Implementation of Industry 4.0 in Czech Food Enterprises: Motivation and Barriers

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Abstract: The current trend of digitization across companies, namely the Industry 4.0 concept, brings a number of challenges but also promises of future benefits resulting from its implementation. The aim of the paper is to analyze and evaluate the motivation of enterprises for the implementation of Industry 4.0 and similarly, to evaluate the barriers to its implementation. The subjects of the survey represent enterprises in the food industry in the Czech Republic. The results showed the main motivations and barriers to the implementation of Industry 4.0 across food enterprises in the Czech Republic. Correlation analysis expanded the results by the possible influence of the size of the enterprise. An important finding also was that environmental and social factors do not play a significant role in the context of motivation and barriers to the implementation of Industry 4.0.

1. Introduction

The significance of the Industry 4.0 concept is described by Philbeck and Davis (2018) who state that technological change is a driver of transformation relevant to all industries and parts of society. Thus, it can be said that the motivations for implementation go far beyond, for example, the goal of increasing efficiency. Other motivations and barriers can thus be influenced, for example, by environmental and social factors, which are represented by the Sustainable development concept as defined in 1987, which is based on a balance of three pillars – environmental, social and economic (World Commission on Environment and Development, 1987).

Reduction of raw material and energy intensity, optimization of logistics routes, increase in productivity in production or decentralized systems for energy distribution are the benefits of implementing Industry 4.0 regarding the efficient use of resources. Fully automated production processes offer the production of even small production batches, which can then reflect the changing demand for production. The efficiency of the production factor of labor will be intensive due to increased labor productivity, reflecting the continuous development of technology and implementing existing resources in complex solutions and promoting their stability (Mařík, 2016).

1.1. Motivation to Implement Industry 4.0

Industry 4.0 as a trend and concept represents very often the subject of empirical research. It is especially important to answer following two questions: what are the motivations for its implementation? What are the barriers to the process? As stated by Bravi and Murmura (2021), it depends mainly on the maturity level of the company whether the benefits of implementation outweigh the associated costs. Just as there is no single valid Industry 4.0 model that is universal for all businesses, there are different motivations for the implementation. Based on the research of these authors, which was conducted in the Italian environment of SMEs, it can be said that the main motivations for the implementation of Industry 4.0 include increasing competitiveness, simplifying internal procedures and the pressure exerted by consumers. Lower weight was given by companies to time saving in the production process and environmental protection.

Lin et al. (2019) present in the Chinese example other major motivations that may be behind the implementation of Industry 4.0 across companies. Improvements in the company's financial performance, innovation activities and return of stocks can be achieved. In addition, a positive impact on the level of information transparency of the company can be noted. Another research among SMEs within the UK is Masooda and Sonntag (2020) which lists as possible benefits, i.e. the motivation for the adoption of Industry 4.0 technologies, improving flexibility, cost efficiency, quality and competitive advantage.

The last and at the same time very important motivation for companies is to remain competitive in the context of other companies on the market in this digital era (e.g. Genest & Gamache, 2020). Turkyilmaz et al. (2021) further state that the industry is expected to improve flexibility, productivity and sustainability. Another impact in a broader sense is also the further development of the knowledge-based economy which is associated with a positive impact on society.

The readiness of enterprises for the implementation of Industry 4.0 can be assessed from many perspectives, for example, regarding the product offered (Gurjanov et al., 2018), the level of digitalization (Xu & Duan, 2019), the technology used (Dalenogare et al., 2018), the management system (Trstenjak & Cosic, 2017), the environment (Bolisani & Bratianu, 2018), the culture or the employees (Gunasekaran et al., 2019). The above-mentioned authors often state that the digitalization of business processes is a necessary condition and a key area regarding the implementation of Industry 4.0.

1.2. Industry 4.0 and its Relation to Sustainable Development

Although it is possible to say from empirical results that environmental motivations and benefits are often lagging behind, sustainable development (World Commission on Environment and Development, 1987) and the Industry 4.0 concept are interrelated and this link cannot be ignored. Furstenau et al. (2020) state that the number of studies related to Industry 4.0 and sustainability is growing significantly. The strong relationship between the concepts is confirmed and characterizes sustainability as one of the pillars of intelligent manufacturing. An important finding is that scientific efforts are primarily aimed at strengthening both the economic and environmental spheres, but there is a shortage in the

third pillar of sustainability – the social one. Based on their results, Bai et al. (2020) recommend the adoption of mobile technology, as it has an impact on sustainability in all industries. They also found that nanotechnology, mobile technology, simulation and drones have the highest impact on sustainability in the following areas: automotive, electronics, food and textiles. However, it is important to thoroughly analyze such an investment in the context of the industry before the implementation. Müller et al. (2018) focused on opportunities and challenges that precede the actual process of implementing Industry 4.0 on a sample of German companies. The results show that strategic, operational, environmental and social opportunities are positive drivers of implementation. On the other hand, challenges related to competitiveness, future viability and a satisfactory organizational and production level hinder the progress, which is a surprising finding that can also be considered as important. The authors further state that various specific characteristics of the examined companies are also important.

1.3. Barriers to Implementing Industry 4.0

Another area with which the Industry 4.0 implementation process is connected is the definition of barriers. Türkeş et al. (2019) state in their research among SMEs in Romania that the managers of these companies agree in particular that the main barriers and future challenges for the implementation process are: lack of knowledge about Industry 4.0 and understanding of the strategic importance of Industry 4.0, more focus on operation at the costs of developing the company, few human resources, the need for continuous education of employees and the lack of standards. Majumdar et al. (2021) present barriers in the Indian clothing industry: lack of trained staff, commitment to top management and government support. The authors also found the area of research and development to be insufficient. Kumar et al. (2020) divided the challenges into two categories: cause and effect. They identified the lack of motivation from original equipment manufacturers and customers as the main challenge or barrier in the "cause" category. In the second category "effect" was found to be the biggest challenge the fear of Industry 4.0 technologies in the context of sustainability.

It is also important to define the factors that can affect the whole implementation process. Jayashree et al. (2021) state that top management and IT infrastructure have the most significant impact on the implementation of Industry 4.0 and the overall trend towards sustainability. On the contrary, supply chain integration represents an insignificant factor among SMEs. It is also possible to conclude from other results that SMEs with high levels of process automation and high product variety have a much easier process of implementation of Industry 4.0, as stated in Yu and Schweisfurth (2020).

2. Methodology

The aim of the paper is to analyze and evaluate the motivation of enterprises for the implementation of Industry 4.0 and similarly to evaluate the barriers to implementation. The source of data represents a survey conducted among enterprises in the food industry in the Czech Republic. The research was carried out at the beginning of 2021 and the data was

collected from 102 enterprises using an online questionnaire survey. The chosen barriers and reasons for implementing Industry 4.0 were selected based on a research that addresses the issue (Kamble et al., 2018; Muller et al., 2018; Raj et al., 2020; Turkes et al., 2019). A questionnaire consisting of more than twenty questions was developed for the research using closed, dichotomous and scaled question types. Prior to the research, the questionnaire was consulted with several managers representing exclusively manufacturing companies. In view of the focus of the research, only enterprises belonging to category C, namely enterprises of division 10 of the CZ-NACE classification, were contacted. Division 10 consists of these subgroups: Manufacture of dairy products, Production of mill and starch products, Manufacture of other food products, Manufacture of bakery and farinaceous products, Production of industrial feed, Production of vegetable and animal oils and fats, Processing and preserving of meat and production of meat products, Processing and preserving of fruit and vegetables, Processing and preserving of fish, crustaceans, and molluscs.

To evaluate the data, descriptive statistics as well as Pearson correlation are used, where H0: $r = 0$ and Ha $r \neq 0$. Hypotheses were established as the size of the company and the specific reason for implementation are independent variables. Similarly, the second hypothesis - the size of the company and the specific barriers to implementation are independent variables. One of the objectives of the data collection was to represent the enterprises in the sample as accurately as possible with respect to the real representation of enterprises in the Czech Republic. The research as well as this paper is not limited to SMEs, as according to Acosta et al. (2016); Traill & Meulenberg, (2002), large enterprises are often the ones that innovate first.

3. Results

The research, described in more detail in the methodology section of this paper, was focused on food enterprises in the Czech Republic. The food industry is a key and historically important sector of the Czech industry. The Czech Republic, similarly to the European Union countries, does not suffer from food shortages and thanks to support programs, production reaches a relatively high level. As already described earlier in the methodology section of the paper, one of the objectives of the data collection was to make the representation of enterprises as accurate as possible with regard to the actual representation of firms in the food industry. According to the CZ-NACE categorization, the food industry belongs to Division 10 with a total of nine subgroups. Figure 1 shows the percentage of enterprises in Division 10 according to the CZ-NACE methodology in the Czech Republic and the representation of enterprises in the survey. A total of 102 enterprises participated in the survey, with large enterprises represented by a total number of 21 enterprises, small and medium-sized enterprises (SMEs) by 78 and finally, micro enterprises by 3 representatives.
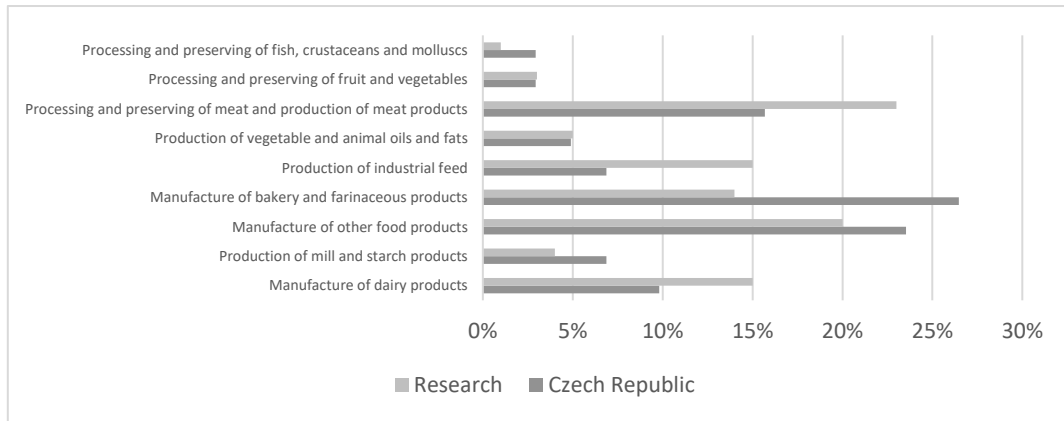
Figure 1. Representation of enterprises in section 10 CZ_NACE in the Czech Republic and own research

The chart shows that the largest difference between the actual market representation and the survey can be observed in the subcategory Manufacture of bakery, confectionery, and other flour products and also in the category Processing and preserving of meat and manufacture of meat products. One of the questions in the survey asked respondents whether they have set key performance indicators (KPIs) as part of their strategies. It turned out that more than 72% of companies do not have KPIs set for the implementation of Industry 4.0. At the same time, in the area of readiness, 26 enterprises reported that implementing Industry 4.0 is part of their corporate strategy. Enterprises were also asked whether they export their own production outside the country. A total of 83% of the enterprises involved in the research export their products abroad.

The literature review provided a brief introduction regarding the reasons – the motivation for the implementation of Industry 4.0. The research itself assesses the readiness of companies to implement the new industrial revolution and the reasons for implementation are also part of the research. The methodology of the paper describes how the different reasons for implementation were selected, which are as follows: competitiveness and market growth, environmental and social benefits, emergence of new business models, higher added value and cost savings. The distribution of data regarding the reasons for implementation is shown in Figure 2.
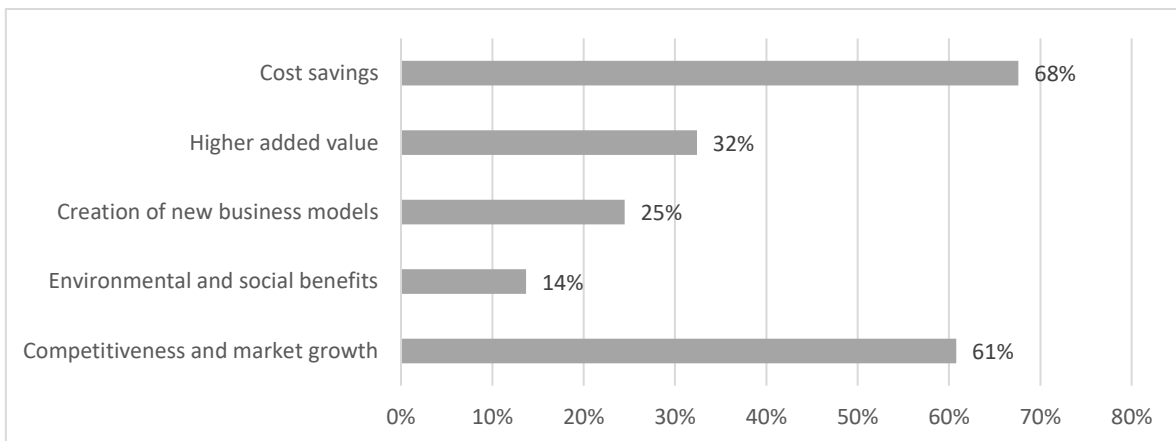

Figure 2. Reasons for implementation – data layout, multiple answers

The chart shows that the most important reasons for implementation are cost savings and competitiveness. This is followed by reasons for implementation such as higher added value, creation of new business models and environmental benefits. Interestingly, a relatively low proportion of businesses (25%) mentioned the creation of new business models as a reason for implementation, as digital transformation is changing the way businesses create value. Social media are changing the way businesses interact with customers and big data is not only being used for customer relationship management but also specifically for emerging data-driven models. The question arises whether the businesses involved in the research differ in some way regarding the different reasons for implementing Industry 4.0. The Pearson X2 test was used to evaluate the relationship between the size of the enterprise, expressed in terms of number of employees and the specific reasons for implementation, with the hypotheses for Pearson correlation set as H0 = 0 and Ha ≠ 0. Table 1 shows the results.

Table 1. The Pearson X2 test – company size – motivation

Employees	Competitiveness	Environmental and social benefits	Business models	Higher added value	Cost savings
Pearson	0.034	0.146	0.376	-0.006	-0.001
Sig.	0.737	0.143	0.000	0.954	0.995
N	102	102	102	102	102

At the significance level $\alpha = 0.05$, we were able to reject the null hypothesis only for the reason of implementation of the emergence of new business models, and thus we speak of a medium strong positive correlation according to Ratner (2009). The second area examined was barriers to the implementation of Industry 4.0, i.e., in general, any obstacles that stand in the way of companies to implement the Industry 4.0 concept. Figure 3 presents the distribution of data in the case of barriers to implementation.
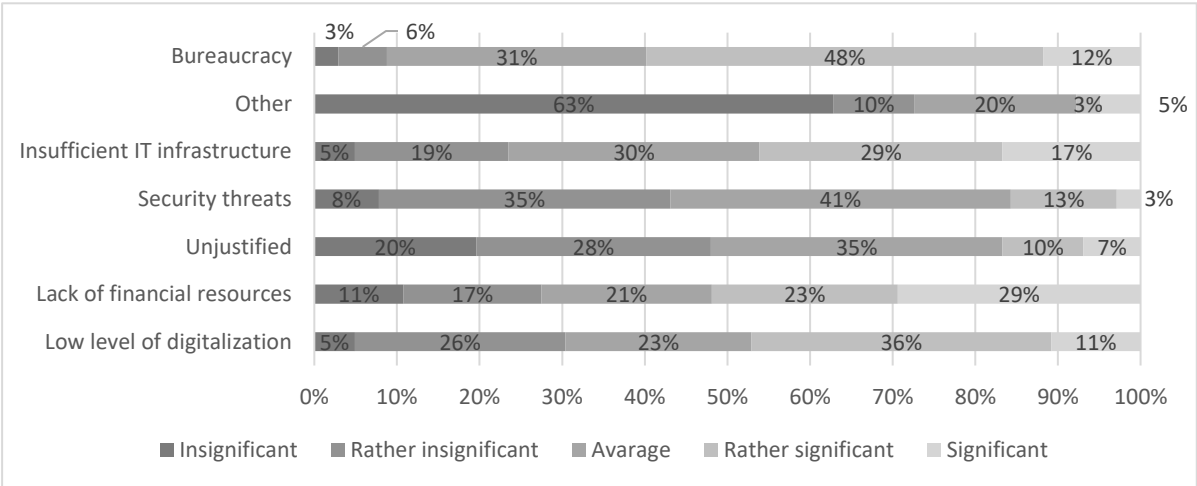

Figure 3. Barriers to implementation – data layout, scale question

The chart shows that more than 50% of businesses identified lack of financial resources as a significant or rather significant barrier. The variables of low level of digitalization, insufficient IT infrastructure and bureaucracy have high values in the range of rather

significant – significant. The barrier to implementation called "Other" was identified as not significant by more than 60 enterprises. Two possible interpretations are offered here. The first suggests that the other barriers considered by enterprises are insignificant and the second that enterprises have not encountered other barriers. Similarly to the individual reasons for implementing Industry 4.0, the barriers to implementation were statistically evaluated with respect to the size of enterprises expressed in terms of number of employees. Again, the Pearson $X2$ test was used, with the hypotheses in the case of Pearson correlation set as H0 = 0 and Ha ≠ 0. The results are shown in Table 2, with significant results marked with * for clarity.

Table 1. The Pearson X2 test – company size – barriers

Employees	Low level of digitalization	Lack of financial resources	Security threats	Insufficient IT infrastructure	Bureaucracy	Other	Unjustified
Pearson	-0.288*	-0.444*	0.059	-0.335*	-0.087	-0.070	-0.315*
Sig.	0.004	0.000	0.556	0.001	0.387	0.428	0.001
N.	102	102	102	102	102	102	102

Based on the available data and the chosen significance level of α = 0.05, the null hypothesis was rejected in favor of the alternative hypothesis, thus demonstrating a relationship between the number of employees for the variables: low level of digitalization, lack of financial resources, inadequate IT infrastructure and unjustified. In all these cases, there is a moderately strong negative correlation.

4. Conclusion

The aim of the paper was to analyze and evaluate the motivation of companies to implement Industry 4.0 principles and to evaluate the obstacles that stand in the way of successful implementation of the modern industrial revolution. The literature review provides the theoretical basis of the paper, characterizes the barriers to implementation, the most common reasons and highlights the importance of sustainability in relation to Industry 4.0. The research is described in detail in the methodology section of the paper.

The introduction of the research part consists of a characterization of the obtained data, especially regarding the individual components of Section 10 according to the CZ-NACE methodology. The research has shown that the most important reasons or aspiration of enterprises to implement Industry 4.0 is cost saving and competitiveness. Similar conclusions have been reached by several other researches that focus on the adoption of Industry 4.0 (Hofmann & Rüsch, 2017; Masood & Sonntag, 2020; Müller et al., 2018). The dependence between the number of employees and the given reasons or motivations for implementation has been shown only for the reason "creation of new business models". A possible reason for this is that Digital Transformation does not directly lead to improved business performance as it requires companies to change their business models in the first place (Bouwman et al., 2019). King and Grobbelaar (2020) state that Industry 4.0 creates the conditions for business model innovation, and it is inevitable that in times of rapid change, business models as well as business tools need to be rethought. Furthermore, they also mention that the use of new

business models leads to the acquisition of key resources in the development of new products, for example in the form of outsourced workers called crowd sourcing which is used instead of hiring professional employees. One of the main challenges of emerging business models is to create new value propositions that ultimately improve the customer experience. The second part of the research focused on selected barriers to the implementation of Industry 4.0. The barriers identified by respondents as significant are: low level of digitalization, insufficient IT infrastructure as well as bureaucracy. Similarly to the reasons for implementing Industry 4.0, the barriers were statistically tested with respect to the size of the company. For the barriers that were identified as significant after the evaluation, a negative correlation was confirmed in all cases at the selected significance level. It can therefore be concluded that the larger the enterprise is – the more employees it has, the less it encounters following barriers: low degree of digitalization, lack of financial resources, insufficient IT infrastructure and the unjustification of the whole concept.

It is also important to emphasize that although a number of authors (Furstenau et al., 2020; Bai et al., 2020; Müller et al., 2018) state that environmental considerations are an important factor that can influence the motivation of companies to implement the Industry 4.0 concept, this relationship cannot be confirmed based on the results of the correlation analysis.

The paper is not exhaustive in its scope. Given the period that elapsed between the acquisition of data and the presentation of partial results in this paper, it is rather a pilot output of a comprehensive research. The period in which the data were collected certainly represents a limitation. During the global pandemic, the food industry was also affected by production cutbacks, supplier outages and employee absenteeism. Innovation projects are clearly the first to be curtailed in times of crisis.

Conflict of interest: none

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