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Content

CHANGE MANAGEMENT IN SMES IN THE INDUSTRY 4.0 ERA

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Abstract

The main aim of this paper is to evaluate whether the concept of Industry 4.0 influences current change management in small and medium-sized enterprises and what obstacles prevent its wider implementation. An online questionnaire survey was conducted in 2024 to collect data, with 203 respondents from small and medium-sized enterprises participating. The questionnaire focused primarily on topics related to the implementation of changes, awareness of Industry 4.0, and the identification of barriers to the further development of change management and modern technologies. The results show that systematic change management is often neglected in companies, and it was also found that this is particularly the case where the perception of the importance of Industry 4.0 is low. It was also found that companies with a functioning strategy are more successful in implementing change. Financial costs, insufficient employee qualifications, and employee resistance can be identified as important barriers, with these barriers particularly affecting small and micro enterprises. Factor analysis also found that the barriers can be grouped into two main categories. The research confirms that successfully managing change in the era of digitalization requires a systematic approach, management support, and knowledge of change management principles. The paper represents one phase of a broader research project.

Keywords: Change management, Industry 4.0, Small and medium-sized enterprises, Implementation, Czech Republic

JEL Classification: L60, M10, O33

1. INTRODUCTION

Change is currently an inevitable part of life for every organization. The environment is undergoing dynamic changes, forcing organizations to adapt in order to survive and remain competitive (Errida and Lofti, 2021). Change management involves both operational and strategic levels, and given its frequency and importance, it has become an essential managerial discipline (By, 2005). Changes are no longer a separate part of business but instead are becoming an integral part of its natural functioning, including planning and the resources needed for implementation (Franklin, 2021).

The term Industry 4.0 can be described as a very significant change that affects a wide range of management functions at all levels. It is an initiative of the German government dating back to 2011, which can be described as a technological transformation (Suleiman et al., 2022). This set of modern technologies, including terms such as artificial intelligence, the Internet of Things, big data, machine learning (Javaid et al., 2022a), additive manufacturing, advanced robotics, virtual reality, cloud computing, simulation (Javaid et al., 2022b), cyber-physical systems, augmented reality, the Internet of Services, digital twins, blockchain (Marinagi et al., 2023), or semantic web technologies (Rikalović et al., 2022). To implement Industry 4.0, it is essential to identify potential threats and barriers in advance, as well as key success factors. The optimal approach is to implement it using project management with a predefined methodological framework or approach (Raddi-Mira et al., 2024; Gajdzik et al., 2021; Stojkovic and Butt, 2022; Jena and Patel, 2023).

The area of small and medium-sized enterprises has long been a primary focus of research. The reason for this is their significant impact on national economies. It is also necessary to consider that this category encompasses micro-enterprises (Varga, 2021). There are specific factors that influence the performance of these companies, including growth-related factors such as size, age, and international cooperation (Garcia-Martinez et al., 2023). Small and medium-sized enterprises also have an extraordinary ability to adapt to global changes and trends, such as Industry 4.0, as well as respond to challenges like an aging population or changes in the workforce (Owalla et al., 2022).

The reason for conducting this research is the limited scope of existing studies examining change management from the perspective of Industry 4.0, particularly in the segment of small and medium-sized organizations, and especially in the Czech environment. Additionally, there is a need to raise awareness that it is precisely in SMEs that assistance is required to implement modern technologies.

The topic of change management in small and medium-sized enterprises in the era of Industry 4.0 is, of course, topical, but it is also almost essential for a whole range of actors. As mentioned above, SMEs form the backbone of the national economy, and their ability to adapt to new conditions, therefore, determines, to a certain extent, the future competitiveness of the entire economy. This issue is important not only for the managers of these companies themselves, who seek ways to enhance the success of their businesses but also for academics who can develop change management models within the context of digital transformation. The importance of this topic is also growing due to the increasing pressure to develop modern technologies, even in smaller companies. Industry 4.0 is no longer the domain of only large players but also of SMEs, whose operations are beginning to be transformed by modern technologies.

Several approaches can be used to define size categories within SMEs, such as those based on the World Bank or the OECD. However, this research is grounded in European Union standards, as described by Berisha and Pula (2015). There are three basic criteria for assessing size categories: number of employees, annual turnover, and annual balance sheet. The number of employees is the decisive criterion. Micro-enterprises are those that employ fewer than 10 people, small enterprises are those that employ fewer than 50 people, and medium-sized enterprises are those that employ up to 250 people (Raczyńska, 2019).

2. RESEARCH BACKGROUND

2.1. Change management models

Given that the main aim of this paper is to evaluate whether the concept of Industry 4.0 influences current change management in small and medium-sized enterprises and what obstacles prevent its wider implementation, it is essential to first understand the mechanisms by which changes in organizations can occur or be managed. Change management models offer a theoretical framework for managing, implementing, and evaluating change in practice.

In an environment of rapid digitization and transformation brought about by Industry 4.0 through its technologies, these models play a crucial role in facilitating the transition to new systems and processes. Without the systematic approach offered by these models, companies face a significantly higher risk that changes will not be successfully implemented and integrated into the organization, as confirmed by literature reporting a 60-70% failure rate in implementing changes (Errida and Lofti, 2021). Therefore, the inclusion of this section is essential for understanding what tools managers (or change managers) have at their disposal and how they can use them in the context of implementing the principles and technologies associated with the Fourth Industrial Revolution (Phillips and Klein, 2023).

As previously mentioned, there are several change management models. The characterized change models were not selected at random but reflect their application in practice and description in professional literature. Of course, models that primarily serve to manage organizational change were selected first, and an overview of these models is provided in several contemporary publications (Sheikh Hamdo, 2021; Phillips and Klein, 2023; Harrison et al., 2021). Similarly, models that were not directly created as a change management methodology but rather as an approach to understanding human behaviour during the change process are also included (Quintero, 2023; Khattak et al., 2025). These models can play a vital role for SMEs, as these companies often lack a specialized change management department; therefore, they need to incorporate the human side of the change process. Among the best-known are undoubtedly Kotter's 8-step model and Lewin's 3-step model of change, as well as the McKinsey 7S framework (Harrison et al., 2021). As mentioned by Bellantuono et al. (2021), Lewin's model of change can be considered a fundamental starting point when discussing the most well-known models. Additionally, the Prosci process can be described as another 3-step model. Karasvirta and Teerikangas (2022) then summarize the most well-known models, including the individual roles that individuals play in the change process. Furthermore, in the context of changes in companies, we can talk about models such as ADKAR (Mudjisusatyo et al., 2024), Bridges Transition Framework (Shy and Mills, 2010), Nudge theory (Müller et al., 2023), Kübler-Ross model (Shoolin, 2017) Senge's model based on the learning organization (Caldwell, 2012) or Satir's growth model (Lee and Rovers, 2016). The reason for including a wider range of change models is to demonstrate that there is no single, universal model but rather that we recognize a diverse range of them, each with its specific application.

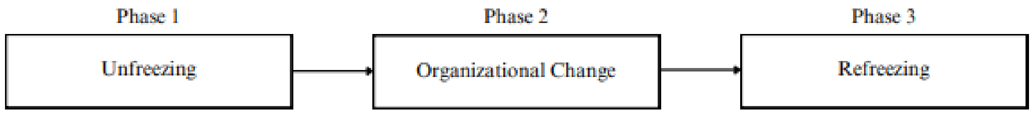
The issue and problem of change management, specifically in SMEs, is often discussed and analysed. It often encompasses not only the characteristics of specific models but also new procedures for implementing changes in SMEs (Filep, 2024; Salgado et al., 2022). Even within the Czech Republic, the issue of change management in companies is often discussed (Jambal and Stuchlý, 2021; Straková et al., 2024). Specifically, the McKinsey 7S model for implementing Industry 4.0 in companies in the Czech Republic is mentioned by Červený et al. (2022). However, there are also cases of new change models created for particular groups, such as farms, where The Triggering Change Model (Mrnuštík Konečná and Sutherland, 2022) can be applied. However, there are also studies focusing on the same issue outside the Czech Republic, often mentioning the implementation of Industry 4.0 through Lewin's change model (Ramos et al., 2021; Hatoum et al., 2021) or the ADKAR model (Chaabi, 2022).

2.1.1. Lewin's model

This is the most basic model of change management. Its creator, Kurt Lewin, is even considered the founder of this management discipline (Martin and Colville, 2017). His model of social change, presented at the end of the first half of the 20th century, was later adopted at the organizational level (Kump, 2023); however, it remains valid and relevant today (Endrejat et al., 2017). The entire model is based on three defined steps: "unfreezing, organizational change, and refreezing," which follow each other in the order listed (Hussain et al., 2018). Figure 1 provides a graphical representation of the process.

The key to consolidating any change (not only in this model) is overcoming resistance. An interesting and unconventional view of resistance is offered by González et al. (2022), who divide it into four main groups: individual (e.g., lack of knowledge or motivation), organizational (e.g., poor communication), group (interaction of individuals with strong influence), and exogenous (or external). The role of the change agent is important in overcoming resistance. Remneland Wikhamn (2020) highlights the position of the change agent, whom he describes as a key player in introducing and consolidating change. This claim is also empirically supported, and the primary and key activities of the change agent are defined as "navigation" and "anchoring."

Fig. 1 Lewing three-stage model



Source: Own processing according to Hussain et al. (2018).

2.1.2. Kotter's 8-step model

It is one of the most widely used and best-known models for managing organizational change, frequently cited in the literature with potential applications across a wide variety of industries (Wentworth et al., 2020). This model places great emphasis on the personal involvement of employees, with the change agent and work teams playing an important role (Bleich et al., 2017). The model is based on the fact that the current state may be more detrimental to the organization than a potential change and future state. However, this view can cause stress and anxiety among employees, which can disrupt the organizational change process (McLaren et al., 2023).

As mentioned in the title, this model consists of eight steps for successfully implementing change. These steps are, in the following order:

- Create a sense of urgency for change.
- Build a team.
- Develop a vision and strategy.
- Communicate the vision.
- Delegate and remove barriers.
- Creating short-term wins.

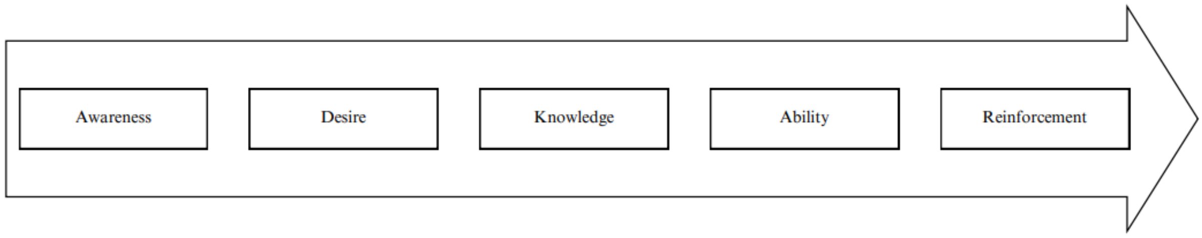
- Encouraging further change.
- Anchoring change in the corporate culture (Kotter, 2015).

Galli (2018) characterizes the strengths and weaknesses of this model. First and foremost, it is noted that this model provides significantly better guidance for implementing change than Lewin's, the second-leading change management model. At the same time, this model provides a more detailed description of how and when to communicate with employees, who are often the primary source of resistance to change. However, one disadvantage is that employees do not have the opportunity to contribute to the creation of the vision and actively participate in the development of the change concept. Another disadvantage is that individual steps cannot be skipped or omitted for the change to be successfully implemented.

2.1.3. ADKAR model

Another tool that can be used during organizational change is the ADKAR model (de Moraes and Cunha, 2023). It can be used primarily at the individual level, specifically in identifying specific resistance to change in individual cases or pinpointing problems. It generally assesses the position of individual employees in the change process (Mudjisusatyo et al., 2024). It also enables management to break down the entire process into smaller parts, making it easier to identify and address problems. The entire model consists of five steps: awareness, desire, knowledge, ability, and reinforcement (Al-Alawi et al., 2019). The entire process is illustrated in Figure 2.

Fig. 2 ADKAR model



Source: Own processing according to Mudjisusatyo et al. (2024).

Awareness – this is the first stage of the change process. At this stage, it is necessary to clearly explain to individuals why change is necessary, what risks arise from the current situation if the change is not implemented, and the origin of the change (Balluck et al., 2020). Desire – as stated by Houben et al. (2020), this is essentially a personification of the first phase, i.e., awareness. This phase is usually a critical point in the process in terms of resistance to change. It is essential to note that this resistance can be partially mitigated during the initial phase of the process. It is a big mistake to believe that providing a sufficient explanation of the change and facts about its origin will automatically generate desire (Jaaron et al., 2022). Knowledge – it is important to provide the knowledge and information necessary for change, usually through conventional educational methods. First and foremost, this involves the knowledge needed to implement change; however, it is also essential to inform employees about how their work is connected to the change (Kachian et al., 2018). Ability – This phase is closely linked to the previous phase. It primarily consists of the ability to apply knowledge (Paramitha et al., 2020). At the individual level, in particular, it is necessary to be able to answer specific questions – e.g., whether I can implement change at all or whether I can achieve the desired change (in performance, behavior, etc.) (Balluck et al., 2020). Reinforcement – this is the final stage of the process, which focuses on a future period without specification, aiming to maintain the change (Sulistiyani et al., 2020). It is essential to acknowledge even small successes and solicit feedback (Balluck et al., 2020).

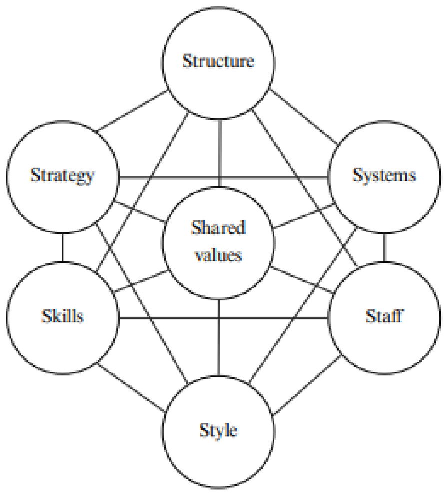
2.1.4. McKinsey 7S

This strategic model is an analytical tool consisting of seven organizational elements (Polyanska et al., 2019). Within the framework of change, it is possible to use individual elements of the model as variables of change and observe their reorientation and interrelationships (Garg et al., 2023). There are already several modifications and extensions to the model, but the original seven elements remain: shared values, strategy, structure, systems, staff, style, and skills (Badi and Nasaj, 2023). The so-called hard elements of the model include strategy, structure, and systems, while the soft elements include shared values, staff, style, and skills (Chmielewska et al., 2022). Cox et al. (2019) then point out the differences between the two groups. While hard elements can be defined or measured, evaluated, or controlled in a relatively specific way, soft elements are much more difficult to "imagine" and significantly more challenging to manage directly. The model is shown in Figure 3.

Briefly description of the individual elements and their general relationship to change management. Skills refer to the competencies and skills that employees can use to achieve set goals. During the implementation of change, however, it is essential to identify the skills required to reinforce, for example, a new strategy effectively (Ponce-Espinosa et al., 2017;

Odeh, 2021; Chmielewska et al., 2022). Style refers to the attitude of managers toward leading people or making decisions. During change, however, it is necessary to approach employees on an individual level in order to support their interest in change and increase their level of personal involvement (Weihrich and Koontz, 2004; Odeh, 2021; Chmielewska et al., 2022). Staff is understood as all human resources working in the organization, including the process of their management (recruitment, remuneration, etc.). During organizational change, it is necessary to use their feedback or set evaluation criteria that can assess the degree of change and employee involvement (Ivanko, 2013; Odeh, 2021). Shared values form the foundation of the organization, encompassing the business's core mission, values, and objectives. To maintain the effective functioning of the organization, it is necessary to harmonize all these fundamental elements. It is clear that a change in any of the previous elements has an impact on the area of shared values and vice versa – any change in shared values must lead to a change in all other elements (Odeh, 2021; Chmielewska et al., 2022).

Fig. 3 McKinsey 7S model



Source: Own processing according to Chmielewska et al. (2022).

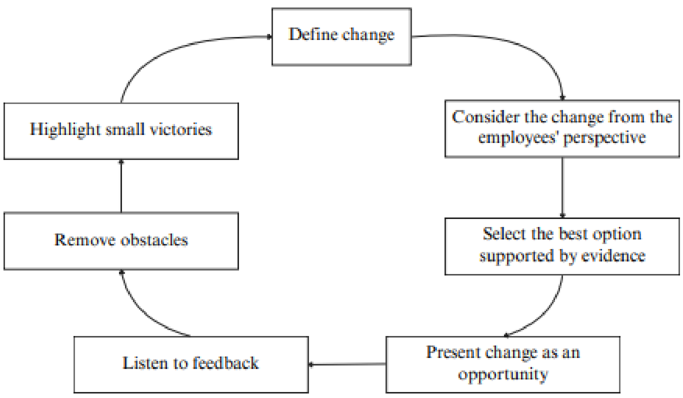
By structure, we mean the internal organization of the organization in terms of responsibilities and relationships of superiority and leadership. Within the change, the structure is usually the most visibly changed element (Robbins and Coulter, 2005; Odeh, 2021). Strategy represents a specific plan for implementing the organization's mission and vision. It usually also includes the value orientation of the organization. When implementing change, it is essential to recognize the magnitude of the organization. In the case of minor changes, there is typically no change in strategy; on the other hand, when implementing large-scale changes, it is not uncommon for the organization's strategic objectives to shift (Ponce-Espinosa et al., 2017;

Odeh, 2021). Systems are then understood as providing technical support within the company's internal environment, encompassing all technical infrastructure related to work procedures, processes, and decision-making.

2.1.5. Other Models

Nudge theory is a model initially developed for psychology and behavioural economics. It is based on the fact that new facts or information are not presented to people strictly but rather as a choice (Olya et al., 2024). The same applies to change management. Change is presented to employees as one of several alternatives, and we attempt to influence individuals' decisions with subtle nudges that are not too confrontational. In general, this technique reduces conflicts when implementing change. It is recommended to combine this technique (model) with another selected model that is more focused on complex elements, as this theory is not primarily a change management model (Bukoye et al., 2022). In general, this model forms the basis of a branch of management called Nudge management (Ebert and Freibichler, 2017). From a change management perspective, it is possible to proceed according to the diagram shown in Figure 4.

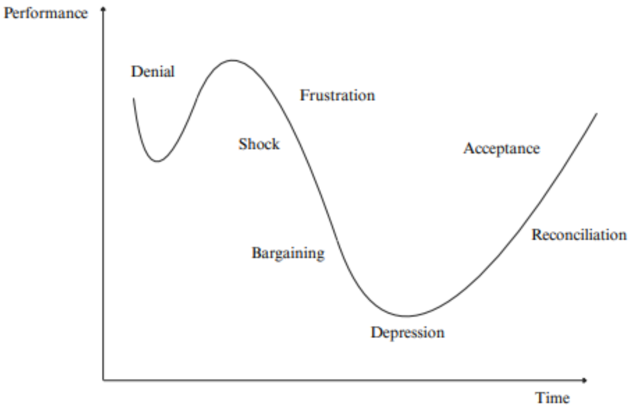
Fig. 4 Nudge theory



Source: Own processing according to Mullholand (2023).

Another model is **Kübler-Ross Curve**. The model dates back to the late 1960s and was not linked initially to organizational change. It was originally a model describing the stages of dying. The process can be expressed by the acronym DABDA, which stands for Denial, Anger, Bargaining, Depression, and Acceptance. In the original sense of the word, it was possible for the individual stages not to occur chronologically or even for all of them not to occur (Bregman, 2019). The individual phases are associated with different levels of performance. The relationship between performance and time horizon can also be expressed graphically in this model, as shown in Figure 5.

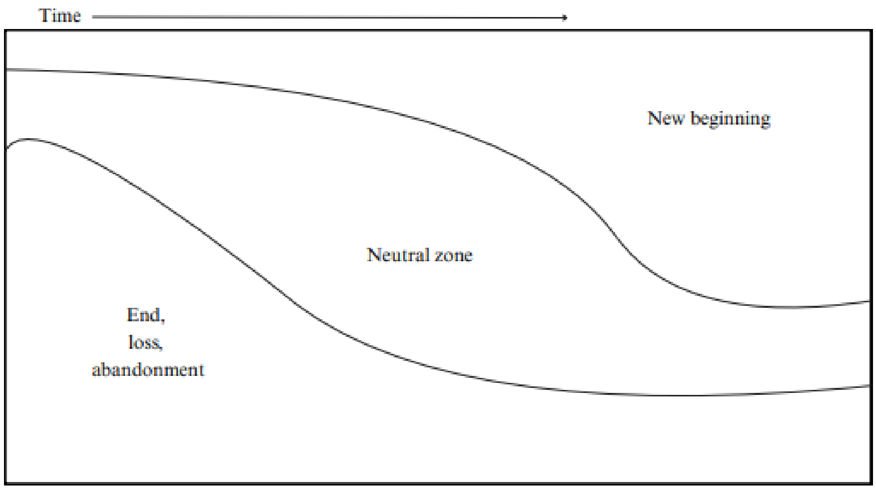
Fig. 5 Kübler - Ross curve



Source: Own processing according to Savolainen (2016).

Another example of an organizational change model is the **Bridges transition model**. It is important to note that the author of this model distinguishes between the concepts of change and transition. In this model, change is perceived as a situation that has occurred – e.g., the establishment of a new branch, the adoption of new technology, etc. Transition is understood on a psychological level – how people can cope with the conditions that the new situation brings (Bridges and Bridges, 2009). It is, therefore, immediately apparent that this is again a supportive model focused on people (in the case of an organization, employees) and that it needs to be combined with one of the other models to facilitate the implementation of the change in question (Page and Schoder, 2019). The process of an individual's acceptance of transition is divided into three basic phases (Wilhelm et al., 2020). Process is illustrated by Figure 6.

Fig. 6 Bridges Transition Model



Source: Own processing according to Bridges and Bridges (2009).

2.2. Industry 4.0 in organizations

The Fourth Industrial Revolution marks a profound change in the way organizations, including small and medium-sized enterprises, operate. The implementation of modern technologies characterizes it, but it is also inextricably linked to the transformation of processes, organizational structures, and the way businesses respond to the external environment (Cimini et al., 2021). This is not an isolated change but rather a controlled organizational change that requires a systematic approach (Brodeur et al., 2023). This is where change models come into play, providing a framework for systematically implementing change. They also offer assistance in addressing employee resistance, establishing effective communication, and integrating change within the company (Bellantuono et al., 2021). The following text builds on the previous description of change models, as it is a concept that examines the use of change models in business practice.

Industry 4.0 is a concept that first emerged in 2011 and aims to characterize highly digitized manufacturing processes in which information flows between machines in a controlled environment, thereby minimizing the need for human intervention. The concept was created and developed by German industrial and academic communities, with the support of the German government, aiming to frame and develop the country's industrial competencies (Lenart-Gansiniec, 2019; Soomro et al., 2021). This initiative was driven by the digitization of production processes in several industrial sectors. Its name is based on the recognition that the integration of cyber-physical systems into manufacturing processes is changing the entire manufacturing and business paradigm, marking the advent of the fourth industrial revolution. Since its German origins as a term focused on addressing strategic German industrial policy, the term "Industry 4.0" has also been used outside German industry as a synonym for self-sufficient manufacturing processes enabled by the ability of machines and equipment to communicate with each other through digital connectivity within the value chain (Castelo-Branco et al., 2019). This concept is associated with various technologies, including robotization, automation, 3D printing, cloud computing, virtual reality, and augmented reality, among others (Wightman et al., 2023).

However, we are currently encountering another term, namely Industry 5.0. According to Xu et al. (2021), Industry 5.0 recognizes the power of industry to achieve social goals beyond jobs and growth, becoming a resilient provider of prosperity by ensuring that manufacturing respects the limits of our planet and prioritizes the well-being of industrial workers at the centre of the manufacturing process. Industry 5.0 complements the existing Industry 4.0 paradigm by making research and innovation the driving force behind the transition to a sustainable, people-cantered, and resilient European industry.

Companies must implement new business models and perceptions of competitive advantages into their strategies, usually related to sustainable production and the circular economy. At the same time, it is essential to implement the strategy so that the company can utilize it to understand the needs and desires of its customers (Serey et al., 2023). De Oliveira Valério et al. (2020) also define specific areas where strategic change is occurring due to Industry 4.0. They mention the need to optimize the business model or, rather, optimization. The need to change the approach to IT from a strategic perspective is mentioned to a large extent. The issue of a more modern view of the concept of a learning organization in connection with modern technology, such as machine learning, is also not overlooked.

In connection with the necessary change in the area of strategic management, the first models are beginning to emerge that consider support for strategic management as one of the key factors for the effective use of new technologies (Kumar Hajoary, 2023). Ramadan et al. (2022) then highlight the impact of individual innovations related to Industry 4.0 on long-term sustainable competitive advantage resulting from strategic management. It has been observed that purely technological innovations, together with innovations labelled as commercial (those that have an impact on the customer and are recognizable to them), have a very significant impact on gaining a competitive advantage in the current environment. Ghobakhloo et al. (2023) also emphasize the importance of addressing individual functional areas within the framework of strategy and strategic management, specifically logistics and the supply chain, with a detailed strategic map for this area, taking into account modern technologies.

A very detailed description of the strategic steps for implementing the concept as a whole is provided by Cordeiro et al. (2019). Among other things, the author describes the barriers that prevent the successful implementation of the entire concept – including employee resistance, safety concerns, and the necessary organizational and procedural changes. As can be seen from the above, the question of adopting a strategy for Industry 4.0 is closely and inextricably linked to the discipline of change management.

The procedural changes mentioned above are inextricably linked to the issue of process management. When linking the topics of process management and Industry 4.0, it is necessary to examine the issue on a broader scale. As some authors point out, it is also crucial to address the issue of risk management in parallel. Risk management and identification are essential components when implementing new technologies into processes (Benešová et al., 2019; Tupa and Steiner, 2019). Trstenjak and Cosic (2017) also note a significant shift in process models and process management across organizations in general. Among other things, they address the question of whether small and medium-sized organizations will be able to afford modern technologies to the same extent as large enterprises. Of course, SMEs cannot keep pace with large companies on their own. For this reason, the study's authors propose a solution in the form of a specialized strategy for implementing Industry 4.0 at the process level in SMEs.

RPA, or robotic process automation, is a highly useful, recognized, and widely used tool for enhancing process efficiency without requiring human intervention. This tool enables the complete automation of any digital processes (or at least part of them). The RPA market is currently experiencing significant growth, with an increasing number of products available on the market. According to reports, companies report operating cost savings of between 30% and 50% after implementing Robotic Process Automation (RPA). Today, it is already possible to observe a significant connection between RPA and AI, which may bring another level of process automation in the future (Ribeiro et al., 2021).

The concept of "process mining" is also discussed. This option should be based on the ability to analyse large datasets and historical process data, resulting in the design of optimal processes. Li et al. (2011) had previously reported on the same concept, even to the extent that process mining would not require any historical data or sample processes. At the same time, several authors have addressed this issue, for example, Turner et al. (2012). In general, this model has been in development for approximately 10 years and is not entirely new. This concept began to develop concurrently with the emergence of Industry 4.0 itself. Osman and Ghiran (2019) present a study that focuses exclusively on the impact of Industry 4.0 and new algorithms on process mining, utilizing historical databases and existing knowledge. The practical application of this study is the mining of BPMN process diagrams.

Human resource management is also a critical area. Mazurchenko and Maršíková (2019) describe new developments and future trends from the perspective of managers, stating, for example, that the position of HR managers will undergo significant changes in the coming years in connection with digitalization. Among other things, the authors highlight the growing trend of HR managers needing to implement social networking platforms. An integral part of this issue is the relationship between human resource management and modern technologies. Terms such as artificial intelligence, virtual reality, and machine learning are frequently associated with this area.

Ra et al. (2019) then highlight the understandable need to develop employees' skills and abilities. However, they also note that there are very few places in the world where a sufficiently functioning modern education system already exists to prepare future labour market participants for modern technologies. They also mention the concept of a "learning society." Industry 4.0 is, understandably, still associated with robots and the possibilities of human-robot collaboration versus robot-robot collaboration. The potential risks associated with this cooperation cannot be ignored (Stein and Scholz, 2020). Brocal et al. (2019) also mention the importance of risk management in the introduction of modern technologies into the field of human resources.

The term "Operator 4.0" is also used in the field of HRM – a robot capable of social awareness and interpersonal interaction, along with other desirable characteristics (Fantini et al., 2020). Kaasinen et al. (2020) then discuss in more detail the method of empowerment and its connection with Operator 4.0.

Modern technologies can be utilized in HR management, for example, to more effectively and efficiently connect job offers with potential candidates (Pejic-Bach et al., 2020) or for intelligent, machine-driven education that is fully personalized (Kohnová and Salajová, 2019). Significant changes in employee competency models can be expected. Jerman et al. (2020) offer an example of a model of key employee competencies in Industry 4.0 conditions, which include willingness to learn, ability to adapt to change, technical skills, IT skills, soft skills, and creativity. Maisiri et al. (2019) offer another perspective on the expected key abilities and skills of employees. They categorize them into two main groups: technical and non-technical. Without an adequate strategy or general plan for change, it is highly likely that the change will not be fully implemented or that the company will struggle to identify when it has been successfully adopted (Predişcan & Roiban, 2014).

It is essential to realize that every change is a process in itself. It is, therefore, not necessary to look for connections at the level of specific processes or their changes. Change management is closely linked to the process-based approach to organizational management at a fundamental level. Nevertheless, Song and Jacobsen (2018) offer a more comprehensive view of the connection between change and processes. As the authors correctly note, process changes are practically the most important type of change that takes place in companies. Furthermore, the importance of modernizing and optimizing processes across all sectors of national economies is expected to continue growing in the future.

2.3. Industry 4.0 technologies

In the context of discussions about Industry 4.0, we encounter countless modern technologies. It is almost impossible to list them all exhaustively so that we can mention technologies such as additive manufacturing, cloud computing, cyber-physical systems, the Internet of Things, Big Data, Extended Reality, Robotics, Artificial Intelligence, Augmented Reality, and many others as examples (Salunkhe and Berglund, 2022; Suleiman et al., 2022; Javaid et al., 2022a; Javaid et al., 2022b). The most well-known technologies that influence the current environment will now be briefly characterized. The description of specific technologies is included to provide a theoretical background for understanding the practical impacts that Industry 4.0 technologies may have. Moreover, these are not just general trends but also specific tools that can be implemented through controlled change.

2.3.1. Artificial Intelligence

The term artificial intelligence was first used in 1956 to describe technologies capable of approximating the functioning of the human brain. Artificial intelligence is characterized as a new generation of technology that can interact with its environment in specific ways and attempts to simulate human intelligence. For software to be considered artificial intelligence, it must possess capabilities in the areas of problem-solving, reasoning, perception, and communication. At the same time, this software is self-learning, so it no longer needs additional programming in advance to ensure its functionality. As mentioned earlier, artificial intelligence could be used to analyse big data because it is capable of recognizing specific characteristics in data that humans might overlook or be unable to find. Artificial intelligence is also faster and more objective in analysing data because it is not subject to emotions. However, the problem arises that it is usually challenging to determine the methodology with which artificial intelligence processes data, so it is more beneficial for data sorted by artificial intelligence to be subsequently processed by humans (Alter, 2022; Gesk and Leyer, 2022).

Process automation in organizations refers to the application of information technology to all or most of an organization's activities. Applying artificial intelligence to business operations can, therefore, increase an organization's performance and create a competitive advantage. Studies have shown that information technology has strategic implications and can contribute to achieving organizational goals (McRobert et al., 2018).

2.3.2. Big data

Big data is the name given to large amounts of unstructured data obtained from various sources and in different formats, but their size is not sufficient to qualify as big data. In order for the information obtained to be considered big data, it must meet the so-called 3Vs, which is a list of criteria consisting of volume, velocity, and variety. However, this model has grown to 5Vs with the addition of the criteria of veracity and value. This model continues to evolve, and a 10V model is now available; however, the criteria overlap and essentially provide the same information about big data (Saraswathi et al., 2022; Schulte and Bohnet-Joschko, 2022).

It is estimated that 2.5 quintillion bytes of data are generated every day, and the speed at which they are created is increasing daily, posing several challenges for their practical use. The main problem is its storage and subsequent processing. This is where artificial intelligence and machine learning come into play, as they can sort the data based on specific criteria, making it easier to analyse and adding value to both companies and customers (Lundberg and Grahn, 2022).

2.3.3. Cloud computing

The manufacturing industry is undergoing significant changes, with progress in this area focusing on the era of smart manufacturing. The creation of digitally connected networks, where data is shared over the internet, presents a significant opportunity. We use cloud storage to store, access, and process large amounts of data (Rai et al., 2021).

A significant advantage is that virtual resources are typically less expensive than physical resources, as the costs associated with maintaining local systems are eliminated. Cloud storage services also offer a higher level of security, as data is constantly duplicated across multiple physical machines in the cloud. Data redundancy is crucial for potential data recovery in the event of a crash. Another advantage is easier software and hardware management and maintenance, as applications that use cloud storage can be managed collectively via a web browser. The use of cloud storage also facilitates planning the necessary IT capacity, as cloud solutions are flexible and provide storage according to current needs (Wu et al., 2010).

2.3.4. Internet of Things

The Internet of Things (IoT) enables communication between objects in the real and virtual worlds, anywhere and at any time, provided there is an internet connection. The goal is to unite everything in our world under a common infrastructure, which gives us control over the things around us (Burian, 2014; Wortmann and Flüchter, 2015).

The first Internet appliance was created in the early 1980s when programmers working several floors above a vending machine wrote a server program that allowed them to connect to the machine via the Internet, check its status, and find out if a cold drink would be waiting for them if they decided to go down to the machine. However, the term was not coined until 1999 by Kevin Auston, executive director of Auto-ID Labs at MIT. Other names are also used, such as Web of Things, Internet of Objects, and Embedded Intelligence (Madakam et al., 2015).

The IoT is gradually introducing a wave of technological changes into our daily lives, helping to simplify and enhance our lives through various technologies and applications. It connects production systems and plants, giving rise to smart homes and buildings where, for example, smart thermostats and security systems are utilized. The IoT also encompasses smart cities, where it is possible to monitor available parking spaces in real-time or utilize bright street lighting, for example. There are numerous practical applications for the IoT across various sectors, including healthcare, manufacturing, industry, transportation, education, government, and mining (Burian, 2014; Madakam et al., 2015; Wortmann and Flüchter, 2015).

To better understand the IoT, consider the example of a light bulb, whose primary function is to provide light in a specific location. Suppose we extend this light bulb with IoT technology. In that case, it can, for example, detect the presence of a person and serve as a cheap security system that activates a flashing light mode when detected and sends a notification to the owner's smartphone (Wortmann and Flüchter, 2015).

One of the main problems with the Internet of Things is that it is such a broad concept that there is no single architecture. For the idea of the Internet of Things to work, it must consist of, among other things, a range of sensor, network, communication, and computing technologies (Madakam et al., 2015).

2.4. Advantages and barriers of Industry 4.0 implementation

2.4.1. Benefits and advantages

Organizations that adopt Industry 4.0 can expect significant improvements in their current competitive position, increased value creation, and minimized risks. The introduction of more efficient and faster production systems, along with innovative technologies, will enable shorter operations, reduced delivery times, and a faster time-to-market for new products and services. In addition, they can reduce process and product variability, ensure greater consistency and quality, and engage consumers more actively and intensively. They can tap into new and emerging markets through differentiation strategies or even create new disruptive business models (Fonseca, 2018).

Robotics and Internet of Things devices may also automate a large part of manufacturing or supply chain processes in the future. The goal of automation is to create autonomous systems capable of performing many tasks without human assistance (Kotzias et al., 2022). Semantic technologies can benefit the supply chain by enabling data interconnection and information integration. A large amount of data is generated and stored throughout the supply chain in various formats, languages, and syntaxes. Semantic technologies enable the creation of relationships between diverse data and its meanings, making the data easier to read and communicate for machines, applications, and supply chain participants (Rad et al., 2022). From another perspective, Big Data and Business Analytics can support business operations in many ways. For many organizations, it can be a driving force for a better understanding of industry and market characteristics, improving margins, optimizing revenue streams, and ensuring market feedback on revenue (Kotzias et al., 2022).

Virtual reality is establishing itself as one of the most innovative applications in Industry 4.0 through the use of 3D modelling. In the case of augmented reality, it refers to the concept of using specialized displays to obtain additional information about a product by simply framing it. In Industry 4.0, this concept is transformed into the potential to access automated and transparent product logistics, which enables the precise location of products within the factory and the real-time tracking of order fulfilment. This method enables the evaluation of products fro m both aesthetic and functional perspectives while also allowing them to be simulated in a reference environment (Selicati and Cardinale, 2021).

Cyber-physical systems can help businesses with automated processes that were previously performed manually or semi-automatically. This can help reduce the number of errors that occur when performing various activities, improve the quality and reliability of activities, and create systems that are synchronized with customer requirements and business capacity. Products can communicate with each other and send all their information to a specific location, where this information is stored and used to understand their status and determine whether any corrective action is needed to remedy anomalous situations (Simonetto et al., 2022).

One of the key factors that need to be addressed in order to optimize processes is increasing their efficiency. This can be achieved, for example, by implementing technologies such as IoT-based solutions that offer real-time data visibility, augmented reality and smart glasses that improve operational performance, or artificial intelligence tools that automate object recognition and derive valuable insights for decision-making through machine learning (Perotti et al., 2022).

2.4.2. Challenges and barriers

For a country to be considered successful in implementing Industry 4.0, it must be evident not only in large companies but also in small and medium-sized enterprises. The concept of Industry 4.0 was closely tied to a specific trend, but recently, it has become apparent that there are numerous ideas yet few tangible results. In addition, digitization has reached a certain level in large companies, whereas it is rarely seen in small ones. No one has shown any enthusiasm for this issue so far (Sommer, 2015).

It may be surprising to find that the difference in obstacles to implementing Industry 4.0 between small and large companies is not significant. The only differences based on company size are in customer requirements for technology, production process optimization, and staff qualifications. Significant differences in the perception of barriers to customer requirements for technology may be due to managers of small and medium-sized enterprises not feeling the need to implement these requirements. Managers of small and medium-sized enterprises often face gaps in developing strategies for implementing new solutions. In terms of the perceived level of production process optimization, managers in small and medium-sized enterprises consider the original technologies to be still suitable, so they do not change them. This may also be due to a lack of information about new technologies (Pech and Vaněček, 2022).

The introduction of Industry 4.0 is expected to lead to a decline in the number of jobs. On the other hand, only qualified workers will be sought for these positions, which will increase the demand for labor in fields such as science, information technology, law, business consulting, and media or artistic professions. This will change the structure of the workforce. There will likely be a shortage of jobs for people without professional education or experience. Education is closely tied to this problem. The introduction of Industry 4.0 would mean changes to education and the structure of the entire educational program (Markova et al., 2022).

The most significant disadvantage of Industry 4.0 is its high cost. Governments often encourage business investment through various incentives and tax breaks. However, the COVID-19 pandemic has shown that replacing human labor with machines can be financially advantageous, for example, because machines are not affected by illnesses that cause production restrictions. In many cases, the initial investment can pay for itself several times over. There are, of course, many advantages, as described above. However, the high financial cost is the biggest obstacle to the introduction of Industry 4.0 for most companies, regardless of the high probability that the investment will pay off (Pech and Vaněček, 2022).

An important part of manufacturing processes in the new generation is also the interaction between people and intelligent machines in smart factories or enterprises. Wireless telecommunications and location technologies are becoming increasingly widespread, but their deployment can cause significant problems in industrial complexes due to electromagnetic interference. This interference can directly affect production or communication equipment (Danys et al., 2022).

When a failure or inaccuracy occurs in a production process in which Industry 4.0 is implemented, and relatively extended downtime is likely to occur. The lengthy process of diagnosing the problem, encompassing all its consequences, often takes a considerable amount of time before technicians can identify the root cause. This process is often delayed by the intercorrelation of problems, where one problem is related to several others, significantly slowing down the discovery of the cause. Once the problem has been detected, the question of its criticality arises, but the process does not end there. This is often followed by a repair that can be just as time-consuming, which may be prolonged by waiting for a replacement part or a more specialized mechanic. Suppose the problem is not severe and the situation permits it. In that case, it is possible to continue production with the machine despite the malfunction. However, there are situations where this is not possible, resulting in downtime, which can lead to significant financial losses for the company, including lost orders and customers (Reis and Gins, 2017).

2.5. Change management models and Industry 4.0 adoption

The literature provides specific information on how to use a range of change models to implement Industry 4.0 in companies or their individual organizational units. The use of the ADKAR model in the implementation of Industry 4.0 in manufacturing has been documented (Mofolasayo et al., 2022). Within this model and the introduction of modern technologies, various aspects can be discussed within the individual phases. In the Awareness phase, it is necessary to focus on employees and introduce the change. In contrast, in the second phase, resistance must be reduced through sufficient education about modern technologies and explaining that they do not pose a threat. In the third step, it is necessary to increase employees' Knowledge through training focused on the technology in question. In the fourth phase, it is essential to apply the technology, and at the same time, management support is crucial in solving problems. The final phase is devoted solely to maintaining change (Chaabi, 2022). The ADKAR model is therefore used when implementing Industry 4.0 in companies, and it provides specific recommendations for managers, e.g., in the form of timely training, communication, and cohesion.

Information can also be found on the use of the 7S model in the implementation of Industry 4.0. It has been found that the absolute basis is the correct definition of the strategic implementation plan (strategy element), with significant attention also being paid to financing the change, employee readiness and skill levels with the involvement of training (staff element), as well as the issue of benefits resulting from the change in the form of modern technologies and the impact of these benefits on shared corporate values as a connecting element within this model (Červený et al., 2022). This model can also be used to assess the readiness of the organization itself or to analyse individual elements. This can reveal various conclusions, such as the level of communication within the company, which is necessary for the successful implementation of Industry 4.0, how management support works within the company and what management style is applied, or what the structure of the company is, whereby it is possible to identify, for example, the persons responsible for the given departments and implementation (Michulek & Križanová, 2022).

Lewin's model can also be used when implementing Industry 4.0. This model identifies specific driving and restraining forces. Driving forces include factors such as supply chain transparency, ROI, and company management. High initial investments, resistance to change, and the risk associated with the implementation of modern technologies are identified as restraining factors, with resistance to change being identified as the strongest factor (Ramos et al., 2021). The literature also sets out 14 principles for implementing Industry 4.0, divided into the phases of thawing, change, and freezing, with a strong emphasis on business processes (Hatoum et al., 2021).

The information provided shows that change models are directly linked to financially demanding and organizationally complex changes, such as the introduction of Industry 4.0, where they contribute to successful implementation. At the same time, they identify specific management recommendations for SME management, for example, in the form of timely training and its forms, types of financing, ways to overcome employee resistance and generally reduce obstacles, and ways to analyse the situation before implementation in order to determine the current state of the company.

3. METHODS

The main aim of this paper is to evaluate whether the concept of Industry 4.0 influences current change management in small and medium-sized enterprises and what obstacles prevent its wider implementation. Based on the literature review, a questionnaire was developed, and the results of this questionnaire can be used to achieve the set aim.

3.1. Methodological approach

Before the main aim could be achieved, it was necessary to conduct a literature review. As Snyder (2019) points out, the need for high-quality literature reviews is constantly growing. There are several reasons for this, ranging from the ever-increasing amount of published knowledge and facts to the high fragmentation of research. Additionally, they provide clear information on the current state of research in a specific field. The main reason for conducting a literature review in this research is the need for comprehensive information on change management, change management models, Industry 4.0, and its advantages and disadvantages. The principal authors who have contributed significantly to obtaining a comprehensive overview of the researched topic include Errida and Lofti (2021), Javaid et al. (2022a), Javaid et al. (2022b), Owalla et al. (2022), Harrison et al. (2021), Hussain et al. (2018), Kotter (2015), Balluck et al. (2020), Odeh (2021), Ghobakhloo et al. (2023), Soomro et al. (2021), Suleiman et al. (2022), Rai et al. (2021), and Ramos et al. (2021). These authors also provided the framework for the questionnaire used in the research.

The second step was to develop a questionnaire as a tool for collecting data from individual respondents (French, 2012). Questionnaire surveys are one of the most common methods of quantitative research. This type of research has several advantages and disadvantages compared to qualitative research. For example, it provides the possibility of generalizing results and explicitly testing hypotheses, and its results can be reproducible (Lim, 2025).

The proposed questionnaire consisted of a total of 34 questions. The first six questions were used to identify the company (CZ-NACE, number of employees, age of the company, respondent's position, and presence of cooperation with foreign companies in two questions), followed by 11 questions on change management and 17 questions focused on Industry 4.0. Eight questions were open-ended, and 26 were closed-ended. The closed questions used dichotomous questions (yes/no) or a Likert scale of 1-4. An even number on the scale was chosen to eliminate the middle option so that it would not be possible to remain neutral (Joshi et al., 2015). A total of nine questions from the questionnaire were used for this paper.

A pilot study was conducted prior to the actual survey. Its respondents were managers and owners of SMEs. The aim of this pilot study was to verify whether the questions asked were understandable and relevant to the topic, and whether the answers would be relevant to the topic under investigation (Anupama et al., 2023). The total number of respondents in the survey was 10. Based on this, 5 questions were modified, 2 questions were deleted, and 4 new questions were added, which the respondents considered important and whose presence in the questionnaire was, in their opinion, very important. The research itself focuses on small and medium-sized enterprises in the Czech Republic. This paper utilizes data collected through a questionnaire survey, yielding a total of 203 responses in the survey. Data collection took place in the spring and summer of 2024. The average time taken by respondents to complete the questionnaire was 14 minutes and 36 seconds. The survey was conducted online via email. The selection of enterprises for the survey was conducted in a manner that ensured the highest possible consistency with the CZ-NACE classification. The sectoral structure was considered in a targeted manner to achieve greater analytical relevance. The sample was formed according to the principles of stratified selection to mimic sectoral representation according to the CZ-NACE classification (Iliyasu and Etikan, 2021). Relatively balanced sectoral representation was achieved. Unfortunately, some businesses identified themselves as belonging to a different group than the one they are registered with, which causes disproportions in the sample.

Three research questions (RQ) were formulated to achieve the main aim:

1. Does the level of knowledge about Industry 4.0 influence the very presence of change management in SMEs?

2. How is the current level of change implementation and what is the role of strategy?

3. What are the main barriers affecting the implementation of Industry 4.0 technologies in small and medium-sized enterprises?

Several statistical methods are used to answer the research hypotheses and research questions. However, Shapiro's test is used at the very beginning to determine the normality of the data (Mishra et al., 2019), and Cronbach's alpha as an indicator of data reliability (Tavakol and Dennick, 2011). Within the analysis itself, Spearman's correlation coefficient was primarily used to determine the relationships between two variables (Wiśniewski, 2022), as was the chi-square test of independence (McHugh, 2013). Factor analysis was used to identify hidden (latent) factors or structures in a larger number of variables, including tests that predetermine data for possible testing using this analysis, namely the Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test (Shrestha, 2021). Ordinal logistic regression is then used to determine importance of single variables for different size categories of companies (Fagerland and Hosmer, 2017). The Kruskal-Wallis test was used to determine the presence of significant difference between individual categories of companies (Ostertagova et al., 2014). To determine between which specific categories the difference was reported, Dunn's post-hoc test was applied (Dinno, 2015). All tests were performed at a typical significance level of 0.05 (Khan, 2021). Frequency tables and graphs were also used throughout the analysis.

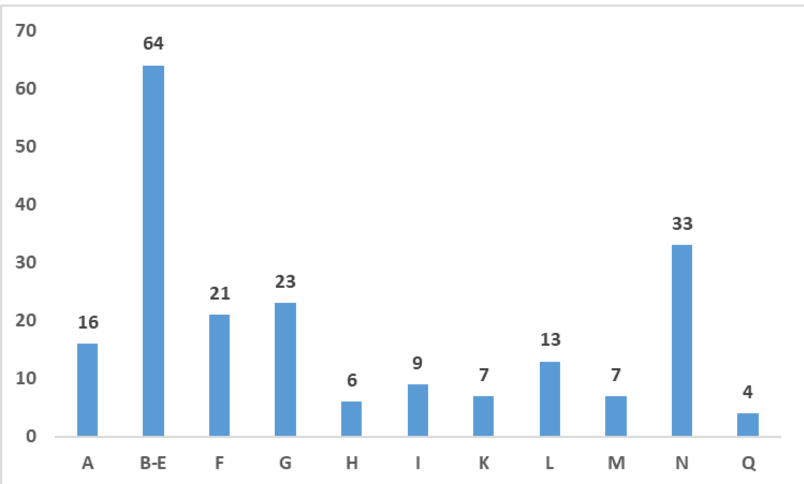
3.2. Main sample characteristics

As mentioned above, this research works with a total of 203 responses, of which 95 companies (46.80%) have established some form of foreign cooperation. The average number of employees per company in the sample, rounded to the nearest whole number, is 29, and the average age of the companies is 20.7 years.

Micro-enterprises are the most represented, with 101 representatives (which accounts for 49.75% of the sample), followed by 64 small enterprises (31.53%) and medium-sized enterprises, which comprise 38 (18.72%) in the sample. Within the Czech Republic, the Czech Statistical Office (b) (n.d.) reports the following numbers of entities with identified activity based on size categories: 1 295 895 micro-enterprises (75.51%), 62 256 small enterprises (3.63%), and 15 032 (0.88%) medium-sized enterprises. A total of 1 716 200 SMEs with confirmed activity are registered in the Czech Republic.

The field of business activity of the companies was also surveyed. The activities were then assigned to the relevant CZ-NACE categories. The NACE classification of economic activities is a generally recognized standard that can also be used for international comparisons (Jurigova, 2016). The classification methodology, as outlined by the Czech Statistical Office (a) (n.d.), was employed to illustrate the scope of individual companies. The CZ-NACE codes covering enterprises that are not primarily business entities, i.e., codes O and P (Activities in the field of public administration, defence, compulsory social security, and Education), are excluded from the research. The breakdown of the sample is shown in Figure 7. Table 1 presents a comparison of the sample structure according to CZ-NACE and the structure of the national economy as reported by the Czech Statistical Office (a) (n.d.).

Fig. 7 Distribution according to CZ-NACE



Source: Own processing

As shown in Figure 7, the distribution by activity is diverse. CZ-NACE codes C and N (manufacturing; administrative and support activities) are particularly well represented, followed by F (construction) and G (wholesale and retail trade). However, other sectors and activities are also represented. When obtaining data from the Czech Statistical Office database, only companies with confirmed activity were included.

Tab. 1 Comparing of distribution according to CZ-NACE

	Research Sample		**Czech Republic**	
	Absolute frequency	Relative frequency (%)	Absolute frequency	Relative frequency (%)
A	16	7.88	93 590	5,45
B-E	64	31.53	234 365	13.66
F	21	10.34	213 712	12.45
G	23	11.33	232 901	13.57
H	6	2.96	61 676	3.59
I	9	4.43	77 642	4.52
K	7	3.45	40 439	2.36
L	13	6.40	96 304	5.61
M	7	3.45	252 162	14.69
N	33	16.26	49 578	2.89
Q	4	1.97	31 049	1.81

Source: Own processing according to Czech Statistical Office (a) (n.d.).

4. RESULTS

First, the normality of the obtained data was tested. The Shapiro-Wilk normality test was chosen for this test. The testing was performed at a standard significance level of 0.05. The following hypotheses are standard for this test:

H_0: The data come from a normal distribution.

H_A: The data do not come from a normal distribution.

The resulting **p-values** for the examined data set are all **well below the 0.05 level**. The null hypothesis of data normality is therefore rejected. It was also necessary to examine the internal reliability of the data. Cronbach's alpha was calculated to determine this. Table 2 shows the detailed results of this test. However, as can be seen, the results of the analysis are excellent, with the alpha itself reaching a **value of 0.91**, which indicates very high reliability, i.e., internal consistency of the data. Generally, all values above 0.90 are considered excellent results (Tavakol and Dennick, 2011). We also observe good results in the average correlation between items (Average r), standard deviation, and standard error of alpha (ASE). The reliability of the data is excellent.

Tab. 2 Cronbach's alpha

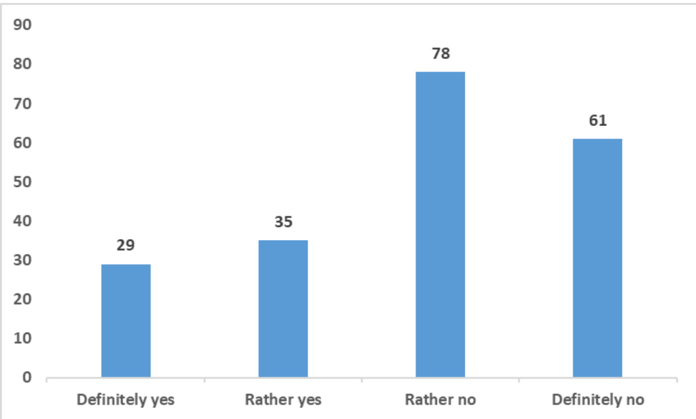
Alpha	Average r	Standard deviation	ASE
0.91	0.097	0.29	0.026

Source: Own processing

Subsequently, specific research questions were addressed. RQ1, *"Does the level of knowledge about Industry 4.0 influence the very presence of change management in SMEs?"*, was investigated first. Two questions from the questionnaire survey were crucial for answering this question, namely whether companies implement change management and whether, in the opinion of the respondents, Industry 4.0 influences the system by which the company manages change. Both questions were rated on a Likert scale of 1 to 4, with 1 meaning "Definitely yes" and 4 meaning "Definitely no."

The introductory part of this issue is devoted to the descriptive characteristics of both questions. First, it will be described whether companies have an established change management system. The distribution is shown in Figure 8.

Fig. 8 Implementing systematic change management



Source: Own processing

As Figure 8 shows, the highest proportion of companies (78 and 38.42%, respectively) do not have systematic change management in place. 61 (30.05%) of companies have not implemented this management at all. In general, companies do not manage change systematically. Only 29 (14.29%) chose the option "definitely yes," while 35 (17.24%) chose "rather yes." Overall, however, systematic change management is not occurring in many companies, with an average mean score of 2.84, which is located in the worse part of the scale.

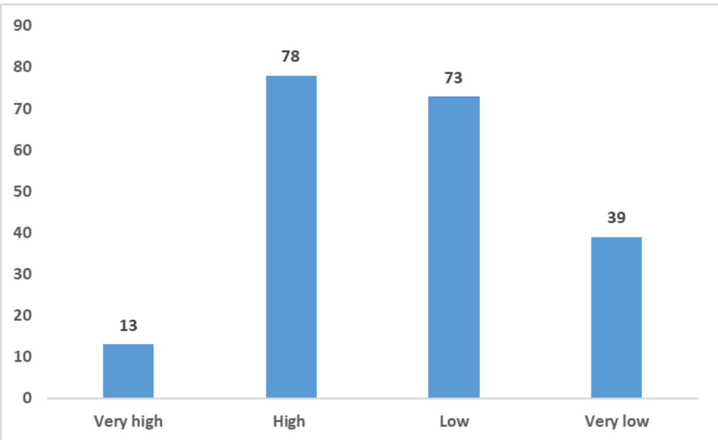
Subsequently, it was investigated whether there was a significant difference in the existence of change management between the individual size categories of companies. The Kruskal-Wallis test was used, and the following hypotheses were established:

H_0: Change management is the same for all size groups.

H_A: Change management differs across size groups.

The resulting **p-value** of this test is **well below the 0.05 threshold**, thus rejecting the null hypothesis. It was found that the size of the enterprise influences whether it systematically manages change. To determine which specific size categories these differences exist between, Dunn's post-hoc test was applied. This test revealed significant differences (p-value significantly lower than 0.05) between micro-enterprises and medium-sized enterprises, as well as between small enterprises and medium-sized enterprises. No statistically significant difference was found between micro-enterprises and small enterprises (p-value 0.134). Micro and small businesses often do not implement change management as a discipline, whereas it is more common in medium-sized businesses. Afterward it was observed whether respondents know what Industry 4.0 means. The distribution is shown in Figure 9.

Fig. 9 Industry 4.0 awareness



Source: Own processing

The results indicate that the highest proportion of respondents, specifically 78 (38.43%), have a high awareness of this term. However, 73 (35.96%) of respondents believe that their awareness and knowledge of Industry 4.0 is low. A very low level of knowledge about this concept is reported by 39 (19.21%) of respondents, while only 13 (6.40%) report a very high level of knowledge. Overall, awareness of Industry 4.0 is relatively bad, although responses on the negative side of the scale predominate. Average mean score is 2.68, again located on the negative part of the scale.

Within this variable, it was also investigated whether there were statistically significant differences between individual size categories of companies. Again, the Kruskal-Wallis test was used. The following hypotheses were established:

H_0: Industry 4.0 awareness is the same for all size groups.

H_A: Industry 4.0 awareness differs across size groups.

The resulting **p-value is 0.343**. Therefore, the null hypothesis cannot be rejected, as it has not been proven that knowledge of Industry 4.0 differs across size categories. For example, it cannot be claimed that managers of medium-sized enterprises are more familiar with this concept than managers of small enterprises.

The chi-square test was used to verify the presence of a relationship between presence of systematic change management and awareness about Industry 4.0. Fourth Industrial Revolution is perceived as one of the primary catalysts for organizational and technological change, and a company's ability to manage these changes systematically can be crucial to its successful implementation (Mrugalska and Ahmed, 2021). Brodeur et al. (2023) also discuss the fact that Industry 4.0 influences change processes in companies. Based on the literature, it is therefore justified to examine this issue. The following hypotheses were tested:

H_0: There is no relationship between the awareness of Industry 4.0 and the implementation of systematic change management.

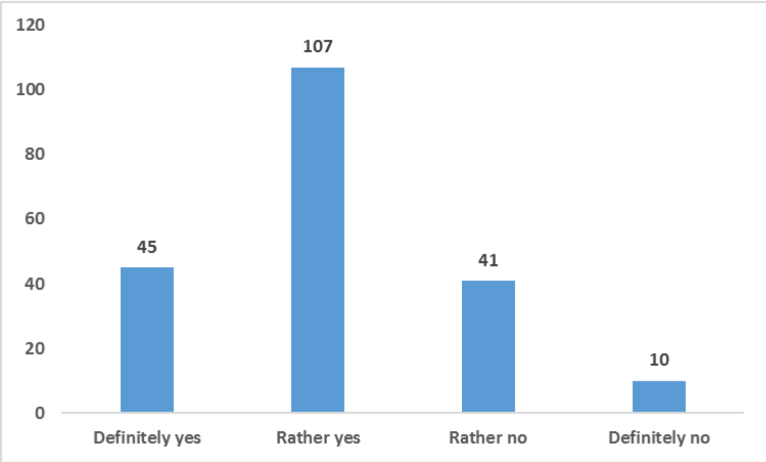
H_A: There is a statistically significant relationship between the awareness of Industry 4.0 and the implementation of systematic change management.

The chi-square test verified whether there is a statistically significant relationship between awareness of Industry 4.0 and whether the company implements systematic change management. The results show a significant relationship between these variables, as the **p-value is well below the 0.05** significance level. We, therefore, reject the null hypothesis in favour of the alternative hypothesis. The awareness of the influence of Industry 4.0 affects change management in the company and the very existence of this discipline in the company. Specifically, it has been observed that companies that perceive the impact of Industry 4.0 also have a change management system in place. In contrast, companies that do not perceive the impact of Industry 4.0 often lack a change management system.

Based on the results of the chi-square test, the RQ1 *"Does the level of knowledge about Industry 4.0 influence the very presence of change management in SMEs?"* can be answered in the affirmative. A statistically significant correlation ($p < 0.05$) confirms that small and medium-sized enterprises that perceive Industry 4.0 as a relevant and influential factor are also significantly more likely to have systematic change management in place. The perception of Industry 4.0, therefore, significantly influences the very presence of change management in companies.

Subsequently, RQ2, *“How is the current level of change implementation and what is the role of strategy?”* was addressed. To answer this question, a total of four questions from the questionnaire survey were analysed. A descriptive overview of the answers to these questions is now provided. The first question concerns whether changes in companies are generally accepted positively. Figure 10 illustrates the distribution of responses, while Table 3 presents the distribution of responses categorized by individual company size. Question was rated on a Likert scale of 1 to 4, with one meaning "Definitely yes" and four meaning "Definitely no."

Fig. 10 Acceptance of changes



Source: Own processing

Tab. 3 Acceptance of changes according to the size

	Absolute frequency				**Relative frequency (%)**			
Size category	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Micro	23	47	26	5	11.33	23.15	12.81	2.46
Small	11	37	11	5	5.42	18.23	5.42	2.46
Medium-sized	11	23	4	0	5.42	11.33	1.97	0.00

Source: Own processing

As shown in the Figure 10, changes in companies are generally accepted positively. The answer “rather yes” prevails, with a 107 (52.71%) share, followed by “definitely yes” with 45 (22.17%) answers. The answer “rather no” occurs in 41 (20.20%) of cases, with the remainder 10 (4.92%) choosing the option “definitely no.” The average mean score is 2.08, indicating that changes in companies are generally positively received.

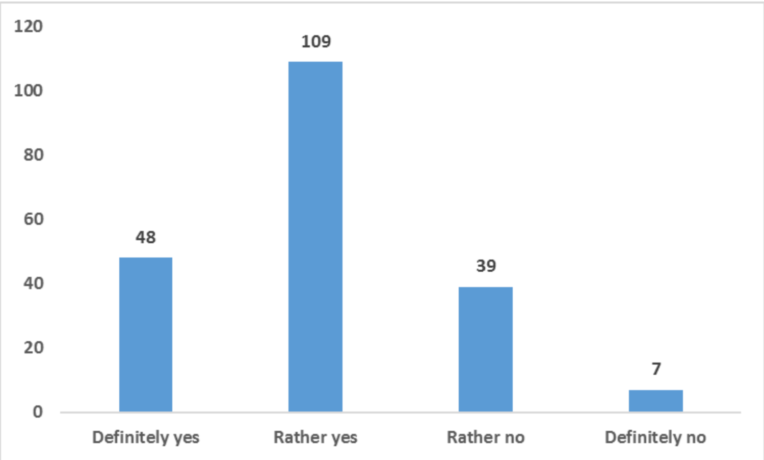
Within this variable, it was also investigated whether there were statistically significant differences between individual size categories of companies. Again, the Kruskal-Wallis test was used. The following hypotheses were established:

H_0: Acceptance of changes is the same for all size groups.

H_A: Acceptance of changes differs across size groups.

The resulting **p-value is 0.089**. Therefore, the null hypothesis cannot be rejected, as it has not been proven that acceptance of changes differs according to size categories. Although there are differences, they are not statistically significant. Next, the question of whether the changes have been successfully implemented is evaluated descriptively. Figure 11 provides an overall evaluation of the distribution of responses, and Table 4, as in the previous case, shows the distribution of responses by size category. The question was rated on a Likert scale of 1 to 4, with one meaning "Definitely yes" and four meaning "Definitely no."

Fig. 11 Successful implementation of changes



Source: Own processing

Figure 11 shows that the implementation of changes, like their positive acceptance, is at a very good level. 53.69% (109) of companies report that changes are rather well implemented, with another 48 (23.65%) reporting that they are very well implemented. 19.21% (39) of companies claim that changes are poorly implemented, with 7 (3.45%) stating that they are not well implemented at all. The overall mean score is 2.02, which indicates that changes are generally well implemented in companies.

Tab. 4 Successful implementation of changes according to the size

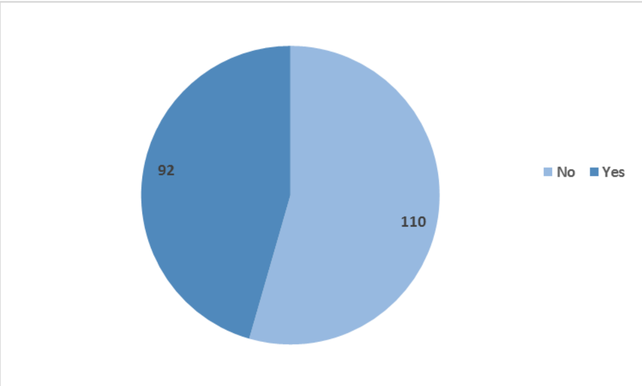
	Absolute frequency				Relative frequency (%)			
Size category	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Micro	25	45	27	4	12.32	22.17	13.30	1.97
Small	13	39	9	3	6.40	19.21	4.43	1.48

Medium-sized	10	25	3	0	4.93	12.32	1.48	0.00

Source: Own processing

However, the differences between the groups are not statistically significant, as indicated by the **p-value** of the Kruskal-Wallis test, which **is 0.173**. Companies were also asked whether they had a strategic plan or strategy in place. Respondents answered this question with a yes or no. The distribution of responses is shown in Figure 12. One company did not wish to disclose the information.

Fig. 12 Strategy or strategic plan



Source: Own processing

The companies were then asked about factors that could contribute to more successful implementation of changes. These factors were communication, leadership, teamwork, financial resources, planning, management support, and knowledge of change management principles. These factors were selected based on the literature (Appelbaum et al., 2017; Dempsey et al., 2022; Straková et al., 2024). Subsequently, the relationship between these variables was observed. This analysis was performed using Spearman's correlation. The results are shown in Table 5.

Tab. 5 Correlation analysis

	Positive acceptance		**Successful implementation**	
Factor	**Correlation coefficient**	**p-value**	**Correlation coefficient**	**p-value**

Communication	-0.034	0.627	0.079	0.259
Leadership	-0.027	0.697	0.091	0.198
Teamwork	-0.0321	0.649	0.111	0.116
Financial resources	0.003	0.962	0.042	0.553
Planning	-0.106	0.133	-0.062	0.383
Management support	-0.039	0.580	0.019	0.785
Change management knowledge	0.073	0.301	0.136	0.052

Source: Own processing

An analysis of the relationship between factors that can contribute to successful change management, positive acceptance of change, and successful implementation shows the following results. In general, weak to very weak relationships were found between the analysed factors and changes. The most significant relationship can be observed between the factor "knowledge of change management" and "success of change implementation," with a correlation coefficient of 0.136. However, the **p-value (0.052)** is very close to the level of statistical significance. This is a significant finding, suggesting that awareness of change management models and principles contributes to better implementation of changes.

In contrast, no relationship with any of the evaluated factors is observed for "positive acceptance of change." Based on this result, it can be concluded that the positive acceptance of change by company employees may depend on other circumstances that are qualitative in nature, such as the opportunity to participate in the change process or prior experience. Weak correlations may also indicate a low variance in responses. It is, therefore, necessary to interpret the results with caution and to apply qualitative analysis as well.

To gain a deeper understanding of individual factors, correlation analysis was also employed to examine the relationships between these factors. The results are shown in Table 6. For greater clarity, the individual factors were coded using the following abbreviations: Communication (COM), Leadership (LEA), Teamwork (TWK), Financial Resources (FIN), Planning (PLA), Management Support (SUP), and Change Management Knowledge (CHA).

Tab. 6 Correlation matrix

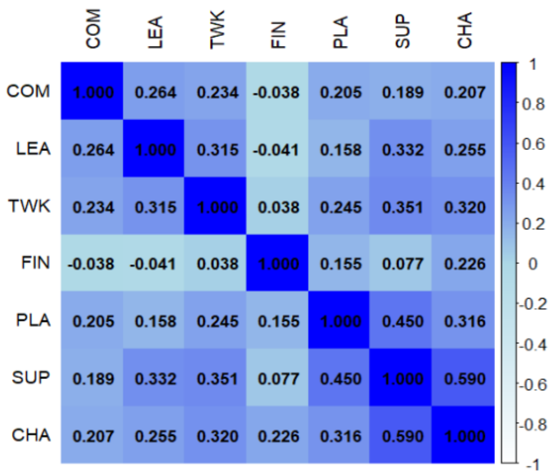
	COM	LEA	TWK	FIN	PLA	SUP	CHA
COM	1.000	0.264	0.234	-0.038	0.205	0.189	0.207
LEA	0.264	1.000	0.315	-0.041	0.158	0.332	0.255
TWK	0.234	0.315	1.000	0.038	0.245	0.351	0.320
FIN	-0.038	-0.041	0.038	1.000	0.155	0.077	0.226
PLA	0.205	0.158	0.245	0.155	1.000	0.450	0.316
SUP	0.189	0.332	0.351	0.077	0.450	1.000	0.590
CHA	0.207	0.255	0.226	0.226	0.316	0.590	1.000

Source: Own processing

Based on the analysis, several correlations are evident. The most significant correlation (r = 0.590) was found between management support and change management knowledge, indicating that a higher level of knowledge and the use of change management models are associated with management support during the change process. A high correlation is also evident between management support and planning (0.450).

In contrast, some factors, such as communication or financial resources, show very weak correlations. Overall, certain factors tend to occur and work together, supporting one another and facilitating the change process. These are mainly factors related to organizational change management. For better visualization, a correlation matrix heat map is provided, as shown in Figure 13.

Fig. 13 Heat map of correlation analysis



Source: Own processing

To determine the role of strategy in the process of successful change management, the chi-square test was again applied. Strategy, or strategic management, should play an indisputable role in the process of implementing changes, which should be anchored and in line with the long-term goals of the organization. The connection between strategy and organizational changes is also a frequently discussed topic. (Zubac et al., 2021; Bakir and Tyas, 2024). The following hypotheses were established:

H_0: There is no statistically significant relationship between the existence of a strategic plan in a company and the successful implementation of changes.

H_A: There is a statistically significant relationship between the existence of a strategic plan in a company and the successful implementation of changes.

After verifying that companies that engage in strategic planning report higher success rates in implementing changes, the following conclusions can be drawn: the **p-value of 0.002** is less than the confidence level of 0.05, so the null hypothesis can be rejected in favour of the alternative hypothesis. The analysis shows a clear statistically significant relationship.

Companies that implement strategic management or have a strategy in place are more successful in implementing changes, while companies without strategic documents are less successful. Strategic planning is a crucial factor, suggesting that the strategic planning of changes in SMEs is a vital component in their successful management. This result highlights the importance of aligning change management with the company's long-term objectives.

The answer to RQ2 may be as follows. Changes are implemented and accepted successfully and positively in most companies. Strategy plays a crucial role in the implementation of change. The results show that companies with a strategy in place report higher success rates in implementing changes. Several factors identified as supporting the successful implementation of change played only a partial role, as no significant links to the success of implementation or positive acceptance were found. However, mutual relationships between them can be seen, especially in the area of organizational factors.

The final research question is RQ3: *"What are the main barriers affecting the implementation of Industry 4.0 technologies in small and medium-sized enterprises?"*

Responses from the questionnaire survey were again used to evaluate this question. Based on the literature (Kapler, 2021; Narwane et al., 2020; Raj et al., 2020), the following barriers to the implementation of modern technologies were considered: Financial cost, Uncertain benefits, Insufficient employee qualifications, Insufficient technical infrastructure, Employee resistance to change, Deterioration of the relationship with sustainable business, and Lack of trust in new technologies. Respondents also rated these barriers on a scale of 1 to 4, with one indicating that it is a barrier and four indicating that it is not a barrier. The frequency of individual responses is shown in Table 7. Table 8 then provides single average mean scores for each barrier.

Tab. 7 Barriers to Industry 4.0

	Absolute frequency				**Relative frequency (%)**			
Barrier	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Financial cost	97	39	56	11	47.78	19.21	27.59	5.42
Uncertain benefits	27	29	91	56	13.30	14.29	44.82	27.59
Insufficient employee qualifications	32	40	71	60	15.76	19.70	34.98	29.56
Insufficient technical infrastructure	29	52	58	64	14.28	25.62	28.57	31.53
Employee resistance to change	28	20	107	48	13.79	9.85	52.71	23.65
Deterioration of the relationship with sustainable business	6	11	103	83	2.96	5.42	50.74	40.88
Lack of trust in new technologies	25	26	104	48	12.31	12.81	51.23	23.65

Source: Own processing

Tab. 8 Mean scores for barriers

Barrier	**Average mean score**
Financial cost	1.91
Uncertain benefits	2.87

Insufficient employee qualifications	2.78
Insufficient technical infrastructure	2.77
Employee resistance to change	2.86
Deterioration of the relationship with sustainable business	3.30
Lack of trust in new technologies	2.86

Source: Own processing

The average scores indicate that the financial costs associated with investing in modern technologies are considered the most significant barrier to adoption. On the other hand, the deterioration of the relationship with sustainable business has the highest average, indicating that respondents perceive it as the least serious obstacle. Other factors achieved approximately the same values, which shows that they are still perceived as obstacles, but not too intensely.

To determine which barriers play the most important role, factor analysis was applied in the first step, including tests that predetermine data for possible testing using this analysis, namely the Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test. This analysis was primarily used to determine whether there are certain groups of barriers with similar characteristics. The first step was to apply the Kaiser-Meyer-Olkin (KMO) test. The test revealed an overall test statistic of 0.57, which, according to the literature (Shrestha, 2021), is not a sufficient value. The weakest value was shown by the factor “Uncertain benefits” (0.42), so it was excluded from the analysis. Subsequently, the KMO test value reached 0.61, which can be considered a sufficient value for factor analysis. Bartlett's sphericity test was then performed. The following hypotheses were established for this test:

H_0: The variables are orthogonal

H_A: The variables are not orthogonal.

The **p-value** of the test is significantly **below the 0.05 threshold**, allowing the null hypothesis to be rejected in favour of the alternative hypothesis. In other words, the correlation matrix differs significantly from the unit matrix, indicating statistically significant correlations between the variables. This conclusion is suitable for factor analysis.

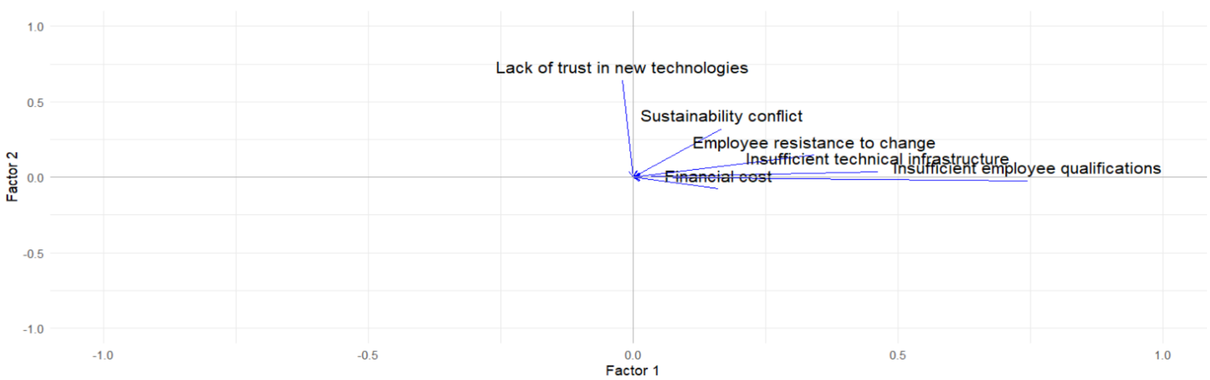
Subsequently, the factor analysis itself was performed. Although the parallel analysis did not indicate a clear factor structure, the two-factor model revealed two distinct groups of barriers. The first factor includes technical and personnel elements (Insufficient employee qualifications, Insufficient technical infrastructure, Employee resistance to change). In contrast, the second includes value aspects (Lack of trust in new technologies and Deterioration of the relationship with sustainable business). The results themselves are shown in Table 9 and Figure 14. Two groups of factors were thus identified: technical and personnel readiness on the one hand and relational and value readiness on the other.

Tab. 9 Factor analysis

Factor	Technical and personnel readiness	Relational and value readiness
Financial cost	< 0.3	< 0.3
Insufficient employee qualifications	0.745	-
Insufficient technical infrastructure	0.463	-
Employee resistance to change	0.341	-
Deterioration of the relationship with sustainable business	-	0.323
Lack of trust in new technologies	-	0.643

Source: Own processing

Fig. 14 Factor loading plot



Source: Own processing

Based on factor analysis, it was identified that the barriers to implementing Industry 4.0 in small and medium-sized enterprises can be divided into two main factors. The first factor, which can be interpreted as technical and personnel readiness, primarily includes insufficient employee qualifications, weak technical infrastructure, and resistance to change. These barriers reflect internal company capacities and readiness for change.

The second factor primarily consisted of mistrust of new technologies and conflict with the principles of sustainable business, which can be interpreted as relating to relational and value readiness. This factor highlights deeper cultural and strategic concerns that can significantly impact companies' willingness to adopt digital transformation. The factor map showed a clear division of variables into these two dimensions, with technical and value barriers differing spatially.

The variable "Financial cost" was not included in any of the extracted factors, as its factor loadings remained below the interpretatively significant threshold (0.3) as stated by Samuels (2017). This suggests that financial costs represent a separately perceived barrier that is not significantly linked to either of the two main latent dimensions identified in the sample.

Subsequently, it was determined which barriers are key for which size categories of enterprises. Ordinal logistic regression was used to determine the results. The results are shown in Table 10. Based on the analysis, the following results were observed regarding the perception of barriers to implementing Industry 4.0 across different enterprise size categories. It is imperative to note that two factors were found to be statistically significant. The following pair of hypotheses was established for each barrier monitored:

H_0: The size of the company does not influence how respondents evaluate the given variable as an obstacle.

H_A: The size of the company influences how respondents evaluate the given variable as an obstacle.

Tab. 10 Ordinal logistic regression

Factor	Coefficient	T-value	P-value
Financial cost	-0.327	-1.881	0.0599

Uncertain benefits	-0.223	-1.331	0.183
Insufficient employee qualifications	-0.543	-3.252	0.001
Insufficient technical infrastructure	-0.015	-0.092	0.927
Employee resistance to change	-0.379	-2.163	0.031
Deterioration of the relationship with sustainable business	-0.009	-0.049	0.961
Lack of trust in new technologies	0.066	0.387	0.699

Source: Own processing

The most significant difference is observed in the obstacle of insufficient employee qualifications. Here, there is a negative coefficient and a statistically significant p-value. In other words, the smaller the company, the more this variable is an obstacle to it. The same trend was also observed in the barrier of employee resistance, with a negative coefficient and a low p-value. The other variables monitored were not found to be statistically significant. The only obstacle that is more of a concern for small and medium-sized enterprises (as it has a positive coefficient) is the lack of trust in new technologies. However, this barrier was not found to be statistically significant.

The conclusion from this analysis is that only two barriers are statistically significant: insufficient employee qualifications and employee resistance, both of which are more concerning for smaller enterprises. Other barriers, except for a lack of trust in new technologies, are also more prevalent in smaller enterprises, but they are not statistically significant.

In response to RQ3, the implementation of Industry 4.0 in small and medium-sized enterprises is primarily hampered by a lack of skilled labour, financial costs, and employee resistance to change. These barriers are most pronounced in smaller enterprises, which often lack both the human and material capacities needed to transform towards Industry 4.0.

Table 11 below serves to anchor empirical findings within the framework of change models. Each identified barrier is assigned the most appropriate change model and immediately suggests a practical intervention and KPIs for verification.

Tab. 11 Connection between barriers of Industry 4.0 a change management models

Barrier	Change model	Action	KPI
Financial cost	Kotter (urgency, coalition, quick wins)	1 process pilot; trial license; business case; monthly steering	Pilot payback (months); savings per cycle/shift; achieved quick-win milestones
Insufficient employee qualifications	ADKAR (knowledge, ability)	Micro-modules (30–45 min) + on-the-job mentoring; buddy system	Pre/post skills test; % of successful interventions
Insufficient technical infrastructure	McKinsey 7S (systems, structure) + Kotter (vision, milestones)	"As-is / to-be" infrastructure workshop; process owner appointed; roadmap of replacements	Number of hand-off errors; achieved integration milestones
Employee resistance to change	ADKAR (awareness, reinforcement)	Visualize benefits; voluntary version of the tool, peer champions	Adoption rate; count of reverts to old practice
Lack of trust in new technologies	Kotter (vision, communication) + Lewin (unfreeze)	Evidence-based demo on real data, reference-site visit, leadership	Attitude shift; demo participation; number of concerns addressed
Deterioration of the relationship with sustainable business	7S (shared values, style) + Lewin (refreeze)	Map I4.0 impacts on ESG, adjust roles; embed metrics into reporting	ESG/KPI trend; 7S alignment pre/post; quality incidents

Source: Own processing

Table 11 presents specific benefits, particularly in the form of linking results to practice, and takes into account the reality of SMEs, as it recommends specific, measurable, short-term steps and their ongoing validation and measurement. In the context of the entire study, the table serves to operationalize the findings within change management frameworks and shows how the barriers can be overcome based on an appropriate model, proposing interventions and KPIs to determine whether the change is actually working.

5. DISCUSSION

The results of this research provide fascinating insights into Industry 4.0 and change management. Based on the three research questions, their conclusions can be discussed by comparing them with other studies.

The first research question found that companies with managers or owners who are more aware of Industry 4.0 try to manage change systematically. This conclusion was also supported by statistical significance. This result indicates that companies that recognize the need to respond to digital transformation are better equipped to manage change through their internal processes. This is also supported by Brodeur et al. (2023), who argue that implementing new technologies requires not only knowledge of change management but also an understanding of technological trends themselves and the active involvement of company management. Mrugalska and Ahmed (2021) note that the implementation of Industry 4.0 is closely tied to change management, a company's readiness for change, and its capacity to manage the entire change process. The results also suggest that a lack of awareness of Industry 4.0 is an obstacle to systematic change management.

Another research question showed that changes in SMEs are accepted and implemented relatively successfully. At the same time, a significant correlation was found between whether companies follow a pre-defined strategy and how successfully changes are implemented. Several studies also confirm the importance of strategy as one of the key success factors. Appelbaum et al. (2017) even state that the success of the change project itself is important for future strategy. Strategy is also an important metric for setting goals within a change project, but it can also support the management of resistance to change or communication with internal stakeholders (Dempsey et al., 2022). In addition, Ghobakhloo et al. (2023) note that implementing Industry 4.0 necessitates integrating the defined digital strategy with other functional areas of the company. The results of this study thus confirm that companies with a defined strategy not only accept change more effectively but are also better able to implement these changes effectively—which is a key factor for future digitalization.

Within the third research question, factor analysis revealed that the main barriers to implementing Industry 4.0 can be divided into two or three groups. The first focuses on technical and personnel readiness, while the second focuses on relational and value readiness. The third, separate group is financial costs. In addition, it was found that the smaller the company, the more it is affected by barriers. Pech and Vaněček (2022) state that, in addition to financial barriers and the need for high initial investments, the low ability of managers to evaluate the benefits of technology also plays a role. In addition to financial and managerial skills, research into SMEs and barriers to implementing Industry 4.0 also highlights factors related to human resources, such as employee resistance or insufficient digital literacy (Horváth and Szabó, 2019). The research results thus reflect global problems but, at the same time, point to the need to adapt the approach to change management to the size of the enterprise. Micro-enterprises often lack both internal resources and access to expert knowledge.

Despite the benefits and findings, it is also essential to consider the limitations of this study. The first limitation is the geographical scope of the research, which focused only on SMEs in the Czech Republic. Results in other countries may vary due to differences in national policies, as well as cultural and economic variations. At the same time, this is a quantitative research approach, which, while allowing for statistical evaluation, does not provide deeper insight into the processes or decision-making of managers. Therefore, it would be appropriate to include a qualitative component in the research. Another limitation is the use of online distribution of the questionnaire.

However, potential directions for further research can also be mentioned. In the future, it would be beneficial to expand the study to include an international comparison, allowing for a comparison of change management about Industry 4.0 across countries with varying levels of support and economic development. The existing quantitative research can be followed up and expanded with qualitative research in the form of structured or semi-structured interviews with owners and managers of small and medium-sized enterprises across various sectors of the national economy. This expansion would help to understand the decision-making logic of companies when implementing Industry 4.0 and reveal the decision-making logic. Similarly, it would be useful to conduct comparisons over time and across regions in future research. At the same time, it would be beneficial to pay more attention to the impact of specific technologies on various aspects of change management. It would also be helpful to expand the research to include the perspective of employees, as their views are essential for implementing changes in practice.

6. CONLUSION

The main aim of this paper was to evaluate whether the concept of Industry 4.0 influences current change management in small and medium-sized enterprises and what obstacles prevent its wider implementation. This objective was achieved. A questionnaire survey of Czech SMEs revealed that knowledge of Industry 4.0 influences the systematic nature of change management. In companies where the relevance and importance of digital transformation are recognized, changes are systematically and strategically managed. Conversely, where this perception of Industry 4.0 does not apply, a structured approach to change management is often lacking.

The research questions were answered using specific analyses. The first question, focusing on the relationship between knowledge of Industry 4.0 and the existence of change management, was answered positively – statistical analysis confirmed that the perceived influence of Industry 4.0 is significantly associated with the presence of change management in the company. The second question examined the level of change implementation and the role of strategy – the research showed that where a strategic plan exists, change is more often successfully implemented and positively accepted. The third question focused on the main barriers to the introduction of Industry 4.0 technologies, and high costs, insufficient employee qualifications, and employee resistance to change were identified as the primary barriers. These barriers were further analyzed according to company size, with micro and small enterprises being the most affected.

The contribution of this paper lies mainly in linking two areas – digital transformation and change management, all in the context of SMEs. Primary data from the Czech environment is presented. It expands on existing knowledge about the specific factors that influence change management and the introduction of modern technologies. The paper helps to identify specific success factors as well as the main obstacles that companies face.

Based on all the findings, it can be recommended that small and medium-sized enterprises place greater emphasis on systematic change management. This includes not only planning and strategy but also consistent communication, training, and involvement in the change process. Business managers should be trained in change models, as these can be effectively utilized to manage digital transformation. It is also advisable to raise awareness of the specific benefits of Industry 4.0. Recommendations for the government and its institutions can also be provided in the form of educational or financial support programs for SMEs, as they often lack the capacity or expertise to manage the changes associated with Industry 4.0 successfully.

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