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BARRIERS OF NEW TECHNOLOGY INTRODUCTION AND DISADVANTAGES OF INDUSTRY 4.0 FOR INDUSTRIAL ENTERPRISES

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Abstract

The rise of new technologies known as the fourth industrial revolution (Industry 4.0), brings a transformation that makes it possible to produce and manufacture products on machines through robots in modern smart factories. Industry 4.0 will increase productivity, quality of goods, foster industrial growth, and modify the profile of the workforce and required competences. However, such benefits and advantages should be assessed in light of potential barriers and negative consequences.

The paper deals with the barriers of new technology introduction and main disadvantages of Industry 4.0. Based on questionnaire research in 217 industrial enterprises, the differences between enterprises according to their size and technological intensity are analysed. The main barriers of technology introduction and Industry 4.0 disadvantages are lack of funds, high costs, production process optimization and high investment need. The research confirmed only small differences in managers' preferences of Industry 4.0 technology barriers and Industry 4.0 disadvantages according to the enterprise size. The technological intensity was important only partly in case of perception of Industry 4.0 disadvantages. The key contributions of this work are promising results for a better understanding of technology barriers and Industry 4.0 disadvantages.

Key words: Industry 4.0, technology barriers, disadvantages, technological intensity

1. INTRODUCTION

The breakthrough in the organization of production has always come with the Industrial Revolution. Until then, the development was characterized only by minor changes, but also by revolutions, which had a predominant impact on political events, less on economic growth. The turning point is the invention of a steam

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engine that has overcome the limitations of physical strength (animal and human) and has produced a huge amount of useful energy. Later, such a revolution continued with the introduction of electricity and computers.

Now we are according to Schwab (2017) at the beginning of the fourth industrial revolution, which fundamentally changes and created a new modern lifestyle. The Fourth Industrial Revolution, commonly called Industry 4.0, is a total transformation through digital integration and intelligent engineering (Muhuri et al., 2019). Industry 4.0 in the next 20 years will completely change the organization of production. There will be a high degree of automation, a digital interconnection of all levels of production and value creation: more and more innovation will be required from product development to logistics. New technologies respond to new demands on both the management and all employees.

Industry 4.0 is an official project by the German government (Meyer, 2019) that seeks to create intelligent (smart) factories by linking automated manufacturing systems to the Industrial Internet of Things using advanced technologies. The Industry 4.0 concept is perceived as a competitive strategy for the future, but with a strong focus on value chain optimization due to autonomous control and dynamic production (Turkes et al., 2019) and product lifecycle management (Kagermann et al., 2013). Industry 4.0 brings a new level to manufacturing and operational management with emerging new technologies as 3D prints, virtual and augmented reality, autonomous vehicles, the Internet of Things, cloud computing, mobile terminals, learning software etc. (Vrchota & Pech, 2019). The smart factory is an important element of Industry 4.0, which addresses vertical integration and cyber-physical systems for intelligent manufacturing to implement flexible and agile production (Wang et al., 2016).

Ślusarczyk (2018) states that most entrepreneurs recognize the Industry 4.0 concept as a great opportunity to develop and improve their competitiveness, although the state of preparation for its implementation varies considerably depending on the country, sector and even different enterprises. Nevertheless, not all technologies are becoming the driving force of market success. Schneider (2018) defines six important challenges of Industry 4.0: 1. Strategy and analysis, 2. Planning and implementation, 3. Cooperation and networks, 4. Business models, 5. Human resources and 6. Change and leadership. Many of these challenges can be viewed as barriers for new Industry 4.0 introduction and implementation.

There is a body of research that has focused extensively on the barriers of Industry 4.0. Obiso et al. (2019) classified these obstacles into three groups: economic and regulatory, social, and technological barriers. Special attention is paid in the literature to the barriers to the implementation of Industry 4.0 in small and medium-sized enterprises (Horváth & Szabó, 2019; Turkes et al., 2019).

2. THEORETICAL BACKGROUND

The authors present a brief overview of barriers and disadvantages and divided them into: barriers of new technology introduction and the general disadvantages of Industry 4.0.

The first group consists of barriers to the

introduction of new technology. Before acquiring new technologies, it is first necessary to decide, whether the production process is sufficiently optimized, i.e. that the technologies are still suitable. Especially for small and medium-sized enterprises it can be a problem to find appropriate technologies due to their unavailability on the market (Pech & Vrchota, 2020). Related to this issue are the difficulties in finding solid partners due to the introduction of new technologies. If technologies are available, the problem for enterprises can be a lack of funds (Peillon & Dubruc, 2019), high acquisition costs, depreciation or implementation costs. Some enterprises may use subsidies or government incentives to acquire new technology, but this may have too complex and confusing conditions set. New digital processes and technologies may not be required by the customer. The customer-orientated digital transformation process is described by Von Leipzig et al. (2017). An equally important factor is the organizational complexity associated with the introduction of new technologies related to the lack of planning skills and management activities (Basl, 2017).

Further, the disadvantages of Industry 4.0 come out the high investment in new technologies introduction. A high amount of capital is needed in order to implement the Industry 4.0 initiatives (Vrchota & Pech, 2019) and these intended capital investments would have to increase over time. At the same time, these high investments may bring a lack of clarity regarding economic benefit. Brynjolfsson (1993) described "productivity paradox", disillusionment and frustration with information technologies. These problems may be supported by insufficient technology compatibility, lack of standards, and forms of certification (Oesterreich & Teuteberg, 2016). As a consequence, new security regulations are required (Li et al., 2016). A considerable disadvantage associated with Industry 4.0 is the risk of personal data theft arising from legal and contractual uncertainty (Lee & Lee, 2015). The security of information systems (cybersecurity) and physical devices is critical (Li et al., 2016). For this reason, the applicability of international regulations and standards is important in internal directives of industrial enterprises (Weber & Studer, 2016) to eliminate the risk of production interruption and cyber-physical systems fragility (Kovacs, 2018). When introducing changes, resistance may arise. This issue is related to inefficient change management, the need to implement radical changes in the organization, management and organizational culture. Some employees do not feel the need to change processes urgently (Glass et al., 2018). On the other hand, management may afraid of a loss of autonomy and control. All these obstacles and disadvantages originate from the low level of human resource management, leadership and management practice. With the arrival of new technologies, the demands and requirements for the qualification of workers, especially their digital skills, are increasing. Benešová & Tupa (2017) identified new job roles and education requirements. New technologies and ongoing digitization will mean a change in employee competence requirements (Erol et al., 2016). Potential risks for employees can lie both in a non-physical, but cognitive overload (Rauch et al., 2020). Many current employees are at risk of losing their jobs. An overview of other existing barriers and disadvantages described by Horváth & Szabó (2019). The research examines, which of these disadvantages are the most

important and whether they differ in different types of enterprises.

3. EXPERIMENTAL (RESEARCH)

The aim of the paper is to find out the barriers of new technology introduction and main disadvantages of Industry 4.0 for industrial enterprises. The partial aim is to analyse whether there are differences between enterprises in terms of their size, and technological intensity.

A questionnaire survey focused on Industry 4.0 took place in the period 2019-2020 in the Czech Republic. Enterprises managers were asked about the barriers of new technology introduction and disadvantages of Industry 4.0. A total of 217 completed questionnaires were obtained. Respondents in the questionnaires rated the questions on a scale from 1 (least significant) to 5 (most significant). The enterprises that participated in the survey can be characterized by size into small enterprises up to 49 workers (n = 86), medium-sized enterprises with 50-249 workers (n = 64) and large enterprises over 250 workers (n = 67). Enterprises were not analysed according to classification by industry or sector dominance, as the results did not provide significant differences. The paper analyses the industrial and sectoral focus of enterprises according to technological intensity (prevailing industry focus of production) based on the OECD methodology (Czech Statistical Office, 2020), which divides them into enterprises with high technological intensity (HTI) (n = 125), enterprises with low technological intensity (LTI) (n = 92).

The following working hypotheses were formulated within the research:

- H_1: The barriers of new technology introduction differ in managers' preferences according to the enterprise size.

- H_2: The barriers of new technology introduction differ in managers' preferences according to the technological intensity of enterprise production.

- H_3: The disadvantages of Industry 4.0 differ in managers' preferences according to the technological intensity of enterprise size.

- H_4: The disadvantages of Industry 4.0 differ in managers' preferences according to the technological intensity of enterprise production.

These hypotheses were subsequently verified by statistical analysis in R software. For the purposes of the analysis, only answers with a rating of 5 were used. From these answers, it was clear that the given barrier or disadvantage is for the manager very important. A z-test of equal or given proportions with the Yates continuity correction (Newcombe, 1998) at alpha 0.05 was used for statistical analysis. For a deeper analysis of given significant differences, pairwise comparisons between pairs of proportions with correction for multiple testing are calculated. In the results, p-values expressing a level of statistical significance are reported.

4. RESULTS AND DISCUSSION

This section summarizes the main findings of the research divided into two parts: barriers to the introduction of new technology and the general disadvantages of Industry 4.0.

4.1. Barriers of new technology introduction

In the research, the managers answered the question of what they consider to be the biggest barriers to the introduction of new technology. The answers were examined with regard to their unambiguous preference (i.e. a rating of 5 on a scale). The results are given in Table 1, which shows the percentage ratio of barriers importance. The total results (column Total) have demonstrated that the most important barriers in managers' preferences are lack of funds and high costs (23.30%) and suitability of technologies (21.84%). Therefore, new solutions based on Industry 4.0 are still relatively expensive for enterprises at present, especially in connection with the economic crisis caused by coronavirus. This problem could be solved, for example, by another form of financing (e.g. leasing of robots). Managers consider the least barrier to the introduction of new technologies their unavailability on the market (1.94%). From this point of view, it may be clear that the supply of technologies on the market is sufficient for industrial enterprises.

Further (Table 1), the percentage ratio of barriers in relation to the size of enterprises (column Enterprises size) and technological intensity (column Tech. intensity) are analysed. Surprisingly, the lack of funds and high costs are the most relevant barrier for large enterprises (29.27%). Conversely, for large enterprises, customer requirement it is the least important barrier (7.32%). The differences according to the technological intensity were not very high.

Hypothesis H_1 evaluation: The differences in managers' preferences of barriers of Industry 4.0 technology introduction were statistically proved according to the enterprise size only for two of six barriers – technologies are not required by our customers (p-value = 0.0011) and the production process is sufficiently optimized and technologies are still suitable (p-value = 0.0429). In case of technology requirements by customers, the deeper pairwise analysis shows differences between small and large enterprises (p-value = 0.0019). The

Table 1. Preferences of barriers of new technologies introduction by managers (in %)

	Enterprise size			Tech. intensity		Total
	small	**medium**	**large**	**LTI**	**HTI**	
Unavailable technologies on the market	1.87	3.45	0.00	1.04	2.73	1.94
Lack of funds and high costs	22.43	20.69	29.27	21.88	24.55	23.30
Organizational complexity associated with technologies	14.95	20.69	21.95	18.75	17.27	17.96
Not required by our customers	**21.50**	**17.24**	**7.32**	17.71	17.27	17.48
Too complex and confusing conditions for subsidies	15.89	18.97	19.51	18.75	16.36	17.48
The production process is sufficiently optimized	**23.36**	**18.97**	**21.95**	21.88	21.82	21.84

Source: Authors calculation
Note: significant differences in bold

differences in the barrier of the production process are between small and other enterprises sizes.

Hypothesis H_2 evaluation: According to the technological intensity were not proved statistically significant differences.

Taken together, these results suggest that there are only small differences in managers' preferences of new technology barriers. The preferences differ only according to the size of the enterprise in perception as the optimization of the production process barrier and technologies requirements by customers.

4.2. Disadvantages of Industry 4.0

In the second part of the research, the managers answered the question of what they consider to be the biggest disadvantage of Industry 4.0. In this group of questions, the prevailing opinion (Table 2) is that the main disadvantage is the high investment costs (30.81% of respondents). For this reason, governments are also trying to support investment activities with various incentives. Investments are needed especially in the current period of the coronavirus pandemic, when it is necessary to prepare for the increased demand for industrial products after its end, or to reduce the extent of this pandemic. The increased illness of workers and the temporary stopping of some production facilities have shown the importance of introducing robots that are not affected by these diseases.

Then, the results are analysed by the size of enterprises and technological intensity. The managers of large enterprises contemplate shortcomings not only in large investment costs (28.46%), but also in the insufficient qualification of employees (21.14%). On the other hand, managers consider the possibility of data theft to be relatively insignificant. However, this is a temporary view until more data theft actually occurs and the negative consequences will manifest themselves. The impact of Industry 4.0 on job losses is most feared by managers of large enterprises, who already have to reckon with this issue.

Hypothesis H_3 evaluation: The differences in managers' preferences of disadvantages of Industry 4.0 were

Table 2. Preferences of disadvantages of Industry 4.0 by managers (in %)

	Enterprise size			Tech. intensity		Total
	small	medium	large	LTI	HTI	
High investment	32.64	31.11	28.46	**31.69**	**30.23**	30.81
Uncertain financial benefits	13.89	11.11	9.76	12.68	11.16	11.76
Organization changes	9.72	13.33	10.57	**11.27**	**10.70**	10.92
Loss of autonomy and control	5.56	4.44	4.07	4.23	5.12	4.76
Technology compatibility	12.50	14.44	11.38	**10.56**	**13.95**	12.61
Personal data theft	5.56	4.44	5.69	4.93	5.58	5.32
Staff qualification	**13.89**	**13.33**	**21.14**	**16.90**	**15.81**	16.25
Job losses	6.25	7.78	8.94	7.75	7.44	7.56

Source: Authors calculation
Note: significant differences in bold

statistically proved according to the enterprise size only staff qualification (p-value = 0.0224). Through a deeper pairwise analysis, it was found the difference between middle and large enterprises (p-value = 0.0500).

Hypothesis H_4 evaluation: The differences in managers' preferences of Industry 4.0 disadvantages were statistically proved according to the technological intensity of enterprise production in half of the observed disadvantages. Statistically significant differences were found in high investment (p-value = 0.000), organization changes (p-value = 0.0455), technology compatibility (p-value = 0.007) and staff qualification (p-value = 0.0095).

Overall, there are mostly differences in opinions of managers on the disadvantages of Industry 4.0 according to the technological intensity of their enterprises. In line with these findings, managers' preferences differ in their opinions on the staff qualifications based on both, technological intensity and enterprise size.

5. CONCLUSION

Industry 4.0 is the driving force and the essence of a new industry based on the digitization, artificial intelligence, automation and robotics. Enterprises are introducing new technologies in anticipation of increased production, internal process efficiency, economical effectiveness, cost savings and other benefits associated with Industry 4.0. However, it should be noted that Industry 4.0 have significant disadvantages too. This study highlights the challenge of barriers of new technology introduction and Industry 4.0 negative consequences for industrial enterprises. Based on the results, the main barriers of Industry 4.0 technology introduction are related to lack of funds and high costs and production process optimization; and the most relevant disadvantage of Industry 4.0 is the high investment need in general. Our findings confirm that industrial enterprises have an increasingly awareness of investment in Industry 4.0 due to their current financial situation, lack of funds and high costs of technologies as tested by Peillon & Dubruc (2019).

In conclusion, the results show only minor differences in managers' preferences for barriers to the introduction of new technologies and Industry 4.0 disadvantages according to the enterprise size. Horváth & Szabó (2019) stated that large enterprises and SMEs do not have equal opportunities in the area of Industry 4.0. Our findings are somewhat surprising since SMEs and large enterprises do not differ in most of the barriers. The differences are proved according to the enterprise size only in technologies requirements by customers, production process optimization, and staff qualification. Significant differences in the perception of the barrier of customer requirements for technology may be caused by the fact that the SME managers do not feel the need to implement these technologies for their customers. Managers of SMEs have a lack of developing strategies to implement new solutions (Glass et al., 2018). In the case of perceiving the level of optimization of the production process, the managers in SMEs consider the technologies to be still suitable, so they do not change them. This may also be due to a lack of information on new technologies (Zhang et al., 2017). Ottonicar et al. (2020) analysed information literacy to overcome the barriers of the innovation process in the context of

Industry 4.0. Especially in large manufacturing enterprises, there are major concerns about the future qualifications of employees (Soukupová et al., 2020).

In summary, the research partly supports the hypothesis that disadvantages of Industry 4.0 differ in managers' preferences according to technological intensity, but did not reveal significant differences for new technology introduction barriers. The technological intensity is important only for Industry 4.0 disadvantages such as technology compatibility, high investment, organization changes, and staff qualification. The technology compatibility is a potential issue for technological enterprises (Oesterreich & Teuteberg, 2016), as it can be a problem for them to connect new systems to existing ones. Conversely, for enterprises in sectors with lower technological intensity, high investment, staff qualification and organization changes (Glass et al., 2018) have a more relevant negative impact. The research did not confirm differences in concerns of enterprises reducing the number of jobs, mainly due to robotics. This is an interesting finding, as it is contrary to what is highlighted by Schwab (2017) that the number of unemployed is expected to increase in the future and most workers will not stay in one job throughout their professional lives.

This research has made a substantial contribution to a better understanding of the barriers of new technology and Industry 4.0 disadvantages. It constitutes implication towards an analysis of managers' preferences. The results emphasise how important the costs of new technology is for investment decisions. This indicates managers' concerns about Industry 4.0 benefits and emphasize the importance of incorporating knowledge about technologies related to Industry 4.0 into routine practice. These findings provide further evidence that technologies and current environment changes may have negative consequences on enterprises. Future research should seek to address the main benefits of Industry 4.0.

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БАРИЈЕРЕ УВОЂЕЊА НОВЕ ТЕХНОЛОГИЈЕ И НЕДОСТАЦИ ИНДУСТРИЈЕ 4.0 ЗА ИНДУСТРИЈСКА ПРЕДУЗЕЋА

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Извод

Успон нових технологија познатих као четврта индустријска револуција (Индустрија 4.0), доноси трансформацију која омогућава производњу и израду производа на машинама путем робота у модерним паметним фабрикама. Индустрија 4.0 ће повећати продуктивност, квалитет робе, подстаћи индустријски раст и модификовати профил радне снаге и потребне компетенције. Међутим, такве користи и предности треба проценити у светлу потенцијалних препрека и негативних последица.

Рад се бави препрекама увођења нове технологије и главним недостацима индустрије 4.0. На основу анкетног истраживања у 217 индустријских предузећа, анализиране су разлике између предузећа према величини и технолошком интензитету. Главне препреке увођењу технологије и недостаци индустрије 4.0 су недостатак средстава, високи трошкови, оптимизација производног процеса и велика потреба за инвестицијама. Истраживање је потврдило само мале разлике у преференцијама менаџера у погледу технолошких баријера индустрије 4.0 и недостатака индустрије 4.0 према величини предузећа. Технолошки интензитет је био важан само делимично у случају сагледавања недостатака индустрије 4.0. Кључни доприноси овог рада су обећавајући резултати за боље разумевање технолошких баријера и недостатака индустрије 4.0.

Кључне речи: Индустрија 4.0, технолошке баријере, недостаци, технолошки интензитет

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