σ N = 4
		A	B	C	D		A	B	C	D	
Automatisation, Autonomous robots	automated machines and production equipment	4	5	3	4	16	2	2	1	2	7
	automated internal transport systems	5	1	0	1	7	1	1	0	1	3
	automated storage systems	5	0	0	1	6	1	–2	0	1	0
	computer-integrated manufacturing, storage and transport systems	4	0	5	3	12	1	0	2	1	4
	industrial robots	2	0	0	0	2	0	0	0	1	1
	smart robots or autonomous devices adapting to variable production	2	0	0	0	2	0	0	–2	1	–1
Simulations	computer software for product modelling	4	5	0	3	12	2	2	0	1	5
	process simulations, e.g. production simulations	4	2	0	3	9	2	2	–1	1	4
	real-time process simulations	3	3	0	2	8	1	2	–1	1	3
Vertical/ horizontal software integration	computer systems	4	3	3	4	14	1	1	1	2	5
	internally integrated computer systems	4	3	3	4	14	1	1	1	2	5
	computer systems integrated with external partners	4	0	3	2	9	1	–2	1	2	2
	remote/system monitoring of the manufacturing process	4	1	0	2	7	1	0	–1	1	1
	integration of physical and computing processes	4	0	2	1	7	1	0	0	0	1
Industrial Internet of Things; Internet of Services	sensors collecting information about the state of a machine, product, etc. in the technological process	4	2	1	1	8	2	1	–1	1	2
	"on line" technology park service monitoring	3	0	0	0	3	1	0	–1	1	1
	electronic "kanban cards" in internal logistics/"on line" contact between the production line and the warehouse	0	0	0	0	0	0	0	0	1	1
	Machine-to-Machine communication (M2M) in real time	3	0	0	2	5	1	0	0	2	3

continued Table 3

	Type of activity/tool	Degree of tool implementation					Impact on the construction of a competitive advantage				
		Assessment scale: 0-5[a]				Σ N = 4	Assessment scale: from -2 to +2[b]				Σ N = 4
		A	B	C	D		A	B	C	D	
Cybersecurity	security of data collected in databases and systems	4	2	3	3	12	1	0	0	2	3
	real-time data backup	5	2	4	4	15	1	0	0	2	3
	standard antivirus security, antispyware	5	2	2	5	14	1	0	0	2	3
	antivirus security and antispyware developed in cooperation with external experts	5	0	1	3	9	2	0	0	2	2
Cloud	cloud-based software	1	2	1	1	5	1	1	0	1	2
	cloud data collection	1	2	1	1	5	1	1	0	0	2
	sharing data with other organisations through the cloud	0	0	0	1	1	0	–1	0	0	–1
	securing and using data off-site	5	3	1	1	10	0	2	0	0	2
Augmented and Virtual reality	use of augmented reality tools, e.g.: 3D glasses displaying the instructions imposed on the observed object (in the course of training, repair work, warehouse activities, etc.),	0	0	0	0	0	0	0	–1	0	–1
Big Data and analytics	real-time collection of data on processes, e.g.: technological or sales processes, in databases	5	2	3	3	13	1	1	1	1	4
	use of databases for real-time decision-making	4	2	4	3	13	1	1	2	1	3
	use of systems autonomously making decisions based on signals received	2	0	2	3	7	0	–1	1	–1	–1
Digital Twin	possession and systematic use of “digital twins”, i.e. reference models for adjustment (calibration) of implemented processes	3	1	1	2	7	2	1	0	1	4

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	Type of activity/tool	Degree of tool implementation					Impact on the construction of a competitive advantage				
		Assessment scale: 0-5[a]				Σ N = 4	Assessment scale: from -2 to +2[b]				Σ N = 4
		A	**B**	**C**	**D**		**A**	**B**	**C**	**D**	
Mass Customisation	manufactured products are modular (the ability to create sets matched to the needs of different customers)	0	4	3	5	12	0	2	1	2	5
	implementation of a system supporting mass customisation (the offer adjusted to individual customers' needs)	5	0	0	5	10	2	–1	1	2	4
Artificial Intelligence; Neural networks	smart processes, i.e.using systems and/or applications, artificial intelligence machines (learning on the basis of current situations, historical data, etc.)	4	0	0	2	6	2	0	–1	1	2
	smart supply chains	0	0	0	0	0	0	–2	–1	0	–3
	smart products	0	0	0	0	0	0	0	–1	0	–1
Total		112	47	46	75	280	34	12	1	38	85
Average		**3.1**	1.3	1.3	2.1	1.9	**0.9**	0.3	0	1.0	**0.6**
1		2	3	4	5	6	7	8	9	10	11

[a] where: 0 – lack of application, 1 – very low degree of development/implementation, 2 – low degree of implementation, 3 – average degree of implementation, 4 – high degree of implementation, 5 – very high degree of implementation

[b] where: -2 – factor is a strong inhibitor of dynamisation of the company's competitive advantage; -1 – factor is a weak inhibitor of dynamisation of the company's competitive advantage; 0 – neutral factor; 1 – factor is a weak stimulator of dynamisation of the company's competitive advantage; 2 – factor is a strong stimulator of dynamisation of the company's competitive advantage

Tab. 3. The questionnaire for diagnosing the degree of use and the importance of Industry 4.0. tools for the construction of competitive advantages of the surveyed companies. Source: Own elaboration.

If we look the activity in the area of Industry 4.0 from the perspective of company size, the large, global company A is significantly more advanced. Compared it its investments, those made by medium-sized companies are less than half in terms of value, mainly due to the limited financial capacity, resources and scale of operations of these smaller entities. Even in the case of D company, operating in a sector is strongly linked to IT, there is little difference in this regard.

6. Conclusions

Both theoretical considerations and empirical findings clearly show that, in the near future, modern companies (including those operating in Poland) should substantially modify not only their resources and skills, but also competition strategies. The emphasis on knowledge, competences, new technologies, computer science, virtual reality and widely understood cooperation networks is a 21st-century prerequisite, and the ability to combine them in a unique manner into a "system" of CA 4.0 is a key to market success. This tendency has been unambiguously confirmed by a growing number of international surveys (Geissbauer, Vedso & Schrauf 2016; Qin, Liu & Grosvenor, 2016; Ajdovec, Kovacic Batista & Vidmar, 2017; Bender & Willmott 2017; Deloitte, 2018).

The findings of the conducted pilot research indicate that companies operating in Poland, although increasingly aware of the benefits offered by modern solutions, still have relatively limited knowledge concerning the requirements of the Industry 4.0age. As a result, they are reluctant to use tools specific to this age, especially in the area of Virtualization & Digital Transformation (V&DX) and, consequently, are still not prepared to effectively create competitive advantages and compete in the age of Industry 4.0.

The accuracy of the presented results is confirmed by the findings of a nation wide study, Smart Industry Poland2017and 2018 (Nowicka, 2017; Nowicka, 2018). Similar conclusions can be drawn from other studies (Adamik & Nowicki, 2018; Ślusarczyk, 2018). In addition, surveys carried out among enterprises in many countries point to similar problems (Fonseca, 2018; Kamblea, Gunasekaranb & Rohit Sharmac 2018; Feng, Zhang & Zhou 2018; Basl, 2017).

Case studies clearly show that measures taken to prepare organizations to navigate the age of Industry 4.0 should effectively blend artificial and human intelligence. Respondents of the pilot study claim to be relatively best prepared to face challenges in the areas of Cybersecurity, Vertical/horizontal software integration and Big Data and Analytics. It should also be noted that the highest degree of tool implementation and the highest impact on the construction of competitive advantages in the age of Industry 4.0 has been observed in the areas of 1) Automated machines and production

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equipment, 2) Computer systems, and 3) Internally integrated computer systems. The following are the greatest obstacles in the construction of competitive advantage in the age of Industry 4.0: lack of smart supply chains and smart products, failure to use systems autonomously making decisions based on signals received, failure to use augmented reality tools or share data with other organisations through the cloud, and the lack of smart robots or autonomous devices adjusting to production needs. Specific and systematic research data presented in this paper (along with the questionnaire for diagnosing the use and the importance of Industry 4.0. tools for the construction of competitive advantages) may serve as a kind of compass or "detector" in terms of what should be subject to modification in enterprises, and a "manual" pointing to the direction of these changes. Using the proposed questionnaire for research, it is possible to gather in a systematic way a lot of information on the readiness of the surveyed entities for building competitive advantage in the age of Industry 4.0.

Due to the minimal size of the research sample used in the pilot study (4 companies) and the limited framework of the paper, these suggestions are quite synthetic, it seems that they can be a source of inspiration for researchers as to directions of further research and for business practitioners as to the areas of potential reorganisation and investment.

Endnotes

1 **Dynamic specialisation** will bring extraordinary results when, by focusing on areas of our potential that can be considered world-class (and discarding those areas that do not provide any special distinction), we will establish active cooperation with world-class specialists in this field and jointly create a common platform.

2 **Connectivity** (ability to connect) will increase the effectiveness of our competition by learning how to gain access to and acquire the ability to mobilise resources of other, equally specialised, companies to co-create more value for customers.

3 **Assisted capacity-building** will be most effective when partners are able to establish such close cooperation that they will be able to mobilise one another to achieve better results, and the companies' potential used in the cooperation will evolve to accelerate the process of learning among the co-operating partners.

4 Digital reality is becoming more important than physical reality. It is evidences, for example, by the fact that when driving a car, we are more likely to look at our navigation than signs on the road, or that communication with people is increasingly taking place in the virtual rather than physical realm. These changes affect all areas of our lives, including business.

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