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HOW INDUSTRY 4.0 SUPPORTS THE STRATEGIC AGILITY OF COMPANIES. A SYSTEMATIC LITERATURE REVIEW

Abstract:
The aim of the article is to identify and assess the state of knowledge in the field of using and supporting Industry 4.0 technologies for the development of companies' strategic agility. In particular, it is of keen interest how the individual Industry 4.0 technologies selected by the authors support the attributes that contribute to strategic agility. The article uses a systematic literature review (SLR), and strives in a rigorous and reliable manner to organize knowledge of the use of Industry 4.0 technology in the development of strategic agility. The systematic review research procedure consists of a five-stage approach, including: formulation of the research questions and determination of the research objective, selection of the literature sample, evaluation of the identified papers, data analysis and synthesis, and reporting on the results. The applied research method allowed for synthesis and consolidation of the existing scientific achievements in the field of supporting Industry 4.0 technologies in the development of strategic agility in companies, as well as indication of the most desirable directions for further research. Simultaneously, the research results allowed a reasonable context for future research to be defined. The literature clearly indicates a scarcity of papers in the field of linking Industry 4.0 with the agility of companies, as well as a lack of information on the state of research in this area, both in theoretical and empirical terms. There

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is a noticeable shortage of studies identifying which Industry 4.0 technologies support the development of strategic agility, to what extent and in what aspects.

Key words: *Industry 4.0, new technologies, strategic agility, systematic literature review*

JEL codes: *L21, L22, L23, L25, L26, M11, M15*

Research area: *Management*

Introduction

The fourth industrial revolution has attracted growing attention in recent years, as has the concept of strategic agility, which is an extremely important ability whose development, especially in the context of Industry 4.0, is a key competence for companies (da Silva et al., 2020; Osterrieder et al., 2020). The scientific literature emphasizes that the use of modern technologies does not only support business, but more and more often is of strategic importance for companies (Ghobakhloo, 2018; Lin *et al.*, 2018; Akkaya, 2020). From a strategic and technological perspective, a company's transition to Industry 4.0 requires comprehensive agility, which, through the attributes that co-create it, ensures the integration of key areas of the company and the transition to a fully digital organization (Sony and Naik, 2020).

Götz (2019) points to an organization's agility as a very important capability in the context of Industry 4.0, thanks to which companies can effectively respond to changes in the environment and reconfigure their business models. The main opportunities resulting from the implementation of Industry 4.0 solutions include "speed of changes" and "flexible production". Accessing both of these benefits is possible thanks to the attributes of agility. The purpose of the strategic agility concept is to encourage organizations to think forward and be proactive in their approach, especially as they operate in today's complex business environment (Doz and Kosonen, 2008). The critical role of strategic agility in enhancing performance has become more crucial with the growing dynamism of the business environment (Ivory & Brooks, 2018). Strategic agility is crucial in order to maximize strengths and provide what is necessary for the organization's survival (Doz & Kosonen, 2008; Ping *et al.*, 2018; Tallon *et al*. 2019). We agree with Ping et al. (2018) that strategic agility is a weapon that can be used to cope with a turbulent and fast-changing business environment.

In the current literature, there is still a lack of systematic reviews on the impact of the new industrial revolution on the attributes of strategic agility

(Tallon et al., 2019). Previous papers have systematically reviewed the literature for both Industry 4.0 and agility, but separately. The literature clearly indicates a shortage of papers linking Industry 4.0 with the issue of company agility, as well as a lack of information on the state of research in this area, both in theoretical and empirical terms (Schirrmacher & Schoop, 2018; Diegmann et al., 2018; Ciampi et al., 2018). One of the exceptions is an article published by Mrugalska and Ahmed (2021), who reviewed the literature from the perspective of agility in Industry 4.0 and concluded that "agility is important for an organization to adopt Industry 4.0 technologies as it helps companies to cope with the changes that arise along with the adoption of Industry 4.0 technologies". Although both aspects were addressed in their paper, the authors presented an entirely different approach and also set different goals. The purpose of their research was to review the literature from the perspective of agility in Industry 4.0. That is, they treat agility as a dynamic ability for the successful implementation of Industry 4.0 solutions, that is as an enabler for the implementation of new technologies. Our analysis perspective is different, we are interested in the relationship between the use of Industry 4.0 technologies and the development of the adopted agility attributes. There is a noticeable shortage of studies identifying which Industry 4.0 technologies support the development of strategic agility, to what extent and in what aspects (Piccarozzi et al., 2018; Walter, 2021). Tallon *et al.* (2019, p. 4) point out that "the literature is relatively silent on how firms should manage their IT resources to deliver greater agility, the capabilities needed to do this, and the resulting implications for firm performance". Hence, it seems reasonable to pose the following research question: Do industry 4.0 technologies support strategic agility, and if so, to what extent?

Taking the above into consideration, the aim of the paper is to identify and assess the state of knowledge in the field of using and supporting Industry 4.0 technologies for the development of companies' strategic agility.

Our paper systematically reviews relevant articles from peer-reviewed academic journals in the period from 2018 to 2020. Adopted time scope is related to the peak of interest of "Industry 4.0" term during this period according to Google Trends database. The article uses the method of a systematic literature review (SLR), and strives in a rigorous and reliable manner to organize knowledge of the use of Industry 4.0 technology to strengthen strategic agility. The research procedure of the systematic review consisted of a five-stage approach, including: formulation of the research questions and determination of the research objective, selection of the literature sample, evaluation of the identified papers, data analysis and synthesis, and reporting on the results. The applied research method allowed for synthesis and consolidation of the existing scientific

achievements in the field of supporting Industry 4.0 technologies in the development of companies' strategic agility.

The structure of the paper is as follows. First, we discuss the growing importance of Industry 4.0 and strategic agility, including the presentation of the specific characteristics of Industry 4.0 and the strategic agility perspective. Section 2 then presents the systematic literature review method and the fundamental review principles. The next part of the paper illustrates and discusses the results. The paper ends with conclusions and a future research agenda.

1. The growing importance of Industry 4.0 and strategic agility

1.1. Industry 4.0 – a set of integrated technologies

In the time of the ongoing Fourth Industrial Revolution, also known as the Industry 4.0 era, the digital and physical worlds are converging (Pham et al., 2019). So-called "general purpose technologies" (or "founding technologies"), usually perceived to be the computer, internet and smartphone (Jovanovic and Rousseau 2005; Śledziewska and Włoch 2020), continue to have the ability to spread to all sectors of the economy, and are constantly improving and stimulating innovations in many areas of the economy and in society in general. They are also the basis of the ecosystem in which new inventions and innovations appear. Many consulting companies have attempted to identify the technologies that have the greatest potential to disrupt the current functioning of the economy and society (so-called disruptive technologies). Among these, the most frequently indicated are mobile Internet, the Internet of Things, cloud technology, automation and advanced robotics, 3D printing, ICT solutions and BI systems (Henke and Wilmott, 2018). The catalogue of technologies, however, remains open, and the boundaries between them are sometimes difficult to define in practice. Moreover, as W. B. Arthur (2009) points out, a single technology does not arise in a linear manner, but rather as a combination of other technologies. This mechanism was also evident during earlier industrial revolutions, but it was much slower, due, for example, to the pace of knowledge transfer.

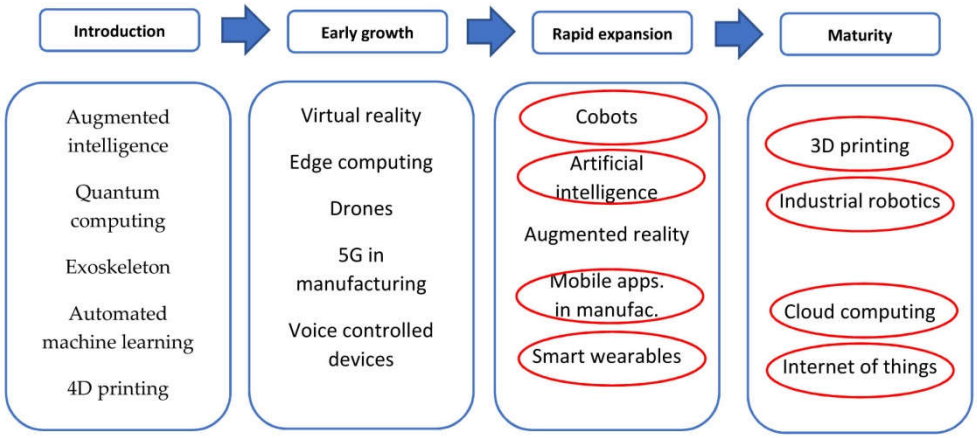
Industry 4.0 technologies create the need for the intensive use of large data sets and processes, organized within various subsystems of an organization. The main goals are improving efficiency, creating new opportunities, and strengthening the resilience of the organization. The transformation of an enterprise forces management to have an understanding of the opportunities, challenges and emerging competency gaps in the implemented business model (Schwab, 2016). The need to implement Industry 4.0 technology has emerged in particular in the face of the COVID-19 pandemic and its consequences, for example, unstable demand or difficulties in coordinating supply chains. The increasingly visible

convergence of the digital and physical worlds has resulted in profound changes that have shaped the value chain. At the same time, the evolution of the technologies themselves, as well as their potential applications, hinder a long-term approach both to investments in such technologies as well as clear planning of the entire ecosystem within which the company operates.

As indicated in a World Economic Forum report (WEF 2020), after 2018 there was a significant acceleration in the implementation of new technologies. The WEF also presents a list of technologies ranked according to the likelihood of their adoption by companies by 2025. Cloud computing, Big Data and e-commerce remain priorities, following the trend set during the Covid-19 pandemic. There has also been a significant increase of interest in encryption, reflecting the weaknesses of the digital age, and a notable increase in the number of companies expecting to use non-human robots and artificial intelligence. A similar observation can be made with regard to the so-called Hype Cycle for Emerging Technologies (prepared by Gartner), which introduces technologies with the greatest potential impact on business, society and people in the medium term.

However, it is worth noting that the essence of an effective digital transformation is the implementation of already existing technologies that can be considered mature. Some Industry 4.0 technologies have matured over the past decade, while others are still in the early stages of development or implementation, or are being tested in laboratory environments. According to one of the latest Kearney reports (2020), Industry 4.0 is essentially an ecosystem of five basic technologies: 1) artificial intelligence, 2) the Internet of Things (IoT), 3) 3D printing, 4) advanced robotics, and 5) wearables, augmented reality (AR) and virtual reality (VR). At the same time, other I4.0 technologies are also quickly being adopted and their market reach has expanded in recent years. Figure 1 shows the key technologies and the level of their maturity.

Figure 1. Maturity levels of I4.0 technologies



* technologies marked with red circles will be of particular interest in the analytical part of the paper
Source: Kearney analysis (2020)

New digital technologies are blurring the lines between the physical and digital spheres of global production systems. Industry 4.0 is turning manufacturing into a more information-intensive ecosystem with a connected environment of Big Data, people, processes, services and production systems. The scale of technology absorption differs depending on the industry analysed. Artificial intelligence is most often adopted in the information and telecommunications industries, as well as in financial services, healthcare and transportation. Big Data, the Internet of Things and robotics are intensively absorbed technologies in the mining and metallurgical industries, while the public sector has a clear focus on encryption (WEF 2020). The implementation of new technologies is aimed at ensuring future growth based on new sets of competences, which is undoubtedly a common feature of digital transformation, regardless of the industry analysed.

1.2. Strategic agility perspective

Today's fast pace of changes in the business environment requires organizations not only to be flexible in their operations, but also to be agile in order to survive (Holbeche, 2018). As Mavengere (2013, p. 327) notes, “growth and survival of companies in the contemporary business environment largely depend on how well the companies understand and relate to the dynamic and increasingly complex business environment”. An increasing number of companies may need to achieve strategic agility and to be flexible and adaptive, while remaining purposeful and consistent in

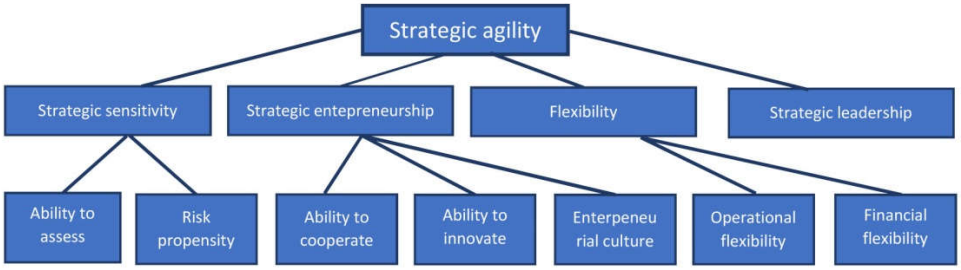
their efforts as they face more diverse and faster competition, strategic redirections and new business models (Doz, 2020).

Strategic agility, defined as the ability to undertake strategic changes aimed at improving company results (Sajdak, 2019b), is a response to the challenges of the modern economy, thanks to which companies can react faster, more efficiently and more effectively. We agree with Doz and Kosonen (2008) that strategic agility constitutes the ability of companies to make strong strategic commitments, while at the same time remaining sufficiently agile so as to manage and adjust to the continuous change caused by growing strategic discontinuities and disruptions. While researchers may agree that agility is about sensing and responding to changes, there are some variations as to the levels on which agility is considered (corporate, business unit, process or work group) and the composition of the construct (Tallon *et al.*, 2019). It may be noticed that the issues of organizational and strategic agility are sometimes treated as synonyms in the literature, emphasizing that agility relates to the ability to detect and respond to opportunities and threats with ease, speed and dexterity (Tallon and Pinsonneault 2011; Ravichandran, 2018).

We assume that strategic agility comprises four attributes, which have been identified as strategic sensitivity, strategic entrepreneurship, flexibility, and strategic leadership (see fig. 2) (Sajdak, 2019b). The first attribute - **strategic sensitivity** (consisting of the ability to assess opportunities and the propensity for risk) relates to the ability to quickly see market opportunities and threats arising from the environment, and the ability to categorize situations as favourable or unfavourable for the company (Zhang & Sharifi, 2000). The aspect of sensitivity concerns the ability to assess emerging opportunities - the company identifies and assesses whether an opportunity is consistent with the company's goals, and whether the company is able to assess the value of the emerging opportunity, regardless of the company's strategy (Maskell, 2001). At the same time, the company knows how to estimate the risk associated with an emerging opportunity (Sajdak, 2019a). Making decisions within the company regarding the use of opportunities is directly related to the attitude of decision-makers towards taking risks and perceiving them as a natural element of the market game (Jambulingam et al., 2005). Risk propensity refers to the propensity of managers to undertake risky projects, and reflects a preference for bold decisions in order to achieve organizational goals. It stands for the tolerance of errors, failures and ambiguities (Chiva et al., 2007). The next attribute is **strategic entrepreneurship**, which contributes importantly in the context of companies' ability to adapt by identifying and exploiting opportunities in the environment, while at the same time being a vehicle of strategic dexterity, flexibility and innovation (Kraus et al., 2011). Strategic entrepreneurship (consisting of the ability to

cooperate, the ability to innovate and entrepreneurial culture) deals with the actions a firm undertakes in exploiting new innovations, which result from the company's efforts to continuously explore opportunities (Sajdak, 2019b). The ability to cooperate is developed thanks to the company's knowledge of how to obtain resources from the environment. Nurturing a network of contacts and developing the company's ability to collaborate with partners (by identifying key partners) can be very helpful (Zhang and Sharifi, 2000; Maskell, 2001). The company's innovative ability manifests itself in the search for innovative technologies and at the same time the resources needed to implement new ideas. As a result, the company is willing to experiment with new concepts and ideas and also becomes known as an innovation leader (Jambulingam et al., 2005; Huang and Li, 2009). Entrepreneurial culture involves promoting attitudes and behaviours in the company so that innovation can develop. The company develops and maintains those values and behaviours that promote innovation and creativity, while the company's structure allows employees to be highly independent (flat organizational structure). Employees' ideas and knowledge are often used, which is conducive to the development of empowerment. The company promotes learning among employees, who, thanks to a wide range of skills, can be more independent in making decisions, and thus management is based on cooperation among multi-functional and committed employees (Vázquez-Bustelo et al., 2007; Huang and Li, 2009). **Flexibility** (consisting of operational and financial flexibility) determines the ability of an organization to respond to changes in the environment by quickly adapting processes and reconfiguring the company's resources to changing needs (Sajdak, 2019b). Operational flexibility - involves a flexible production process (the possibility of quick conversion, changes in manufactured products), a flexible logistics process (supply chain, implementation, control), a flexible marketing process (marketing contracts, communication channels, promotional tools), and a flexible sales process (customer needs research, preparation of offers and finalization of transactions, service) (Chan et al., 2017; Yousuf *et al.*, 2019). Financial flexibility is revealed mainly by the use of targeted sources of financing (loans, guarantees, subsidies) and the use of financial leverage. The fourth and last attribute of strategic agility is **strategic leadership**. Under this concept, leaders can emerge from the group instead of being formally designated, while the essence of leadership is to introduce changes and ensure the company's adaptation to the environment (Crocitto, 2003; Crossan et al., 2008). As Ireland and Hitt (2005) emphasize, the concept of strategic leadership relates to a person's ability to anticipate, maintain flexibility and think strategically, as well as simultaneously work with others to initiate changes that will create a better future for the organization.

Figure 2. Strategic agility concept



Source: own elaboration

1.3. Perspective of previous SLRs on Industry 4.0 and agility

There is still a lack of papers combining Industry 4.0 and strategic agility based on SLR methodology. There are some examples of articles presenting relationships between these two concepts, however they perceive them in different ways, as academics offer various understandings of Industry 4.0 and agility.

For example, Mrugalska and Ahmed (2021) show that agility is one of the most important elements for an organization in adopting Industry 4.0 technologies. They reviewed the literature from the perspective of agility in Industry 4.0. The authors systematically reviewed 381 relevant articles from the years 2016 to 2019, and ultimately analysed 91 of them. They argue that agility helps companies to cope with the changes that arise along with the adoption of I4.0 technologies. In addition, they also show that technologies such as smart manufacturing, cyber-physical systems, big data and analytics, cloud computing and IoT provide companies with enhanced agility in both value and supply chains.

Tallon et al. (2019) used a different theoretical lens to investigate the relationship between IT and organizational agility, as well as how the literature has conceptualized agility, its antecedents and consequences. They took into consideration 169 publications and recognized that companies are unlikely to respond to change by buying new IT resources. Diegmann et al. (2018), meanwhile, analysed a sample of 775 papers. They shed light on the existing knowledge on agile information system development by applying a structured literature review and computer aided analysis consisting of distinct text mining techniques.

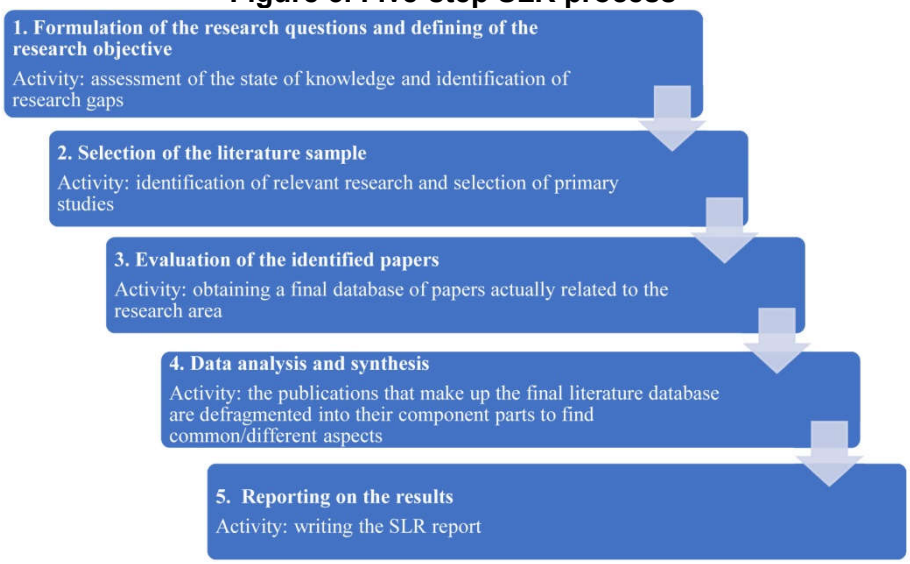
2. Methodology

Taking into consideration the aim of the paper, which relates to identifying and assessing the state of knowledge in the field of using and supporting Industry 4.0 technologies for the development of companies' strategic agility, we applied the Systematic Literature Review (SLR)

method. SLR has become the standard method for locating, selecting and evaluating research and transferring synthesized results (Czakon, 2011; Klimas et al., 2020). In a similar vein, Fish and Block (2018, p.103) indicate that a literature review "serves as the foundation for advancing knowledge, facilitates theory development. An SLR is a complex and comprehensive review identification, evaluation and synthesis of all literature on a given topic". As Okoli (2015) emphasises, an SLR should always be limited to scientific publications directly related to the area of inquiry and studies that provide answers to the research questions.

There are many more or less detailed SLR approaches in the literature, including those with 10 stages (Tranfield *et al*. 2003) and others with only 3 stages (Anello & Fleiss, 1995). Our research procedure for the systematic review followed a 5-stage approach (Booth et al., 2012; Klimas et al., 2020), including: formulation of the research questions and determination of the research objective, selection of the literature sample, evaluation of the identified papers, data analysis and synthesis, and reporting on the results. Exploratory research was carried out of existing review studies, which made it possible to perform an overview of the state of knowledge in the area of Industry 4.0 and strategic agility (Figure 3).

Figure 3. Five-step SLR process



Source: Own elaboration based on Booth et al. (2012) and Klimas et al. (2020)

The first activity provided the basis for formulating research questions and defining the aim of the study, as well as identifying research gaps. At the next stage, a sample of literature was selected. A set of 30 deliberately

selected scientific journals provided the source for the publications identified. In line with Peppard (2018) and Tallon et al. (2019), we selected a list of journals in two areas: strategic management and information systems organization[3].

At the stage of evaluation of the literature sample (the third stage), decisions were also made regarding the appropriate set of criteria, in particular inclusion and exclusion criteria, and the development of the initial database (Zumsteg et al., 2012). This stage involved a cursory review of the literature based on analysis of the content of the titles and abstracts, and an in-depth analysis of the content of the entire publications. Particularly important from the point of view of transparency and the replicability aspect is the definition and description of the criteria for acceptability of works for analysis (eligibility criteria) (Yuan & Hunt, 2009). These criteria can be divided up according to the review stage at which they are implemented. As Fish and Block (2018, p. 104) emphasize "this involves a description of the databases where the literature search was conducted, a definition of the search terms and keywords used to identify literature, and a careful description of the practical (e.g., language, availability) and methodological (e.g., time frame, article type) screening and exclusion criteria used". Based on the screening and the exclusion criteria, the final database relating to the research area was created. The result of this stage was the division of the initial database into three categories: the final database, studies partially of value - useful to some extent or inspiring, and studies entirely excluded from further analysis.

At the fourth stage, the data was analysed and synthesized. Publications comprising the final literature database were defragmented into their component parts so as to identify common aspects, as well as parts that were different, but also complementary. This enabled links

[3] These journals are: Strategic Management Journal, Long Range Planning, Strategic Entrepreneurship Journal, Journal of Management, Journal of Management Studies, Journal of Business Research, Organization Science, Management Decision, Academy of Management Journal, Academy of Management Review, International Journal of Technology Management, Journal of Business Ethics, International Journal of Operations & Production Management, Journal of Business Venturing, Organization Studies, Technovation, Industrial Marketing Management, Journal of International Business Studies, Journal of the Operational Research Society, Technological Forecasting and Social Change, Information Systems Management, Information Systems Research, Journal of Management Information Systems, Journal of Strategic Information Systems, European Journal of Information Systems, International Journal of Information Management, Information & Management, Information Technology & People, Journal of Information Technology, Information and Organization.

between them to be identified. It is suggested that the synthesis and analysis of source data should go beyond simple description, transforming the information so that it is new or different, and developing knowledge that is not evident from individual studies (Okoli, 2015). The fifth and last stage relates to the discussion of the results.

We adopted the first 3 stages of the procedure presented above (Table 1), which enabled further analysis.

Table 1. Replication of the first 3 stages of the SLR procedure

Stage I: Formulating research questions and defining the purpose of the research			
Main goal: identification and assessment of the state of knowledge in the field of using and supporting Industry 4.0 technologies for the development of strategic agility in companies	Research question: do industry 4.0 technologies support strategic agility, and if so, to what extent?		
Stage II: Selection of literature sample			
Databases: academic databases were selected and journals were indexed: EBSCO, Springer, ScienceDirect, Proquest, Emerald Insight and Taylor Francis			
Keywords: "Industry 4.0" *and/or "*Technologies *4.0" and "*Agility" *and/or* "Agile" identified in the same article			
Inclusion criteria: • search in: title or abstract or keywords • year of publication: 2018-2020 • type of publication: scientific articles (published in selected 30 scientific journals) • reviewed: peer review OR double peer review • Access: works available in full version • Language: English • Field: strategic management / information systems	Exclusion criteria: • type of publication: no conference papers, proceedings, book chapters, scientific announcements etc.		
A priori selection process:	**Researcher 1**	**Researcher 2**	**Researcher 3**
*results based on 10 journals assigned to each researcher	56	60	88
Initial database:	204		
Stage III: Initial evaluation of the sample			
A posteriori selection process:	**Researcher 1**	**Researcher 2**	**Researcher 3**
Papers marked as *selected*	17	28	11
Papers marked as *inspiring*	13	18	25
Papers marked as *useless* – off the topic	26	14	52
Final database: 56 papers			

Source: Own elaboration

3. Results and discussion

3.1. Overview of papers included

The articles included in the SLR were diverse in many respects, for example, from the point of view of the research methods adopted by the authors. The papers presenting the results of qualitative (22 out of 56) and quantitative research (25 out of 56) were definitely dominant, while relatively few articles were theoretical (9 out of 56).

Figure 4. Type of paper / research method

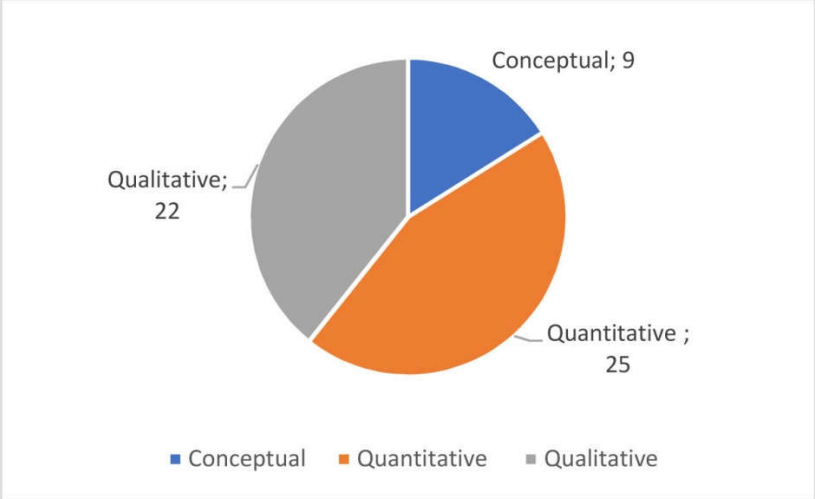


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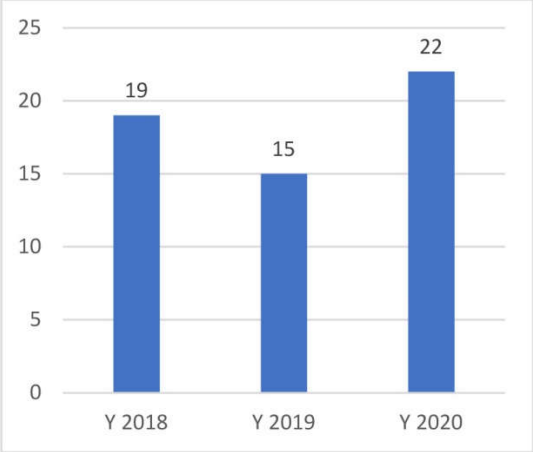
Figure 5. Year of publication

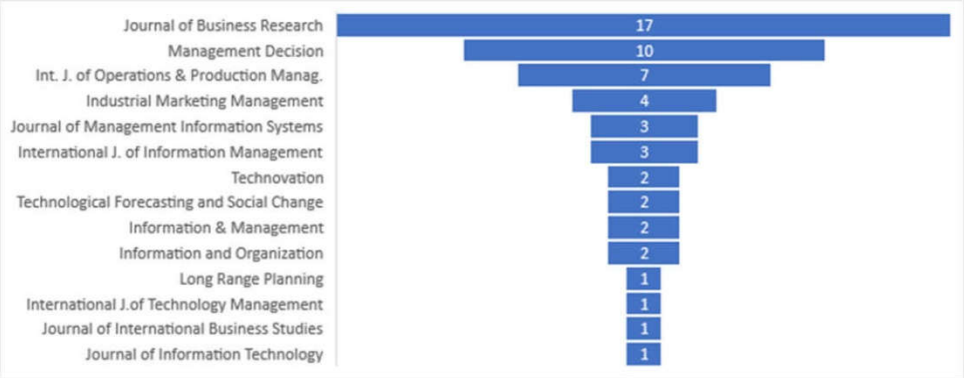


Source: own elaboration

The number of articles in the three years under consideration (Figure 4) remained fairly stable with a slight increase in 2020, which may be associated with an overall increase in interest in Industry 4.0. (according to Google Trends data). However, it should be noted that we were looking for a relationship in the papers between 4.0 technologies and agility, so by definition the number of works included, regardless of the year of publication, was limited.

As part of the adopted SLR procedure, we originally included 30 journals. In the course of the research, however, we identified articles of interest to us in 14 periodicals (Figure 6). It is worth noting, however, that over half of all the articles (34 out of 56) were published in the Journal of Business Research, Management Decision and the International Journal of Operations & Production Management.

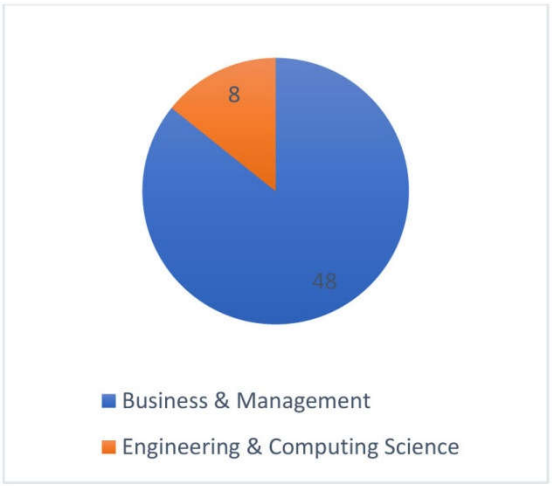
Figure 6. Literature distribution by journal



Source: own elaboration

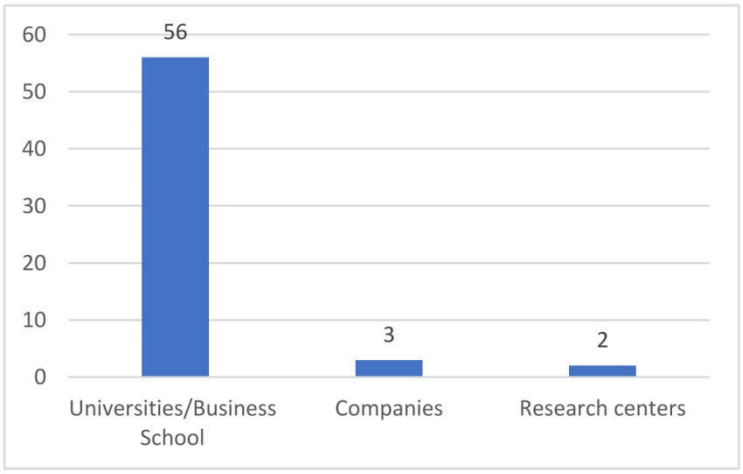
The vast majority of the papers ultimately analysed were in the *Business and Management* area (Figure 7.). This was the product of the final search results in bibliographic and abstract databases based on keywords, followed by qualitative analysis, and not the original list of 30 journals, which covered both areas relatively evenly.

Figure 7. Article main interest area



Source: own elaboration

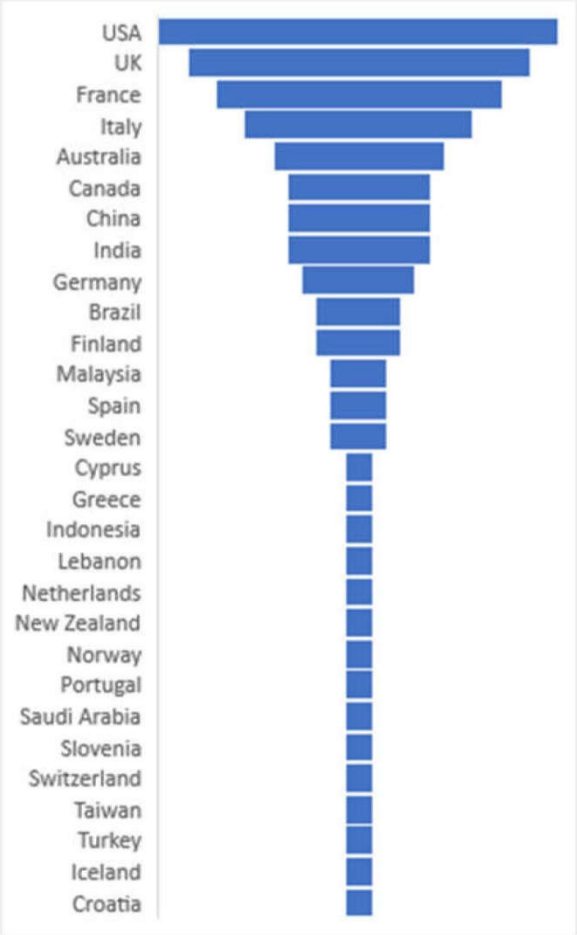
Figure 8. Authors by institution



Source: own elaboration

All the articles included were prepared by academics representing Universities and Business Schools, in 5 cases co-authored by representatives of companies and research centres (Figure 8). Articles co-authored by people from outside the academic community were usually of a slightly more 'practical' nature, although their number is insufficient for drawing further conclusions.

Figure 9. Authors by country of origin



Source: own elaboration

Figure 9. shows the origin of the authors, representing 29 countries in total. Many of the analysed articles were prepared in international teams, which emphasizes the importance of the issue of agility and its connection with the development of technology across a wide geographical scope.
The dominance of developed countries is visible, in particular EU countries, which are interested in the implementation of the Industry 4.0 concept. In these countries, significant public funds are allocated to supporting projects related to digital transformation. It is also worth adding that publications from Europe are dominated by the UK and original EU Member states. CEE countries (except for Croatia and Slovenia) are not represented.

3.2. The scope of using and supporting 4.0 technologies for the development of strategic agility

Objective and comprehensive assessment of technological support for the development of individual agility attributes is a complicated process due to the evolution of the catalogue of 4.0 technologies used across various sectors of the economy. The basis for the set of technologies taken into account in the SLR was the degree of maturity, i.e. the possibility of their wide implementation and adaptation by companies (see Fig. 1). This catalogue was extended to include advanced business intelligence solutions, advanced data analytics / Big Data, blockchain technology and IT systems / solutions, which resulted from the frequency these technologies and solutions were indicated in the analysed articles.

The SLR results show the strong support of technologies such as 1) IoT / M2M, 2) Cloud computing 3) Smart, mobile devices, mobile applications, 4) BI Solutions and 5) advanced data analytics / Big Data. However, the impact of these technologies is observed only in the case of selected agility attributes, in particular such dimensions as: ability to assess opportunities, ability to cooperate, ability to innovate and operational flexibility (see table 2).

In the case of the strategic sensitivity attribute, in particular the ability to identify and assess opportunities, strong support from advanced data analytics / Big Data and IoT / M2M can be noted. The literature suggests that thanks to the implementation of Big Data analytics, companies are able to sense emerging opportunities and threats and adjust their activities based on the trends observed in the competitive environment. As a result, the main competitive distinguishing feature of Big Data is the fact that it facilitates the making of more informed decisions, giving the possibility not only to identify opportunities, but also to evaluate them in the context of their use (Mikalef et al., 2019). Other authors found evidence that Big Data analytics help detect, predict and respond to industry disruptions. By analysing the relationship between levels of data analytics capabilities and strategic dynamic opportunities, they found that descriptive data analytics improves an organization's ability to understand the business context (sensing), and predictive data analytics helps deliver business opportunities (seizing). Their research contributes to the understanding of Big Data analytics as a dynamic organizational ability that supports strategic decision making in times of uncertainty (Rijmenam et al. 2019). Meanwhile, cloud computing can make it easier for firms to scale up and extend their services and IT architecture according to market changes. As Liu et. Al argue “cloud computing can help enterprises rapidly configure IT resources to respond to market dynamics, thus improving operational agility” (2018, p. 102). On the other hand, Leminen et al. (2020) argue that the Internet of Things creates

Table 2. Support of 4.0 technologies for strategic agility attributes based on SLR

Attributes of strategic agility / Industry 4.0 technologies		3D printing/3D scanning	IoT/M2M	Artificial intelligence	Cloud computing	Smart, mobile devices, smart, mobile apps	Industrial robotics, incl. collaborative robots	Advanced BI solutions	Advanced data analytics / Big Data	Blockchain technology	IT systems/ solutions
Strategic sensitivity	Ability to assess opportunities		21,29, 39, 41, 44	3, 28, 36	23,29, 44	11, 21, 46		50	1,2,4, 5, 6 7,9,11,17,19,20,21, 22, 23,24,25,26,27,29, 33,36, 37, 41, 44		18
	Risk propensity		41		23				5, 22, 37, 41		
Strategic entrepreneurship	Ability to cooperate		21,31, 41	3, 43	13, 31	11,13, 21, 47		30,31, 50, 52, 55	1, 5, 6, 7,11, 13, 19,21,25,30, 31, 41,	30,31	13, 18
	Ability to innovate	42	10, 38, 39, 41, 44	3, 38	10,23, 44	10, 11, 54	48	52	1, 5, 6, 7,11, 14, 15, 19,21,25,27, 44, 46		8,18
	Entrepreneurial culture		10, 41	3, 43	10,23	10, 11	16	50, 52, 55, 56	1, 5, 6, 7, 11, 19,21,25, 45		8, 12, 18
Flexibility	Operational flexibility	32	21, 29, 31, 35	3, 28, 34	23,29,31, 34, 35	11, 21, 35	16	31, 34, 35, 49	1, 5, 7,11,19,21,25, 31, 33, 34, 35, 37, 40, 45, 46	31, 51	
	Financial flexibility		21	3		21	53		1, 5, 7,11,19,21,25		
Strategic leadership	Strategic leadership			3	23			30	1, 5, 7,11,19,21,25, 30		

1 - Mariani and Fosso (2020); 2 - Mikalefa et al. (2019); 3 - Makarius et al. (2020); 4 - Yasmin at el. (2020); 5 - Van Rijmenam at al. (2019); 6 - Yunis et al. (2018); 7 - Shastri et al. (2018); 8 - Zhanga et al. (2018); 9 - Merendino et al. (2018);10 - Galindo-Martín et al. (2019); 11 - Côrte-Reala et al. (2019); 12 - Crittendena et al.; 13 - Cenamor et al.(2019); 14 - Ghasemaghaei and Calic (2019); 15 - Ghasemaghaei and Calic (2020); 16 - Ballestar et al.(2020); 17 - Yasmin et al. (2020); 18 - Mariani and Wamba (2020); 19 - Dubey et al. (2019); 20 - Fosso et al. (2019); 21 - Rajput and Singh (2018); 22 - Zeng and Khan (2019); 23 - Gupta et al. (2019); 24 - Fiorini et al.(2019); 25 - Ferraris et al. (2019); 26 - Caputo et al.(2019); 27 - Chierici et al.(2019); 28 - Assunta et al. (2020); 29 - Tortorella et al. (2019); 30 - Faruquee et al.(2021); 31 - Keller et al.(2021); 32 - Hohn and Durach (2021); 33 - Yu et al. (2019); 34 - Seyedghorban et al. (2020); 35 - Lorentz et al. (2021); 36 - Banalieva and Dhanaraj (2019); 37 - Kashav et al. (2020); 38 - Gebauer et al. (2020); 39 - Leminen et al. (2020); 40 - Gupta et al. (2020); 41 – Sestino et al. (2020); 42 - Candi and Beltagui (2019); 43 - Xiong et al. (2020); 44 - Frank et al. (2019); 45 - Roßmann et al. (2017); 46 - Zhao et al. (2020); 47 - Yan et al.(2018); 48 - McKnight et al. (2020); 49 - Rajput and Singh (2019); 50 - Pejic-Bach et al.(2020); 51 - Karamchandani et al.(2020); 52 - Zhou et al. (2018); 53 - Cram and Marabelli (2018); 54 - Tumbas et al.(2018); 55 - Zaitsev et al. (2020); 56 - Wagner et al.(2018).

the potential to transform traditional industry structures, leading to the convergence of industries, but also the emergence of new industry fields not only "between" industries, but also "beyond" these industries.

Summarizing the results concerning strategic sensitivity, it is worth emphasizing that while there is strong support from technologies in terms of the assessment of opportunities, in the case of strengthening the propensity to risk, this impact was much less often indicated in the case of all the technologies considered.

In the case of strategic entrepreneurship, a broad scope of the use of technology 4.0 can be noted in almost all of its dimensions. Cloud computing can play an important role when companies develop collaboration with business partners in the exploration and exploitation of innovation opportunities. The relationships between IT capability and agility have been supported by Ping et al. (2018), who confirmed that IT capability and business intelligence use have a positive impact on strategic agility. Unfortunately, the literature does not indicate how companies should manage their IT resources to deliver greater agility (Queiroz *et al.*, 2018).

Generating valuable information from data can be an important driver of innovation. Accessing and using Big Data from different sources helps companies to come up with new ideas and better understand the needs of consumers. To improve innovation competencies, companies can expand their existing skills, processes and knowledge in product innovation, or renew their knowledge and skills (Ghasemaghaei & Calic, 2019). Digital technologies are based on ICT systems that standardize information and allow organizations to rapidly code, store, formalize and distribute increasing amounts of knowledge, which is becoming ever more diverse. Digital platform capability may enhance the different aspects of network capability. Digital architecture has a significant influence on how internal units and external partners interact (Cenamor et al., 2019).

In turn, artificial intelligence is or can be applied to a wide range of organizational functions, such as assembly lines, interaction with customers, suppliers, employees and making strategic decisions. Successful use of the opportunities AI presents is possible with the full involvement of employees, as they interact with each other and integrate their behaviour with AI systems (Makarius et al., 2020).

It is worth adding that the spreading of IoT guarantees the proliferation of "intelligent spaces" - physical and digital environments where people and technology systems interact in a coordinated and networked manner. These elements relate to the spaces, processes, services and objects that make up engaging, interactive and automated activities (Sestino et al. 2020).

A significant relationship is also noticeable between the use of modern technologies and operational flexibility. As in the first two attributes, the key

technology is Big Data. When it comes to delivering business value, academics note that Big Data analytics help companies improve their business processes or customer experience and satisfaction. The concept of Big Data Analytics (BDA) arose from the need to effectively manage large volumes of data to improve business insight, in particular the operational process (Côrte-Real et al., 2019). In the same vein, Ballestar et al. (2020) argue that robotic devices are associated with better performance, higher productivity and employment rates, as well as a knowledge-driven value process.

IoT is also spreading and can help industries increase the accuracy and precision of their processes, minimize costs and see the benefits of real-time information that can help them make informed decisions. IoT offers the ability to monitor the actual performance and KPIs of an organization (Rajput and Singh, 2018).

In addition, organizations can reap the benefits of AI by building their own innovation ecosystem, or by joining an existing ecosystem of technology partners, vendors, customers and other stakeholders. Building an innovation system requires shifting to an organization that enables interdisciplinary collaboration, data-driven decision making, and an agile, experimental and flexible mentality (Makarius et al., 2020).

The results of our SLR show that the 4.0 technologies investigated support the strategic leadership attribute to a small extent. However, we found some importance in the relationship-building process. Faruquee et al. (2020) studied the effectiveness of management mechanisms in the era of digital transformation (in the context of supplier management). Their findings make it clear that digital connectivity at the company level is not a substitute for building strong interpersonal relationships. Technologies that support relational capital (such as Enterprise Resource Planning software) can be much more helpful than technologies that try to replace relational values (such as artificial intelligence, blockchain). Companies that strive to adopt new technologies should not consider advanced digital technologies as an alternative to trust.

If companies want to survive and operate in an era where speed is paramount, they need to adapt, and to implement the right combination of agility-oriented IT capabilities (Tallon *et al.*, 2019). Ravichandran (2018, p. 23) indicates that “IT enables firms to enhance the flexibility of firm resources”. Highly unpredictable events in the business environment require businesses to be agile, and IT is viewed as a way to respond faster in a changing environment. In previous research, it was found that IT capability strongly relates to agility (Lu & Ramamurthy, 2011).

Concluding remarks

The literature in the areas of strategic management and information systems in organizations indicates a growing interest of researchers in the connection between both issues. The use of Industry 4.0 technologies is not only for business support, but more and more often is of strategic importance for companies (Ghobakhloo, 2018; Młody & Weinert, 2020). The results of our SLR demonstrate that Industry 4.0 technologies support strategic agility. However, the extent of this impact varies. Our results show support from technologies such as 1) IoT / M2M, 2) Cloud computing, 3) Smart, mobile devices, mobile applications, 4) BI Solutions and 5) advanced data analytics / Big Data. A significant impact of these technologies was observed in the case of selected agility attributes, in particular: the ability to assess opportunities, the ability to cooperate, the ability to innovate and operational flexibility.

The volatility of the business environment forces companies even in stable industries to adopt strategic agility based on digital technologies. A static approach may result in a loss of competitive advantage. It is believed that if organizations are to survive and thrive in fast-paced era, they need new ways to create and implement the right combination of agility-oriented capabilities (Tallon et al., 2019).

Strategic agility in the Industry 4.0 era means that an organization can leverage its IT infrastructure, applications and data, as well as a range of assistive technologies, so as to redirect and develop new value propositions to gain a competitive advantage. It is also worth noting that much is still unknown, and, as Jesse remarks: “while there is no doubt about the need for keeping pace with the technical progress it is blurry how much this affects leadership and organizational agility” (Jesse, 2018, p. 486).

Limitations

With regard to the results of this study, several limitations should be noted. Firstly, we decided to use the list of journals suggested by Peppard (2018) and Tallon et al. (2019) as the most influential in the area of strategic management. Embedding strategic agility in the strategic management framework was the basic selection criterion. We are aware that with the use of bibliographic and abstract databases taking into account a wider list of journals and a wider range of languages, the number of identified articles could be greater, but our intention was to reduce the phenomenon of garbage in - garbage out (Klimas et al. 2020). Secondly, the search criteria within the accepted list of journals included subjectively selected phrases determining a priori selection. At the a posteriori selection stage, additional criteria constitute a significant limitation, the consequence of which could be incorrect cleaning of the initial database. However, in

order to minimize the risk, we used researcher triangulation. Finally, we are aware that boundaries between technologies are sometimes difficult to define as they are blurred, e.g. the differences between advanced data analytics solutions, and BI solutions and advanced IT systems. This results from two aspects – first, there are no complex and general definitions, second, the application possibilities are still developing, depending on industry characteristics.

Future research areas

In today's world, agility and new skills have been induced by Industry 4.0 in many organisations, not only in companies. Our SLR can be a starting point for determining the directions of further research that may be required in industries other than manufacturing (Götz, 2019; Hizam-Hanafiah et al., 2020; Walter, 2021). Our results show the connections and dependencies between 4.0 technologies and the attributes of strategic agility, however, the open question remains as to how technologies develop agility, to what extent and for which entities and industries. Future research should use a mixed research approach, including qualitative and quantitative methods. In particular, interviews with senior strategic managers on digital transformation could lead to a better understanding of the impact technology has on strategic agility. In the first place, research should focus on capital-intensive sectors open to the implementation of 4.0 technology, such as the automotive or electromechanical industries.

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