

Industry 4.0: Opportunity or threat to controlling?

Pavol Zahoran¹, Ondřej Žižlavský²

¹Ing. Pavol Zahoran, Brno University of Technology, Faculty of Business and Management.

Pavol.Zahoran@vutbr.cz, ORCID 0000-0003-0831-471X

² doc. Ing. Ondřej Žižlavský, Ph.D., Brno University of Technology, Faculty of Business and Management.

Ondrej.Zizlavsky@vut.cz, ORCID 0000-0001-8520-4747

Abstract: The gradual introduction of automation, robotization, digitalization, and other elements of Industry 4.0 into business processes also has implications for the work of controllers and the organization of controlling departments. The literature review divides the impacts into three main areas of concern. The first area is the issue of roles, competencies, and status of controllers in today's enterprises. It turns out that the impact of new technologies on the work of controllers is not unidirectional. The degree of integration and use of new technologies in an enterprise is largely influenced by the position of the controller or controlling unit within the enterprise. The strength of the controller's position positively correlated with the degree of use of new technologies for controlling purposes. The second area examined is the new requirements for competence and knowledge profiles of controllers. The issue is related to the Big Data phenomenon. Enterprises currently have a large volume of data at their disposal; the problem arises in the processing and analysis of this data and its use for controlling purposes. This fact results in a change in the requirements for the knowledge of controllers, and also for the organization of larger controlling departments. The third area examined is the technical context of the use of new technologies for controlling purposes. The literature review focuses on the technical limits of introducing new technologies into controlling processes. Secondary data collection was conducted through a literature review. The authors of the research also identified and formulated other areas in which follow-up research should be conducted.

Keywords: controlling, management accounting, automation, robotization, big data, management of change

JEL classification: G17, O14, M15, M41

INTRODUCTION

Since 2013, elements of Industry 4.0 have been gradually implemented and used in the corporate sphere. Companies under pressure to increase sales, reduce costs or, for example, streamline processes, are looking for ways to use new technologies in various areas of business management. Many successful applications of Industry 4.0 in business processes have already been described in the professional sphere. Now, experts and researchers dealing with individual areas of business management are particularly concerned with the outlook for further developments and trends that the rather dynamic developments in the field of new technologies bring. New technologies are an opportunity for businesses, but they can also be a threat. Globally, businesses operate in a relatively fast-changing environment and only those companies that can use new technologies to their advantage, and thus increase their performance, can be successful (Častorál, 2008).

Controlling is one of the areas of corporate management that is undergoing quite significant changes due to the introduction of new technologies. Although many articles have been written on the impact of new technologies on controlling, research in this area can still be considered insufficient (Cavélius, Enderich & Zicari, 2020). According to research by the German Ministry of Economics, only 5% of German companies use artificial intelligence in their processes (Losbichler & Lehner, 2020). Therefore, the use of new technologies in controlling can be considered negligible for the time being (Losbichler & Lehner,

2020). One reason is that it is a complex and complicated issue, with many companies not knowing exactly how to grasp the problem. Much of the problem is related to the fact that, to date, controlling has been done within ERP programs that use historically structured data (Songyue & Shangyang, 2019). However, nowadays, companies also have large volumes of unstructured data and are looking for ways to process, analyse and use these data in controlling processes (Cavélius, Eendenich & Zicari, 2020). The complexity of the issue lies in the fact that the company must be able to answer the following questions. In which area of controlling can we introduce the new technology? Do we have a software tool within the enterprise to process and analyze the data? If not, how much will the new software cost, and will it be compatible with the existing ERP system? Do we have staff within the controlling department with sufficient knowledge of data processing? Will we be able to measure the effectiveness of the new technology implementation? Is there adequate support on the management side to implement the new technology? The success of introducing new technologies into controlling processes is primarily related to the quality of controllers available to the company. In case a company decides to implement a new technology, it must have controllers with excellent knowledge of statistics and data management (Nielsen, 2022). Therefore, the role of the controller is expected to shift towards the data scientist in the future (Oesterreich & Teuteberg, 2019). This places entirely new demands towards the knowledge and skills of controllers. The enterprise must also rethink the competencies and position of controllers within the company or controlling departments. In this sense, the specialization of data processing and analysis activities can be observed, which forces enterprises to rethink the organization of at least the controlling units. In addition to the quality of the personnel background, the success of introducing new technology into the controlling process will also be influenced by the size of the company, the current level of digitalization of the company and, last but not least, the position of the controlling unit within the company. The above shows that new technologies can be both a great opportunity for companies, but also a threat if the implementation of new technology is unsuccessful.

The literature review is part of a more extensive doctoral research that focuses on the impact of new technologies on the management discipline of controlling. The literature review aims to analyse the impact of the influence of new technologies on the work of controllers and the organisation of controlling departments, and to formulate further areas of follow-up research.

1. METHODOLOGY

The methodology chosen for the research consists of the following three parts:

- 1. Planning a research**
- 2. Conducting research** (data collection and analysis)
- 3. Data synthesis**

Planning a research

As part of the research planning, a keyword string was compiled and used to search scientific databases. The keywords were chosen so that the articles found best reflect the interaction between new technologies and controlling. As the aim with new technologies was not to focus on the impact of a specific type of technology, the authors chose a relatively broad range of Industry 4.0 elements that often appear in academic articles. The final string, including Boolean operators, had the following form:

"Controlling" OR "Management Accounting" OR "Management Control" AND "Big Data" OR "Internet of Things" OR "Artificial Intelligence" OR "Digital Twin"

Web of Science and Scopus databases were selected as the search source. The reasons for selecting these databases were mainly the advanced search systems of these databases, the high number of indexed publications and the proven relevance of the included articles. After an initial search for documents based on the above keywords, the results were further reduced as follows:

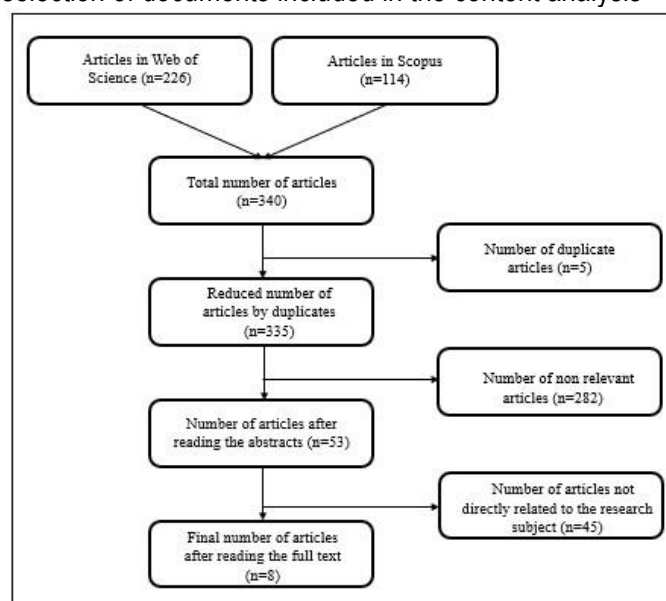
- a. Only articles in scientific journals were considered
- b. Only articles that contained the keywords mentioned in the title of the article, in the abstract or in the author's keywords were considered
- c. The search period was chosen as 2019-2022; Rationale: given that we see a relatively dynamic development of the Industry 4.0 concept, older articles would have limited predictive power about the impact of new technologies on controlling
- d. Only articles in the sections "Business Finance" were taken into account; Rationale: the issue of Industry 4.0 is also addressed by a number of technical, especially ICT disciplines. As the aim of this research is the direct impact of new technologies on corporate financial management, only the finance sections were chosen.

After adjusting the search parameters, 226 articles were found in the Web of Science database and 114 articles in the Scopus database.

Conducting research (data collection and analysis)

Based on the final search, a content analysis was subsequently prepared. The content analysis was based only on relevant articles. This required adjusting the number of articles originally found as follows. Out of the 226 articles originally found in the Web of Science database and the 114 articles found in the Scopus database, five duplicate articles in both databases were excluded. Subsequently, the abstracts of the remaining articles were read and a further 282 articles were discarded because the content of the articles was not directly related to the topic under investigation, and thus the articles were not relevant to this research. The remaining 53 articles were read, with a total of 8 articles included in the final content analysis. The main reason for the exclusion of 45 articles was the difference in the investigated areas of the impact of new technologies on controlling. The aim of the literature review was to analyse the use of new technologies in controlling processes, especially their impact on the change of the nature of controllers' work and the organisational structure of controlling units. The excluded articles either did not deal directly with these aspects, or the research dealt with these influences only partially. The overwhelming majority of the group of 45 excluded articles dealt with research oriented more towards the technical aspect; controlling had a rather minor role in these researches. Although the remaining articles analysed the impact of new technologies on controlling, the research focused on the impact of new technology in a specific area of controlling rather than analysing the conceptual change in the nature of controllers' work or the impact of the introduction of new technologies on changes in the organisation of the work of controlling departments.

Fig. 1: Diagram of the selection of documents included in the content analysis



Source: the author's own processing

Data synthesis

This part of the research is itself an added value of the literature review. Based on the synthesis of the data, the authors identified research gaps that will be the focus of subsequent research. The review also enables the formulation of research questions and hypotheses that will be tested in the aforementioned subsequent research.

2. RESULTS OF THE CONTENT ANALYSIS

The themes of the selected articles can be divided into three areas according to the way they view the impact of new technologies on controlling. The first area is the role and position of controllers within firms, which is changing due to the introduction of new technologies in firms. The second area is the completely new knowledge and skill level requirements of controllers, especially regarding ICT knowledge and working with big data. The third area is the technical context of the use of Industry 4.0 elements within controlling. The content analysis included articles that examine the impact of Big Data on controlling and the use of artificial intelligence in Big Data processing, or the use of artificial intelligence in other areas of controlling. Therefore, the content analysis does not include the originally searched terms "Digital Twin" and "Internet of Things." While there were articles that addressed these concepts in the original search of 340 articles, they were excluded as part of the reduction process for the reasons described in Chapter 1 Methodology.

Tab. 1: Number of articles according to the researched technology

Technology	Total number of found articles	Number of articles included in literature review
Artificial Intelligence	127	4
Big Data	106	4
Digital Twin	34	0
Internet of Things	73	0

Source: the author's own processing

2.1 The roles, competences and position of controllers in today's companies

The roles, competencies, and positions of controlling employees have changed significantly since the first mention of controlling. At the beginning of the twentieth century, the controller had exclusively supporting functions, with its calculations and calculations primarily serving as a basis for managerial decision-making (Kutáč & Janovská, 2012). One hundred years later, we can already see a completely different position of controllers within companies. Over time, controlling has become much more important, and with it, the importance and position of controllers have also increased. However, it is essential to mention that the position of controllers within Anglo-American companies is quite different from the position of controllers in Europe, especially in the countries of the DACH region (Germany, Austria, Switzerland). As Oesterreich & Teuteberg (2019) state, the most significant difference is that the scope of the controller is broader than the tasks of a management accountant, which is the term used in the Anglo-American area. While the management accountant is usually part of the accounting department and his tasks do not go beyond the accounting area, the controller is in many cases a separate position or even a department within the company. Also, his position tends to be much more powerful and is closer to the management and decision-making of the company. As both functions are in principle the same, only the term controller will be used in the following.

One of the most important factors influencing the change in the position of controllers in today's enterprises is the phenomenon of Big Data. Big Data is defined by Oesterreich & Teuteberg (2019) as large and complex datasets from different sources that require special techniques to store, manage, analyze and visualize them. This is a relatively time-consuming task, with a large part of the time taken by sorting the data so that the controller has the correct data ready for analysis. In this context, Cavélius,

Endenich & Zicari (2020) point out that controllers spend much time collecting and sorting data, leaving little time to prepare the basis for important top management decisions. Andreassen (2020) takes a different view, and while he agrees that today's controllers are overwhelmed by large volumes of often disparate data, fortunately, they can use artificial intelligence to process this data efficiently. There are already a number of AI-based tools that can be used to manage data and spend more time on decision-making processes within the enterprise. Andreassen (2020) uses terms such as "bean counters" and "business partners" in this context. He uses the term "bean counters" to refer to controllers who have a weaker position in enterprises and whose main task is to collect and sort data or prepare calculations for managerial decision-making. "Business partners," on the other hand, are controllers who have a strong position in companies, often being part of the management. These controllers usually participate directly in key management decisions.

Cavélius, Endenich & Zicari (2020) divide businesses into three types according to the degree of digitization and big data work. The first type is the traditional enterprise, where no digitization process is yet underway. These firms either have no awareness of Big Data tools or are ignoring them for the time being, and it is not their priority to deal with it at this point. The second group are companies that are already digitizing. They are aware of the importance of Big Data for business management and are looking for ways and tools to leverage Big Data. However, they have not yet reached the point of generating added value from Big Data. The third group are fully digitized companies that are already exploiting the potential of Big Data and are able to generate added value from it. In this context, Cavélius, Endenich & Zicari (2020) mention that the status and authority of controllers vary significantly across groups of firms. In traditional enterprises without digitalisation, the controller usually has a weak position and spends time on routine tasks. Typically, the controller's role in these enterprises is limited to providing data and numbers to management. The opposite is the position of controllers in digitised companies. Here the controller has a strong position and is part of the strategic decision-making of management.

Another consequence of the impact of Big Data on the position of controller that can be observed is the growing competition between professions (departments) within companies. Andreassen (2020), in his case study based on data from a large Norwegian insurance company, describes the competition between controlling, CRM and product management departments. All of these departments independently use artificial intelligence to process Big Data. Before the use of Big Data occurred, controlling was also tasked with tracking customer turnover and forecasting sales. After the introduction of Big Data analysis by the CRM department, this function is no longer claimed by this department on the grounds that their tool is better and more accurate. Similar arguments are raised by the product management department, which claims product pricing, which, until recently, has also been commonly on the controlling department's agenda. It can therefore be assumed that, particularly in large companies, tensions between the various departments will grow over time and that companies will have to respond to this trend with organisational changes.

The third implication that Andreassen (2020) highlights in his case study is the specialisation of controller functions. Particularly in large firms, this is a context where Big Data is handled by several controllers, each responsible for only their part of the data. This implication is also confirmed by Oesterreich & Teuteberg (2019), who reach similar conclusions in their research. In general, it can be assumed that large companies will experience a greater degree of specialisation in the job descriptions of controllers, which has already been confirmed by previous research by Becker & Ulrich (2009).

2.2 Controller knowledge and skill requirements

Today, businesses are exposed to a vast amount of data in the global environment, with the volume of data in the global environment expected to increase more than 50 times in the coming years (Rybicka, 2019). This fact places entirely new demands on the knowledge and skills of controllers, especially in enterprises that have already implemented Big Data. Currently, we can observe the dilemma that enterprises are facing. Enterprises will face two options when analyzing data. Either they will want controllers with advanced knowledge of data science and statistics (Pérez & Blasco, 2020), or they will

have to outsource data analysis. At the moment, it is not possible to state clearly which way will prevail in the future; most likely it will be a coexistence of both approaches.

In order to process the vast amounts of data and use it to create value, firms will need highly skilled employees (Oesterreich & Teuteberg, 2019). Oesterreich & Teuteberg (2019) use the term "industrial data scientist" in this context, which should be the person responsible for the preparation, analysis and application of data. Businesses will need to determine where to incorporate this position within their organizational structures. If this position were to be part of the controlling units, this would mean a significant increase in requirements towards controllers, especially in the areas of ICT, data analysis management, and, last but not least, statistics. This view is also held by Nielsen (2022), who mentions that controlling staff should embrace new technologies such as Big Data, machine learning, and artificial intelligence as an opportunity rather than shying away from these tools. Nielsen's (2022) main conclusion is that controllers will need to embrace data integration, data science and collaborate with AI experts as future developments will have transformational impacts on business and operational models of enterprises. Nielsen (2022) also points out that working with big data should already be part of the concept of teaching controllers in universities.

Interesting research was conducted by Oesterreich & Teuteberg (2019), who examined the profiles of controllers on the work social network XING. XING, like LinkedIn, is a social network that is mainly used by employees and businesses in the DACH region. Both employees and companies can create their profiles and share information or multimedia content there. The aim is the self-presentation of employees and companies. Nowadays, these social networks are frequently used by the HR staff of companies when looking for new employees. Therefore, it is essential that the employee has a properly created profile and provides complete information regarding the field in which he or she would like to work. Oesterreich & Teuteberg (2019) examined the profiles of 2,331 controlling professionals. The main objective was to determine whether the knowledge and skills reported by the employees matched the current and future requirements of the job of a controller. According to the authors of the research, a comprehensive knowledge of ICT and business analytics is expected to be included in the knowledge and skills profile of controllers in the near future. More specifically, the controller will need to have knowledge of statistical methods and the ability to acquire, analyse, link, and integrate data and find connections between them (Oesterreich & Teuteberg, 2019).

The research shows in the field of data analysis, the most common knowledge mentioned by employees is "business intelligence". In principle, this term can be considered synonymous with the term 'business analytics'. Currently, due to new technologies, the aforementioned term 'Big Data Analytics' is used. As far as ICT knowledge and skills are concerned, controllers using the XING network most often reported knowledge of working with ERP systems such as SAP, Oracle, and Microsoft Dynamics, as well as knowledge of CRM applications and MS Office tools. Oesterreich & Teuteberg (2019) also found differences between male and female member profiles. A total of 69.1% of males reported knowledge in data analytics, while 30.9% of females reported such knowledge. In terms of ICT knowledge, although the numbers were more balanced, a similar trend to data analysis knowledge can be observed.

Oesterreich & Teuteberg (2019) also examined the effect of educational attainment on the level of declared knowledge. In this context, it was confirmed that the level of education is positively correlated with the level of data analysis and ICT knowledge.

On the contrary, the authors of the research came to surprising results when they linked the size of companies and the declared knowledge. Especially in the area of data analysis, employees of DAX30 companies declared the lowest level of knowledge, followed by profiles of companies in the TOP100, followed by profiles of companies in the MDAX (Oesterreich & Teuteberg, 2019). One explanation for this may be the results of previous research, which reported an increased specialization of controller tasks depending on the size of the company (Becker & Ulrich, 2009). The conclusions of this research are that large companies hire data specialists, that is, they prefer outsourcing in this area over upskilling their controllers.

Based on the above, it can be expected that in the future, knowledge in the field of data analysis and ICT tools for controllers will be a "MUST HAVE," and it is necessary that both companies and education systems respond to this trend.

2.3 Technical context of introduction and use of new technologies in controlling

Businesses are currently working with massive amounts of data that can be used for further analysis and thus generate high added value. Nielsen (2022), citing research by International Data Corporation, states that investing in data management is more critical than ever. Companies that have already implemented Big Data report 22% higher profitability, 21% higher revenue and 21% higher efficiency in processes (Nielsen, 2022). Until recently, businesses made do with ERP systems, the evolution of which was and still is also very dynamic. Today's ERP systems significantly ease the work of controllers, especially in the areas of routine, repetitive tasks, allowing controllers to spend more time preparing for strategic decision-making (Andreassen, 2020). The problem with ERPs, however, is that they work with historically structured data, which controllers then use for analysis (Oesterreich & Teuteberg, 2019). Cavélius, Eendenich & Zicari (2020) have a similar view, adding that there is a noticeable trend nowadays where companies focus on unstructured data from internal and external sources and try to "extract" value for the company. The same view is shared by Oesterreich & Teuteberg (2019), who state that it is insufficient to rely on historical data alone for decision making; rather, there is a need to use forward-looking big data analytics to identify and understand market trends, customer behaviour, and predict future customer behaviour. Dynamic developments in data processing, thanks to machine learning and artificial intelligence, can serve this purpose.

In this context, however, Losbichler & Lehner (2020) point out the limitations associated with the introduction of AI in data processing in controlling. First, referring to a study by the Federal Ministry of Economics, they point to the fact that currently only 5% of German companies use AI in one of their divisions, which means that the use of AI in controlling is currently negligible. Furthermore, there are three significant limits to introducing artificial intelligence in controlling, namely the Bremermann limit, the problems of partial controllability of complex systems, and the natural variation in the complementarity of human and machine information processing (Losbichler & Lehner, 2020).

Bremermann's limit states that there is an insurmountable limit to human knowledge that cannot be removed even with the greatest technological advances (Losbichler & Lehner, 2020). For this reason, even the most powerful computer setups today may not have sufficient computational power for completely accurate analyses and predictions.

The partial controllability of complex systems is related to the problem that complex economic systems are, in simple terms, composed of a large number of elements and relationships between them. However, some of the elements are not visible, which prevents the system from being fully controllable and predictable. Losbichler & Lehner (2020) cite the Coronavirus as an example. Such unknown and unforeseeable elements cannot be taken into account in decision-making. From the above, the ideal of perfect predictions seems to be an unattainable goal. However, this does not mean that controlling should abandon efforts to introduce artificial intelligence in data analysis. Machine learning can still help us automate routine tasks, and secondly, it can significantly help us refine predictions.

The third factor to be aware of when implementing AI is that there is complementarity between human and machine information processing. In their study, Losbichler & Lehner (2020) list the positives and negatives of both methods and remind us that there is a balance to be found within each business as to which tasks and jobs will be processed automatically and which will be analysed by controllers. The issue is related to controlling departments deciding which tasks will be automated and which will continue to be performed by human resources. Basically, it is about identifying what is programmable and non-programmable within the controlling process (Korhonen et al., 2020). Korhonen et al. (2020) developed an interesting case study that analysed an attempt by a large Finnish engineering company to automate a certain part of the controlling process. Specifically, this was the pricing process, which was very complex due to the sophistication and customisation of machines for individual customers in the company under study. The company's controllers proceeded by dividing the tasks of the controlling process into routine

and non-routine tasks. The non-routine tasks included, in particular, the expertise of experts who assessed the customisation of machines to the special wishes of customers. Machine customisation requires highly specific expertise in both product engineering and costing. Consequently, an attempt was made to automate this part of the non-routine tasks as well, which turned out to be a mistake. The resulting costing system became even more complex, took longer and was found to have quite significant deviations compared to the original costing system.

Korhonen et al. (2020) conclude the case study by stating that automation in controlling is the right trend, only mentioning the risk of overestimating the automation of some tasks within the controlling process.

DISCUSSION

Current companies can be divided into three categories according to the degree of use of new technologies in controlling. The first group are enterprises that do not use new technologies yet; the second group is aware of the necessity of using new technologies, but for various reasons has not yet proceeded to do so. The third category is the enterprises that are furthest along in digitalization and already use new technologies in their processes and in controlling. There are a number of reasons why companies in the second group hesitate to introduce new technologies into their controlling processes. Implementing such a solution is a complicated matter and requires management support. Furthermore, companies must have employees with adequate data processing skills who will be able to integrate the new technology into existing business processes. This places entirely new demands on the knowledge and skills of current controllers. The controller in these enterprises is no longer a mere data collector; knowledge of statistics and data science is required. Particularly in large enterprises, there is also a specialisation of roles within controlling departments. In particular, companies are now analysing which areas of controlling are programmable and which cannot be programmed. The literature review shows that it is still problematic to program processes where subjective human cognition and human judgement play a large role. The analysis also shows that if a company overestimates the possibilities of automation, this can have negative consequences for the company. This matter is related to the fact that the use of artificial intelligence within controlling has its technical limits, in particular the Bremermann limit, as well as the limited controllability of complex systems and the fact that a balance must be found between the human factor and automation. Last but not least, the introduction of new technology must deliver business value that is ideally measurable.

Currently, the use of new technologies in controlling is still negligible. Especially in the area of Big Data processing, although many companies are aware of the positive benefits in the form of increased efficiency in processes or higher profitability, there are still significant barriers to the greater use of new technologies for controlling purposes within corporate practice. While the articles analysed identify the individual causes, there is a lack of comprehensive research that focuses on the barriers to the integration of new technologies in controlling processes. Another problem may be the fact that, for example, the use of Big Data in corporate practice is a rather complicated and complex issue that has overlaps with multiple departments within a company. The integration of Big Data can vary substantially depending on the type of enterprise (manufacturing, sales), the size of the enterprise, the subject of activity, and, last but not least, the volume of unstructured data and the way the enterprise intends to use it. For this reason, enterprises are very cautious about introducing new technologies. In this respect, the authors lack research that aims to analyse the integration of Big Data into the business process in the industry under study. The output of such research could be a methodology or a decision-making model that would serve as a guide for the introduction of Big Data into corporate practice.

Another obstacle for enterprises may be the measurability of the benefits of investing in new technologies. The introduction of Big Data can be a relatively costly investment, starting with the time invested, training of employees, or, for example, the acquisition of data processing software and its integration into an enterprise's existing information system. It can be quite problematic for a company to evaluate the effectiveness of the investment in the initial phase. Although the analysed articles describe examples of integration of Big Data into the enterprise practice, the evaluation of the investment is always missing. The authors see as a potential problem the fact that in the case of such investments, it is quite challenging

to set up metrics that would have the right predictive power regarding the effectiveness of the investment. However, there is certainly room for research in this area that would focus on the evaluation of investments in new technologies in controlling.

CONCLUSION AND FUTURE RESEARCH

The aim of the literature search was to analyse the impact of new technologies on the work of controllers and the organisation of controlling departments, as well as to formulate areas for further research. The research showed a relatively large impact of new technologies on the nature of controllers' work, especially in the form of increasing demands on controllers' knowledge and skills. It is evident from the research that companies that have introduced or are planning to introduce Big Data, for example, need controllers who are very knowledgeable in working with data and integrating this data with the company's ERP systems in order for the innovation to be successful. The research further shows that new technologies clearly facilitate the work of controllers in areas that are easy to program. This leaves controllers with more time for detailed analyses and reports that serve as a basis for managerial decision-making. As far as the impact of new technologies on the organisation of controlling departments is concerned, the impact can also be observed here, especially in the form of specialisation of controllers' work. However, this effect appears to be much smaller compared to the change in the nature of the controllers' work. The authors of the literature review consider the objective to have been met.

The authors consider the biggest limitation of the literature review to be the relatively small research sample, which is due to the fact that relatively little research has been done in the field. The authors still consider research in this area to be insufficient. Another reason is the fact that the use of artificial intelligence for controlling purposes in corporate practice is still very small, even negligible. The above facts open up room for future research in this area.

The authors of the literature search have identified the scope for research in the following areas:

1. In the analyzed literature, there is no deeper analysis of why new technologies are not more widely used in controlling.
2. In relation to point 1, there is no methodology or decision-making model for introducing artificial intelligence into the company's controlling process.
3. In companies that use AI, there is a lack of evaluation of the effectiveness of the investment.

The authors plan to follow up on these points. The first step will be a comprehensive content and bibliometric analysis. The aim should be to confirm/refute/complement the above areas of research. This should be followed by a preliminary study in which the authors would like to confirm the validity of their research direction. The pre-research should be conducted in cooperation with the Controller Institute and should focus on Czech companies operating in the manufacturing industry. As far as the research methods are concerned, it is planned to use a questionnaire method and a focus group. The aim of the pre-survey is to verify the correctness of the research direction and to test the questionnaire for the focus group. Based on the pre-survey, the research area should be defined, and the research questions formulated afterward. Regarding the timeframe, the comprehensive research should be completed in autumn 2022. The pre-research is planned for the period autumn 2022 - spring 2023. The last phase of the research should be the focus group research in the selected sector.

The theoretical contribution of the research should consist of a comprehensive analysis of the use of Industry 4.0 elements in large and medium-sized enterprises of the selected sector for the needs of controlling. Another theoretical contribution may be a change in the paradigm of controlling corresponding to the new needs and conditions of the business environment. In practical terms, it should be a confrontation of theoretical possibilities of using new technologies for controlling purposes with the real business situation in the Czech Republic.

The optimal result of the research, which would also be a practical benefit, would be the possibility of establishing a generally valid conclusion for the industry sector, or specific recommendations for individual

companies, for example in the form of a methodology for introducing artificial intelligence into the controlling process.

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