ARTIFICIAL INTELLIGENCE FOR SMALL AND MEDIUM-SIZED ENTERPRISES: IDENTIFYING KEY APPLICATIONS AND CHALLENGES

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ABSTRACT

Purpose. Small and medium-sized enterprises (SMEs) play a crucial role in the global economy, yet they often face significant challenges in implementing cutting-edge technologies such as artificial intelligence (AI) due to limited resources and expertise. This study aims to address this gap by identifying the most important applications of AI for SMEs, exploring their benefits and challenges and assessing their impact on business processes.

Design/methodology/approach. A quantitative research approach was employed, including an online survey distributed through various social media platforms. The survey, which was conducted in May 2023, used a standardized questionnaire with closed-ended questions. The survey data were analysed using statistical methods to identify patterns and trends in AI adoption among German SMEs, with a particular focus on their experiences, challenges, and perceived benefits of AI implementation.

Findings. The results of this study highlight the most important AI applications for SMEs in various professions and business activities, including virtual assistants, recommendation systems, and machine learning. The study also highlights the benefits of these applications, such as improved efficiency, productivity, and decision-making, as well as the challenges they present, such as privacy concerns and the need for specialized skills.

Research limitations/implications. The study is limited by the sample size and the self-reported data collected through an online survey. The findings may not be generalizable to all industries and regions. The implications of this study are that SMEs need to carefully consider the potential benefits and challenges of AI before implementing it in their processes.

Originality/value. This study provides a comprehensive overview of the most important AI applications for SMEs and their impact on business processes. Thus, this research serves scientists as a theoretical basis for future research in the field of AI implementation in SMEs. Furthermore, the findings have practical implications for SMEs considering implementing AI in their operations.

Keywords: artificial intelligence, SME, digitalization, business processes.

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INTRODUCTION

In recent years, the rapid development in the field of artificial intelligence (AI) has revolutionised the entire technology landscape and influenced many aspects of modern society. From image recognition to speech processing and automated decision-making, AI technologies have the potential to increase efficiency, accuracy, and innovation in various business areas, such as healthcare (e.g., Rajpurkar et al., 2022), the automotive industry (e.g., Grigorescu et al., 2020), or higher education (e.g., Ma and Siau, 2018). Due to the diverse manifestations and applications, the term "artificial intelligence" is not uniformly defined (Meub and Proeger, 2022; Bunte et al., 2021). McCarthy (2007) defines AI as the development of intelligent machines and computer programs that focus on understanding and mimicking human intelligence but are not limited to biologically observable methods. Other definitions describe AI as a branch of computer science that simulates human intelligence in intelligent machines to enable them to perform a task that normally requires human effort (e.g., Borah et al., 2022; Szedlak et al., 2021; Brynjolfsson and McAfee, 2017). Overall, the term "artificial intelligence" serves as an overarching framework that encompasses various performance components, including those based on advanced techniques such as deep learning, machine learning, and neural networks (Borah et al., 2022; Meub and Proeger, 2022; Tikkanen et al., 2022). These developments have attracted the interest of companies seeking to leverage the benefits of AI to gain competitive advantage.

Small and medium-sized enterprises (SMEs) play a crucial role in the global economy. An annual report by the European Commission (Muller et al., 2021) underlines the immense importance of SMEs for the European economy. In 2020, there will be more than 22 million SMEs in the EU-27, representing 99.8% of enterprises in the non-financial sector. These SMEs contribute significantly to employment as they employ 65% of the workforce in the EU-27. They generate 53% of the EU-27's total value added and drive economic productivity and innovation (Muller et al., 2021). Their adaptability and innovative power make them important drivers of economic productivity, often transforming industries and boosting competitiveness (Brodny and Tutak, 2022). Despite the wide availability of AI technologies and their impressive performance potential, SMEs often struggle to take full advantage of them (Brodny and Tutak, 2022). While large companies in various industries have already made significant progress in implementing AI applications, SMEs face unique challenges that often hinder their adoption of AI solutions, in particular limited financial and human resources. SMEs typically operate with limited budgets and have limited access to capital, making it difficult for them to afford the expensive technologies required for digital transformation (Brodny and Tutak, 2022). This leads to a situation where SMEs face difficulties in transitioning to the use of AI-based solutions, potentially excluding them from the benefits of these technologies. This situation has led to a growing gap between large and small companies, highlighting the need to further investigate the use of AI in SMEs.

This study summarises the German situation regarding the application of AI in SMEs and discusses experiences with the implementation of AI, the challenges encountered and the resulting benefits for the companies. Given the difficulties SMEs face in adapting to market changes, it is important to investigate the integration of AI technologies in these companies and to understand the determinants that influence the adoption of AI in the SME sector. Therefore, the main objective of this study is to

investigate the current state of implementation of AI technologies in German SMEs. Furthermore, the study will provide in-sights into the challenges and opportunities that SMEs face when adopting AI. The study will contribute to a deeper understanding of digital transformation in Germany, with a particular focus on the integration of AI technologies. It also aims to inform policymakers, industry players and SMEs themselves about strategies and support mechanisms that can facilitate the successful adoption of AI in SMEs. Therefore, the following research questions will be answered in this study:

1. What are the barriers and challenges SMEs face in adopting AI, and what measures can be taken to overcome these barriers and promote the wider use of AI technologies in SMEs?

2. What is the current state of use of AI in SMEs, in particular in terms of areas of application, challenges and opportunities?

This research is structured as follows: First, in Section 2, the importance of digitalization for SMEs in Germany is explained. After this, related work on the implementation of AI in SMEs is discussed in Section 3. Section 4 describes the underlying study design and research methodology. Section 5 explains and analyses the findings of the online survey. A critical discussion of the survey results follows in Section 6. In this context, the results are compared and evaluated in relation to the research questions. Finally, the paper concludes with the limitations of this research and recommendations for further research in Section 7.

THE IMPORTANCE OF DIGITALIZATION FOR SMES IN GERMANY

Digital technologies play an integral role in fostering economic expansion by optimising internal business processes and encouraging the development of new products and services. They also enable firms to venture into unexplored markets and regions (Brodny and Tutak, 2022). As shown by the Digital Economy and Society Index (DESI; European Commission, 2022), which assesses digital adoption at enterprises in areas such as e-commerce, cloud services, and AI, some countries have made progress. However, significant gaps remain, especially among SMEs. For example, only 18% of EU SMEs participated in online sales in 2021, and only 14% of all EU businesses used big data. These figures fall well short of the Digital Decade targets, which call for more than 90% of European SMEs to achieve basic digital adoption and 75% of EU enterprises to use cloud computing, AI, and big data (Euro-pean Commission, 2022). Table 1 compares various measures of digitalization and technology adoption among SMEs in Germany (GER) and the 27 Member States of the European Union (EU-27). According to DESI, Germany ranks 16th in Europe in terms of integrating digital technologies into business activities.

Table 1 Integration of digital technology in Germany compared to the EU-27 average.

Status level	Metrics	GER	EU-27
Digital Intensity Index	SMEs with at least a basic level of digital intensity	59%	55%
Standard Advanced Technologies	SMEs selling online	19%	18%
	Enterprises using electronic information sharing	38%	38%
	Enterprises using social media	30%	29%
Most Advanced Technologies	Enterprises using cloud solutions	32%	34%
	Enterprises using big data solutions	18%	14%
	Enterprises exploiting artificial intelligence	11%	8%

Source: European Commission, 2022

The data presented in Table 1 include relevant measures of the "Digital Intensity Index", "Standard Advanced Technologies", and "Most Advanced Technologies", which represent the state of digitalization of SMEs in Germany in the context of different categories of digital technologies. The "Digital Intensity Index" measures the proportion of SMEs that have achieved at least a basic level of digital intensity. In Germany, this figure is 59%, above the EU-27 average of 55%. This indicates a comparatively higher willingness and ability of German SMEs to integrate digital technologies into their business processes. "Standard advanced technologies", such as online sales and the use of electronic information exchange services, refer to the use of basic digital technologies by SMEs. With 19% of SMEs selling online, Germany is slightly above the EU-27 average of 18%. Similarly, 38% of German enterprises use electronic information exchange, which is in line with the EU-27 average. The use of social media by 30% of German enterprises is also in line with the EU-27 average of 29%. "Most Advanced Technologies" refer to the adoption of more advanced digital solutions in SMEs. These include cloud solutions, big data, and AI. Germany shows a slightly lower use of cloud solutions compared to the EU-27 average (32% vs. 34%). In terms of the use of big data solutions, Germany is above the EU-27 average of 14% at 18%. However, the use of AI is particularly noteworthy, with 11% of German companies using AI compared to only 8% on average across the EU-27.

The results in Table 1 show that Germany has a slightly positive overall trend in the integration of digital technologies in SMEs, with a significant lead particularly in the area of AI. This could indicate an advanced technological infrastructure, a strong culture of innovation, and a growing awareness of the benefits of digital transformation in the German economy. Nevertheless, there is still room for growth and innovation to realise the full potential of digitalization in German SMEs and thus further strengthen their competitiveness and efficiency. Therefore, the available figures illustrate the necessity of digitalization for SMEs in Germany and throughout the European Union. The integration of digital technologies in SMEs is no longer an option, but an urgent need to remain competitive and adapt to the dynamic changes in the business world (Brodny and Tutak, 2022; Meub and Proeger, 2022; Iftikhar and Nordbjerg, 2021). Ongoing digitalization affects not only the way companies deliver services, but also how they interact with customers, optimise operations, and drive innovation

(Godlovitch and Bodin, 2022; Szedlak et al., 2021; Proeger and Runst, 2020). SMEs that refuse to embrace digitalization risk losing out and jeopardising their long-term viability.

This urgent need for SMEs to embrace digital technologies underlines the relevance of this research. Given the increasing importance of AI technologies and their potential to transform businesses, it is essential to take a closer look at the use of AI in SMEs. The next section first identifies and discusses the current state of related work. This allows us to build on existing findings, identify gaps in the literature and provide a sound basis for further analysis. The results of this research will help us to derive targeted recommendations for the successful integration of AI in German SMEs.

RELATED WORK

The study of AI in SMEs is underpinned by a wide range of theoretical and technological achievements. To better understand the approach, methodology and findings of this research, the various facets of AI, current trends in the field and its growing importance in the business sector, especially in SMEs, are first discussed.

AI is broadly defined as a subfield of computer science that focuses on the development and management of technologies capable of autonomously making decisions and performing actions on behalf of humans (Rouse, 2023). Technically, AI is defined as the application of advanced analytics and logic-based techniques, including machine learning, to interpret events, support and automate decisions, and perform actions (Gartner, 2023). AI reflects human cognitive functions such as perception, reasoning, learning, interaction with the environment, problem solving and creativity (McKinsey, 2023). One notable trend in 2023 is the explosive growth of generative AI tools, which will significantly impact various sectors (Jaffri and Sicular, 2023). Other notable trends include the rapid democratisation of AI technology, increased industry regulation and increased collaboration between humans and AI (Chui et al., 2023). AI is seen globally as one of the most important technologies of the future, with a particular focus on its potential to radically change production processes in SMEs (OECD, 2021; Ulrich and Frank, 2021). As a key digital technology, AI significantly influences the international performance of SMEs, especially in terms of export intensity (Denicolai et al., 2021). SMEs use AI to improve business processes; promote new business models, products and services; and measure and promote AI readiness in their operations (e.g., Bettoni et al., 2021).

As mentioned in the introduction, the study of AI integration in SMEs is part of a rap-idly evolving research landscape that explores the tension between AI technologies and the challenges faced by SMEs. This section summarises relevant studies, research, and findings to provide an overview of the current state of knowledge in this area. Due to the heterogeneity of German SMEs, a complete literature review is hardly feasible. Therefore, the aim was to identify current literature related to the implementation of AI in SMEs, which is why a general literature overview is presented in this section. The following literature databases were searched for relevant research using keyword searches: Google Scholar, EBSCO Academic Search, Scopus, ScienceDirect, and the Directory of Open Access Journals. The following keywords were used: artificial intelligence, AI, SMEs, small and medium

enterprises. Finally, the bibliographies of the results already identified were analysed to collect further relevant literature. The contents of the identified literature are briefly summarised in Table 2.

Table 2 Related work focusing on the adoption of AI in

Author(s)	Year	Research topic	Methodology	Focus country(ies)
Baierl and Nitzsche	2021	Researching recommendations for action for the successful implementation of AI in German SMEs	Expert interviews	Germany
Borah *et al.*	2022	Researching AI applications and the challenges, solutions, and benefits of implementing AI in SMEs	Literature review	Europe
Bunte *et al.*	2021	Researching the adoption, benefits, and success of AI in manufacturing SMEs	Expert interviews	Germany, Austria, and Switzerland
Iftikhar and Nordbjerg	2021	Researching the adoption, barriers, solutions, and benefits of AI in Danish SMEs	Literature review	Denmark
Meub and Proeger	2022	Researching the role of AI for craft and SME sectors in Germany	Literature review	Germany
Szedlak *et al.*	2021	Researching the perceived risks and benefits of AI for SMEs	Online survey	Germany (only northern Rhineland-Palatinate)
Tikkanen *et al.*	2022	Researching the AI phenomenon and how it affects regional, Finnish SMEs	Literature review and guided interviews	Finland

SMEs Source: Developed by the author

The adoption of AI in SMEs has recently attracted considerable attention in academic circles, as evidenced by several studies covering different geographical and sectoral contexts (see Table 2). A consolidated assessment of these studies to date highlights interrelated issues and already identified opportunities and challenges, shedding light on the multifaceted relationship between AI and SMEs. Foremost among the potential benefits of AI in SMEs is its role in new product development and service enhancement. Szedlak et al. (2021) and Tikkanen et al. (2022) both emphasize AI's transformative capability in bolstering product portfolios and augmenting service offerings. This aligns with a broader narrative of technology-driven innovation where AI emerges as a key facilitator. Another consistent observation relates to operational efficiency. Both studies, along with others (e.g., Borah et al., 2022), advocate for the proficiency of AI to streamline processes and automate monotonous tasks, reinforcing the argument for its integration in SME operations. Furthermore, AI's role in augmenting customer relationships and optimizing sales processes cannot be understated, as endorsed by both Szedlak et al. (2021) and Borah et al. (2022). Their findings further intimate the centrality of AI in modern customer relationship management paradigms.

However, this promising landscape is not devoid of challenges. An overarching concern reiterated across studies is the pronounced knowledge and expertise deficit among SMEs, as illustrated by

findings from Szedlak et al. (2021), Borah et al. (2022), and Bunte et al. (2021). This expertise chasm often manifests itself in apprehensions about integration, with SMEs grappling with melding AI within extant business models or organizational cultures, a sentiment echoed by Iftikhar and Nordbjerg (2021). Resource constraints, encapsulating both financial impediments and high operational costs, emerge as another formidable barrier, as observed across multiple studies (e.g., Tikkanen et al., 2022; Bunte et al., 2021; Szedlak et al., 2021). Particularly noteworthy is Borah et al. (2022), their mention of security and privacy qualms, which introduces an ethical dimension to the debate and underscores the necessity of robust governance frameworks.

In summary, the research described above shares some common characteristics. In terms of research methods, most of the papers use a qualitative approach, either through expert interviews, systematic literature reviews, or a combination of both. This allows for a comprehensive analysis of the issue from different perspectives and sources. In terms of geographical focus, the majority of studies focus on specific countries or regions, including Germany, Austria, Switzerland, Denmark, and Finland. This allows for a detailed examination of the conditions and challenges within these regions. The research efforts focus in particular on SMEs and their challenges, solutions, and benefits related to the integration of AI. The sectors covered range from manufacturing and IT to services. The results of these re-search efforts show a certain convergence in the identified challenges and solutions for the implementation of AI in SMEs. Challenges such as lack of expertise, data privacy concerns, financial constraints, and unclear benefits are frequently mentioned. Benefits include increased process efficiency, new product development, and improved customer relationships. Given the limitations of this research, such as a focus on specific industries, limited data collection approaches, or insufficient description of research methodologies, it is reasonable to conduct an up-to-date survey on the adoption of AI in SMEs. A comprehensive, wide-ranging survey that considers the diversity of SME situations and industries can provide valuable insights into current challenges and opportunities and thus provide a broader basis for decisions regarding the implementation of AI.

STUDY DESIGN AND METHODOLOGY

Design and contents of the survey

To investigate the research questions outlined in the introduction, a standardised online questionnaire was developed with closed-ended questions that were always asked in the same order to ensure better comparability across participants (Bradburn et al., 2004). The questions aim to identify the attitudes, opinions, and behaviours of the participants reporting on behalf of their organisation in relation to the implementation of AI. The questionnaire design and question wording are based on general and widely accepted recommendations and rules of construction (e.g., Bell et al., 2018; Sekaran and Bougie, 2016; Bradburn et al., 2004).

Table 3 Structure and contents of the online questionnaire

Section	Contents / indicators	Items	Scale
Introduction	Introduction to the research topic, information on the duration and length of the survey, conditions for participation and emphasis on anonymity and data protection	-	-
Basic information	Industry, number of employees, annual turnover, importance of AI, experience with AI	5 items	Multiple-choice; 5-point Likert
Implemented AI applications	AI technologies implemented, planned implementations, planned timeframe for implementation	4 items	Multiple-choice; 5-point Likert
Benefits and challenges of AI implementation	Challenges experienced in implementing AI, arrangements to overcome these challenges, benefits experienced from implementing AI, expected challenges from implementing AI, planned arrangements to overcome these challenges, expected benefits from implementing AI	6 items	Multiple-choice; 5-point Likert
Importance of AI applications	Importance of AI for competitiveness, willingness to invest in AI technologies, reasons for not planning AI implementations, other comments on AI implementations	5 items	Multiple-choice; 5-point Likert; text field
Demographics	Gender, age, number of years with current employer, department, working experience	5 items	Multiple-choice; text field
Closing	Gratitude for participation	-	-

Source: Developed by the author

Sample and data collection

The decision to choose Germany as the subject of this study on AI in SMEs is already explained in Section 2 and is also based on several important factors: As one of the largest economies in Europe, Germany is at the centre of technological change and plays an important role in the European innovation landscape. In addition, Germany is characterised by a diverse range of SMEs that form the backbone of the economy and are active in different sectors. Looking at Germany thus opens up the possibility of gaining insights that can be transferred to different sectors and company sizes (European Commission, 2022).

Webropol, a professional survey tool, was used as the medium for presenting and conducting the online survey. The online questionnaire consists of 25 questions in German and was published via *Webropol* in the survey period from 04 May 2023 to 07 June 2023. The link to the survey was deliberately shared on the social platforms LinkedIn and Insta-gram. These platforms offer a diverse participant base from different industries and age groups, which promotes the generalisability of the results. *LinkedIn*, as a professional platform, allows for targeting professionals and decision-makers to gain insights from a variety of business perspectives. Instagram, on the other hand, complements this reach by reaching a younger, tech-savvy audience that is increasingly interested in AI in business. The combination of these platforms promises a multi-layered database, contributing to comprehensive and meaningful analysis.

To minimise known biases in questionnaire surveys, such as common rater effects, item characteristic effects or non-response bias (Bell et al., 2018; Sekaran and Bougie, 2016; Podsakoff et al., 2003), some precautions were taken in advance. For example, common rater effects were mitigated by

ensuring anonymity and confidentiality and by varying the type of questions and scaling (Podsakoff et al., 2003). To minimise item characteristic effects, a pretest was conducted, and the 5-point Likert scale was used as a neutral scale. The pretest was carried out with 20 students of business administration and computer science at the University of Applied Sciences Kaiserslautern and served to identify possible errors in the completion of the questionnaire, avoid comprehension problems, and prevent the generation of measurement errors (Sekaran and Bougie, 2016). The 5-point Likert scale was chosen because it avoids a forced positive-negative emphasis and reduces the tendency towards the middle due to the larger but still comprehensible number of response options (Sekaran and Bougie, 2016). To counteract a possible non-response bias, a follow-up message was sent after two weeks (28 May 2023) with a friendly reminder to participate in the survey, in line with the recommendations of Podsakoff et al. (2003). In the end, 105 people participated in the survey.

RESEARCH FINDINGS

Demographic data

In terms of gender, 32.7% of respondents are male and 18.3% are female. For 49% of the respondents, gender is not specified. These results indicate that the sample is heterogeneous in terms of gender. The age structure of the participants shows a wide range: 1% of the participants are 25 years old or younger, 13.5% between 26 and 35 years old, 29.8% between 36 and 45 years old, and 7.7% between 46 and 55 years old. The largest group (48.1%) does not indicate their age. The professional experience of the participants is recorded according to the number of years they work in their professional field. Here, 15.4% of the participants state that they have less than 5 years of professional experience, 22.1% have less than 10 years, 12.5% have less than 15 years, and 1.9% have more than 20 years. 48.1% of the respondents do not provide any information about their work experience. The distribution of the length of employment of the participants is similar to that of the work experience. 13.5% of respondents have been in their current position for less than 5 years, while 26.9% have been in their position for less than 10 years. For 10.6% of respondents, the length of employment is less than 15 years, and only 1% have been in their current position for more than 20 years. For 48.1% of respondents, the length of employment is not specified. The survey reflects a broad distribution of departmental affiliation. The largest group of respondents is in management (14.4%), followed by IT (9.6%), finance (4.8%), sales (4.8%), and marketing (1.9%). Departments such as quality management (2.9%), customer service (3.8%), production (2.9%), and development (3.8%) are also represented. 1% of respondents work in other departments, while 50% do not indicate their departmental affiliation.

The results of the survey show that a large proportion of the companies surveyed are medium-sized companies, which make up 62.5% of the respondents. The high proportion of medium-sized companies underlines their importance in the business landscape. After medium-sized companies, 16.3% of respondents are small companies, according to the survey. A further 13.5% of respondents are micro enterprises. The companies surveyed come from a variety of industries. The distribution shows that the IT and communication sector accounts for the largest share with 26.9%, followed by manufacturing and trade (25%), education and training (13.5%), health (10.6%), energy and the

environment (4.8%), finance and insurance (3.8%), trade and distribution (7.7%), and other sectors (7.7%), e.g., engineering, consulting services, or research. This distribution shows the diversity of the industries represented in the sample and allows for the analysis of different perspectives on the use of AI. The size of the enterprise was measured by the number of persons employed. The turnover structure of the enterprises surveyed is also reflected in the data. Thus, 24% of the enterprises report a turnover of less than EUR 2 million, 38.5% report a turnover of less than EUR 10 million, 24% report a turnover of less than EUR 50 million and 1% report a turnover of more than EUR 50 million. This turnover distribution shows that the sample is dominated by companies with low to medium turnover. The focus of the study on SMEs requires a clear delimitation. For this reason, participants who stated that they worked in larger companies (n = 7) were excluded from the analysis. This exclusion allows for a targeted analysis and interpretation of the results in an SME-specific context and helps to ensure the validity of the study. The demographics of the sample are shown in Appendix 1.

Implemented AI applications

The survey results provide insights into the experiences and perceptions of participants regarding their interactions with AI. A significant 46% of respondents acknowledged the critical importance of cutting-edge technologies such as AI to their business operations. This notable finding underscores a significant proportion of participants who have a sophisticated understanding of the inherent value and potential benefits that AI can bring to their organisations. In contrast, 34% of respondents expressed a neutral attitude towards AI. These respondents appear to be adopting a more cautious stance, which may be indicative of either an inherent reluctance to embrace new technologies or a desire for additional information and empirical evidence to fully understand the relevance and implications of integrating AI into their business landscapes. Of particular interest is the fact that, despite recognising the overarching importance of AI, only 23% of respondents reported having first-hand experience of actually implementing AI solutions. This apparent dichotomy between the recognition of AI's importance and the tangible deployment of AI technologies within the surveyed organisations highlights a discernible gap that merits further investigation. In addition, the survey revealed that a modest 28% of the companies surveyed had successfully integrated AI solutions into their operations. This relatively low prevalence rate provides indicative insights, suggesting that the adoption and integration of AI technologies within the surveyed sample may still be in its early stages. This observation, coupled with the recognition of the value of AI, underscores the potential for a transformative yet untapped avenue that requires careful consideration and tailored strategies to accelerate the effective integration of AI in the context of these businesses.

Of the SMEs surveyed, only 28% reported using AI solutions. This suggests that a significant majority of SMEs have yet to adopt AI technologies in their operations. This trend highlights the cautious approach of many SMEs towards AI integration, which may be influenced by factors such as limited resources, lack of awareness, or the perceived complexity and cost of implementation (Brodny and Tutak, 2022). Within the subset of SMEs that have adopted AI, the landscape of AI solution usage reveals interesting insights. Among these adopters, the most commonly used AI solutions are chatbots or virtual assistants, with 52% of respondents incorporating these technologies

into their businesses. This prevalence of chatbots or virtual assistants suggests that SMEs recognise the value of automated customer interactions and the potential to improve user experience and engagement through AI-powered conversational interfaces. Following the prominence of chatbots or virtual assistants, recommendation systems emerged as the next most common AI solution, implement-ed by 41% of SME respondents. This observation highlights the recognition of AI's ability to enhance personalised customer experiences by providing tailored suggestions and recommendations, potentially contributing to increased customer satisfaction and retention rates. In addition, machine learning solutions were reported by 31% of SME respondents. The adoption of machine learning reflects a propensity to use AI for data-driven insights, predictive analytics, and automation of decision-making processes within SMEs, indicating a growing appreciation of the transformative potential of AI technologies to improve operational efficiency and informed decision-making. Figure 1 provides an overview of the implemented AI technologies mentioned in the sample.
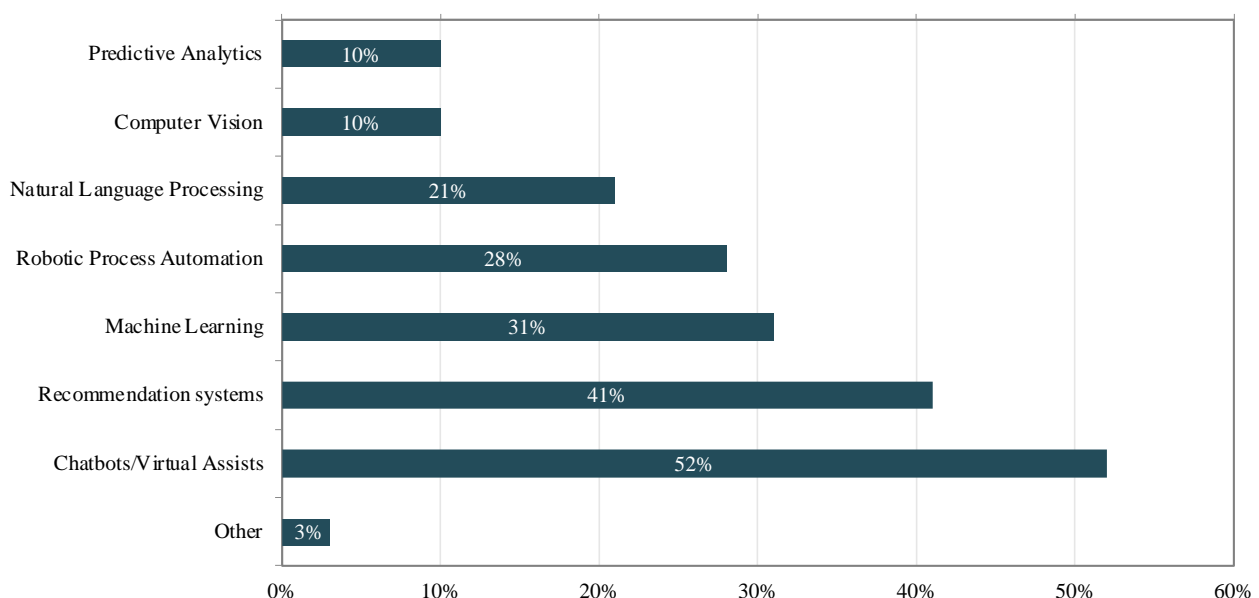

Figure 1 Implemented AI technologies mentioned in the sample

Source: Developed by the author. Note: Multiple answers possible

Challenges and benefits through AI

The adoption of AI in organisations brings a number of challenges that can influence the successful integration of these innovative technologies into existing business processes. The analysis of the responses shows that the lack of knowledge and experience in dealing with AI was cited by 48% of companies as one of the biggest challenges. This underscores the importance of training and skills development to strengthen AI skills and ensure that the necessary knowledge is available to effectively exploit the potential of AI. Similarly, 34% of companies report difficulties in integrating AI into existing systems. This challenge highlights the need to create a seamless interface between AI technologies and existing business structures. This often requires a major overhaul of systems to effectively integrate AI applications into workflows. It is also worth noting that 41% of organisations

are concerned about data privacy and security. This highlights the increasing sensitivity of handling sensitive data in the age of AI and the need to develop appropriate security mechanisms to ensure data confidentiality and integrity. The high cost of implementing and maintaining AI technologies is cited as a major challenge by 38% of companies. The financial burden of implementing AI shows that investment costs can often be a key barrier to wider AI integration, especially for smaller companies with limited resources. Concerns about the impact on employment are expressed by 7% of companies. This highlights the need for a responsible approach to AI integration that considers the potential social impact on employment. A further 7% of companies report having encountered other challenges, such as a lack of data or lack of traceability of results. Figure 2 provides an overview of the reported challenges of implementing AI technologies.
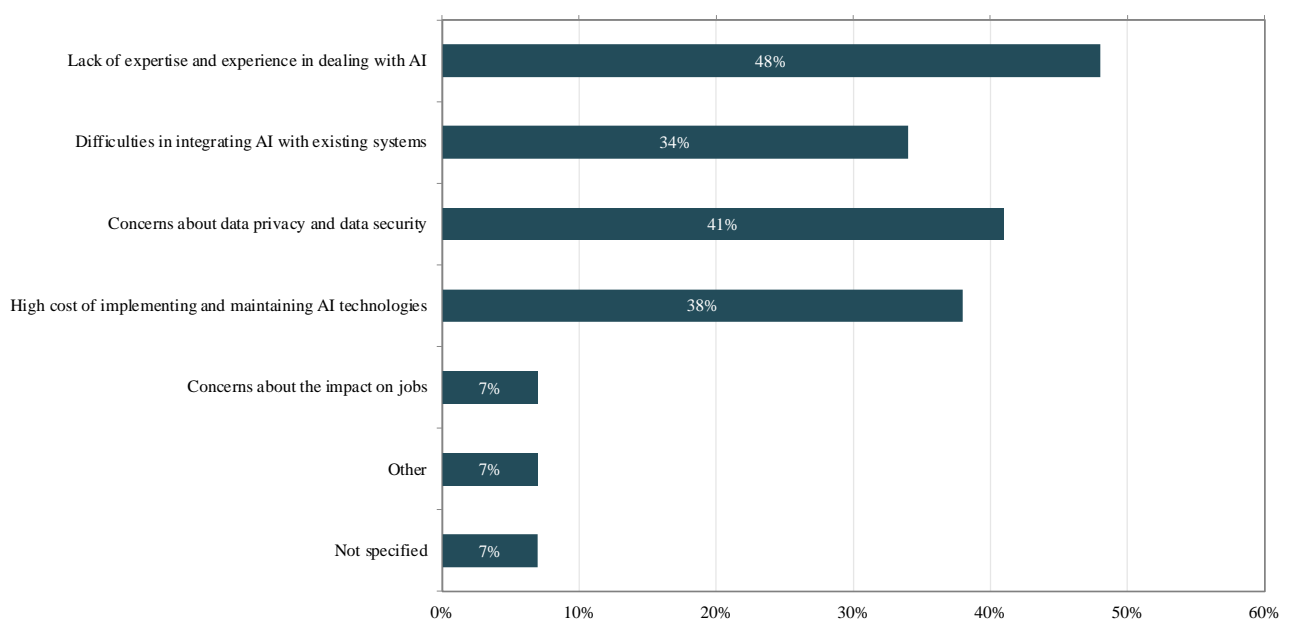

Figure 2 AI implementation challenges
Source: Developed by the author

When asked about the precautions they are taking and the measures they plan to take to overcome these challenges, 55% of companies said they are relying on working with external AI experts and consultants to overcome implementation hurdles. This highlights the need for external expertise and technical knowledge to ensure the smooth running and success of AI projects. Similarly, 48% of companies report that they are providing training and development for their employees to improve their knowledge of AI. This reflects an understanding that skilled employees play a critical role in the successful adoption and use of AI technologies. Training develops the skills needed to effectively address the challenges associated with AI.

In addition to the challenges mentioned, AI technologies also have the potential to deliver transformational benefits and impact business processes and the organisation as a whole. Analysis of the responses shows that improving business processes through automation is cited by 59% of organisations as one of the most important benefits of implementing AI. This highlights the potential

for AI to take over repetitive tasks and automate manual processes, saving time and resources. In fact, 45% of organisations report that the implementation of AI applications has led to an increase in efficiency and productivity. These efficiency gains are reflected in faster workflows, optimised use of resources, and increased production output achieved through the use of AI technologies. Improved decision-making is cited by 24% of companies as a benefit of integrating AI. AI can analyse data and identify patterns to provide in-depth insights for better business decisions. This benefit highlights the data-driven nature of AI and its ability to help companies develop strategies and policies. The development of new products and services is cited by 21% of businesses as a benefit of using AI. AI's ability to analyse data and identify patterns can help companies develop innovative solutions that meet customer needs and expectations. Cost reduction is cited by 14% of companies as a benefit of integrating AI. AI can streamline processes, reduce labour costs, and contribute to a more efficient use of resources, which can lead to financial relief. Personalisation of offers and services is cited as a benefit by 10% of companies. AI enables companies to develop a more personalised and tailored approach to customers, which can improve the customer experience and increase customer loyalty. Figure 3 provides an overview of the reported benefits of implementing AI technologies.
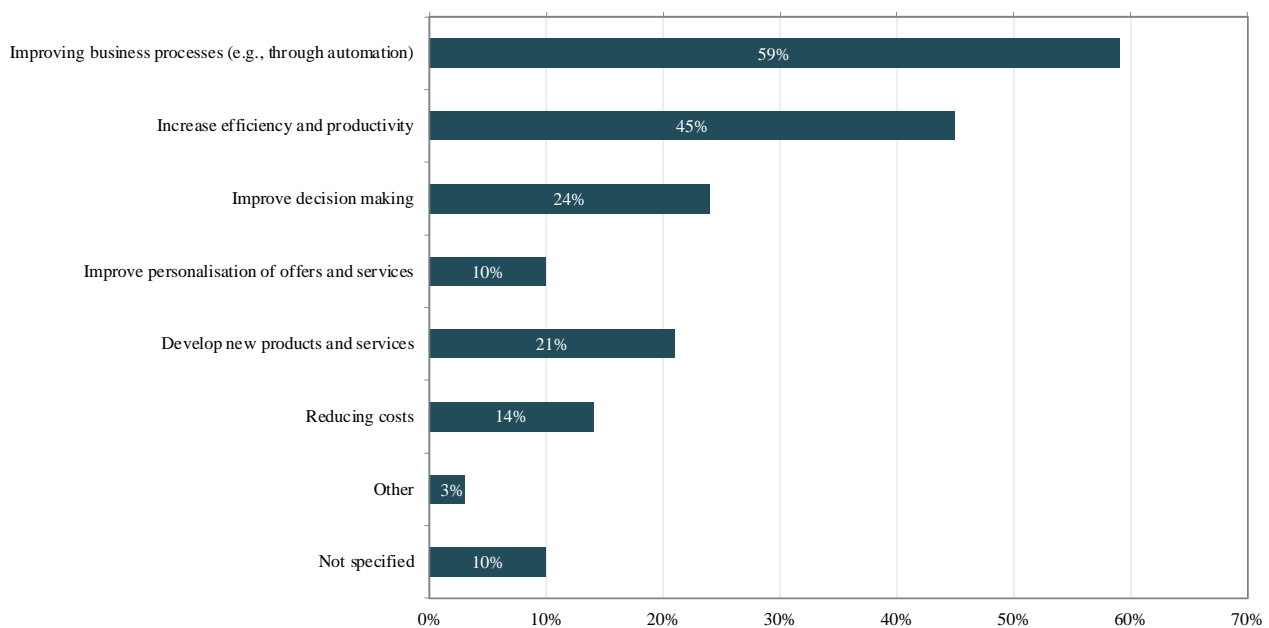

Figure 3 AI implementation benefits

Source: Developed by the author

Investments in AI technologies

In terms of willingness to invest, the survey revealed a range of different attitudes among SME respondents. A remarkable 10% of respondents showed an increased willingness to invest significantly in AI solutions, underlining a strong confidence in the potential benefits and returns of such investments. These visionary companies appear to be driven by a strong desire to leverage the transformative capabilities of AI to gain a strategic competitive advantage in their respective market

environments. A significant segment, representing 44% of SME respondents, showed a more general willingness to allocate resources to AI solutions, indicating an optimistic attitude towards the adoption of AI technologies. This trend highlights an awareness of the potential benefits of AI in improving operational efficiency, innovation and competitiveness. In contrast, 36% of respondents expressed a relatively reluctant willingness to invest in AI solutions. The differentiated attitude of this group can be attributed to various considerations, such as fears about the complexity of implementation, the financial outlay or possible disruptions that could accompany the integration of AI into existing work processes. Finally, a small proportion of respondents (7%) indicated that they were not ready to invest in AI solutions. This subset of organisations may be characterised by a more conservative approach to technology adoption, possibly due to risk aversion or a preference for maintaining established operating paradigms. It is also plausible that resource constraints may limit their ability to engage in large-scale AI initiatives. The different investment attitudes across these categories illustrate the complexity of SMEs' strategic decision-making processes in relation to AI. This range of perspectives underscores the complexity associated with addressing the challenges and opportunities of AI and ultimately shapes the diverse landscape of AI adoption in the SME sector. Figure 4 provides an overview of the willingness to invest in AI technologies.
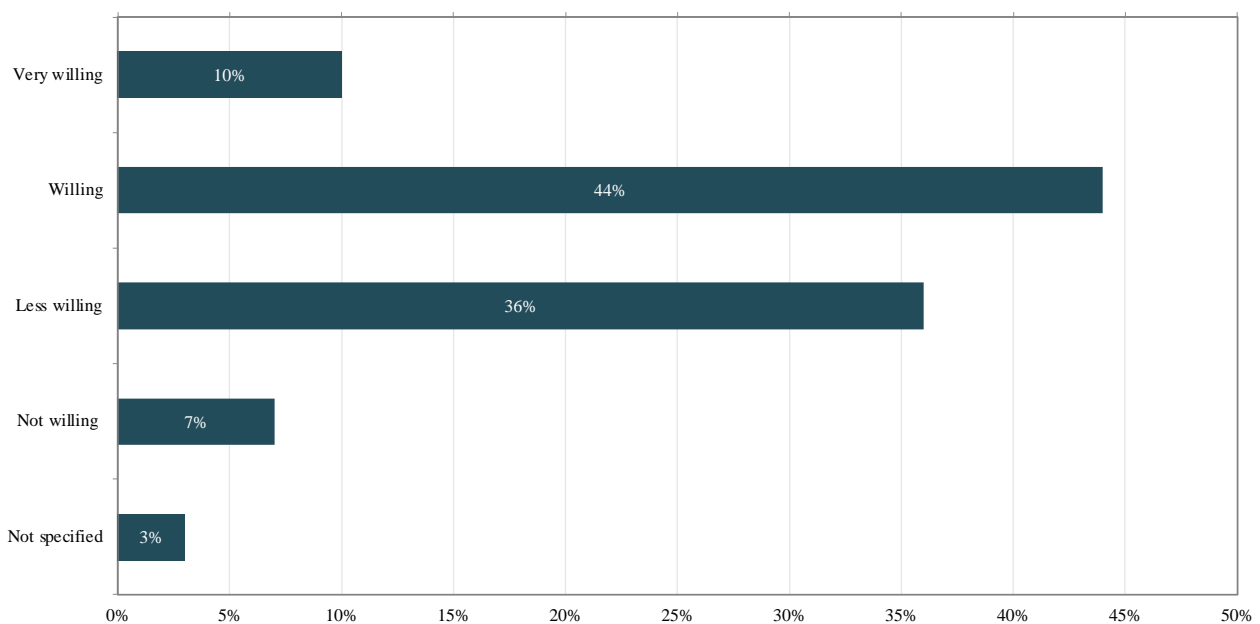
Figure 4 Willingness to invest in AI technologies

Source: Developed by the author

The question about plans to implement AI technologies in the near future is of central importance in order to gain insight into the strategic directions of the companies surveyed. Analysis of the responses shows that 16% of respondents intend to implement AI technologies within a year. This underlines the significant interest and planned readiness to adopt AI within a relatively short timeframe. Similarly, 11% of companies plan to implement AI technologies within two years. This timeframe reflects a slightly longer lead time, during which companies are more inclined to prepare the

necessary resources, skills, and infrastructure to facilitate the successful implementation of AI. When asked about planned AI implementations, the respondents' main intentions were to deploy chatbots and virtual assistants, as well as recommendation systems. Interestingly, 29% of companies report that they have no plans to implement AI technologies in the near future. These results suggest that a significant number of companies are taking a cautious approach to AI, or do not currently see the necessary conditions or resources to integrate AI technologies. It is also worth noting that 38% of companies stated they have no plans to implement AI technologies. This significant percentage reflects a certain reluctance or a conscious decision not to introduce AI technologies into their business operations. When asked about the reasons why companies currently have no plans to implement AI technologies, 62% of the companies surveyed do not see clear benefits in implementing AI technologies that could improve their current business processes. In addition, 31% of companies stated that the implementation of AI technologies requires a large investment budget that they cannot currently afford. This finding highlights the financial challenge that can accompany the integration of AI technologies.

Companies planning to adopt AI technologies in the next two years were asked what challenges they expect to face when implementing AI technologies. Analysis of the responses revealed that a lack of knowledge and experience in dealing with AI is expected to be one of the biggest challenges for 90% of companies. This finding highlights the urgent need for training and skills development to build the necessary knowledge and skills to deal with AI. A skilled team is critical to managing the technical demands of AI integration and getting the most out of these technologies. Similarly, 52% of organisations say they expect difficulties in integrating AI into existing systems. Concerns about privacy and security (33%) and the high cost of implementing and maintaining AI technologies (33%) are also cited by businesses as anticipated challenges. The same group of companies was also asked about the expected benefits. An analysis of the responses shows that 57% of companies consider improving business processes through automation to be one of the most important expected benefits. Similarly, 48% of companies expect to increase efficiency and productivity through the implementation of AI applications. This expectation reflects AI's ability to take over repetitive tasks and optimise workflows, which can lead to an increase in overall business performance. Similarly, 24% of organisations expect to be able to develop new products and services through the implementation of AI applications. Improving decision-making (14%), better personalisation of offers and services (24%) and cost reduction (19%) are other expected benefits cited by respondents.

Competitiveness through AI

Among the SME respondents to the online survey, there are different perspectives on the importance of AI as a competitive factor. Of the respondents, 11% consider AI to be an extremely important competitive factor, indicating a clear recognition of its potential impact on business success. In addition, 60% of respondents consider AI to be important, further highlighting its relevance in the competitive landscape. On the other hand, 27% of SMEs consider AI to be less important, suggesting that they may not be fully aware of the potential benefits or competitive advantages that AI can offer. A small minority of respondents consider AI to be insignificant as a competitive factor. This minority

view can be attributed to a number of factors, such as a lack of awareness of AI's capabilities or an industry-specific context that doesn't rely heavily on AI-driven solutions.

The different perceptions of the importance of AI as a competitive factor among the SMEs surveyed highlight the range of assessments of the impact of AI on competitiveness. Those who see AI as highly relevant recognise the transformative power of AI in the business world and understand how it can impact their business success. On the other hand, those who see AI as less relevant may need further education and awareness of the diverse applications of AI to realise its full potential. The diversity of perspectives underscores the need for a nuanced examination and communication of AI as a competitive factor. Comprehensive education on the benefits, opportunities and challenges of AI can contribute to a deeper understanding of the business landscape and encourage companies to integrate AI-based solutions into their operations, thereby enhancing their competitiveness.

DISCUSSION AND CONCLUSION

This study has provided a comprehensive insight into the attitudes, experiences, and expectations of SMEs regarding the adoption of AI. Analysis of the survey results highlights the complexity of integrating AI in SMEs and provides valuable insights for shaping future strategies and actions. The following conclusions provide answers to the research questions posed in the introduction:

1. The survey results suggest that despite widespread recognition of the importance of AI for business processes and competitiveness, only 28% of SMEs surveyed have implemented AI solutions. This discrepancy between the recognition of the importance of AI and its actual implementation highlights a challenge that requires further investigation. Overall, the results suggest that the integration of AI in SMEs is still at a relatively early stage and that targeted measures are needed to promote the effective use of AI technologies (Jaffri and Sicular, 2023). The study shows that among SMEs that are already using AI, chatbots or virtual assistants are most commonly used, followed by recommendation systems and machine learning. These findings highlight the potential of AI to automate customer interactions, improve personalised offers and use data for data-driven insights and decisions.

2. In general, the survey results on the challenges of implementing AI applications suggest that there are a number of complexities associated with integrating AI into businesses; in particular, lack of expertise, integration difficulties, privacy and security concerns, and high costs were identified as prominent barriers. These challenges require targeted measures, such as training, external expertise, and the development of appropriate security mechanisms, to support the smooth deployment of AI, make AI integration successful and realise the full potential of these technologies. The findings also emphasise the need for a holistic strategy, addressing both technical and organisational aspects, to effectively realise the benefits of AI and address the challenges that will arise.

3. The expected benefits of AI integration are also diverse. Automation of business pro-cesses, increased efficiency and productivity, improved decision-making, personalised offers and services, and cost savings were identified as key benefits (Tikkanen et al., 2022; Bettoni et al., 2021). These benefits underline the transformative potential of AI in optimising business

processes, fostering innovation and increasing the competitiveness of SMEs. Overall, the data on the benefits achieved from implementing AI applications provides a clear picture of the positive impact that AI can have on businesses.

4.   The study also reveals a range of attitudes towards investing in AI. While some companies are opting for short-term implementation, others are taking a cautious approach or have no current plans to adopt AI in the near future. These different responses reflect the complexity of the decision-making process and the various factors influencing the integration of AI technologies into organisations. These different perspectives highlight the need for a nuanced approach to promoting AI integration in SMEs.

5.   The study highlights that the perception of the importance of AI as a competitive factor can vary among SMEs. Some SMEs recognise the transformative potential of AI and see it as an opportunity to improve their competitiveness. Others are less convinced or may need further education on the possibilities of AI. Comprehensive education on the benefits, opportunities and challenges of AI can contribute to a deeper understanding of the importance of AI as a competitive factor and promote the integration of AI-based solutions in SMEs.

6.   Overall, the results of the study underline the need for a holistic approach to promoting the integration of AI in SMEs. This requires targeted training, strategic advice, security measures and specific support to ensure the smooth adoption of AI and to fully exploit the transformative potential of these technologies. The diverse findings of this study provide a valuable basis for future research, policymaking and action aimed at promoting AI integration in SMEs and ultimately strengthening their competitiveness.

The results of the current study show parallels with findings from similar research. Insights into the challenges associated with AI implementation in SMEs, such as lack of expertise (Borah *et al.*, 2022; Bunte *et al.*, 2021), integration difficulties (Meub and Proeger, 2022; Iftikhar and Nordbjerg, 2021) and financial constraints (Borah *et al.*, 2022; Szedlak *et al.*, 2021), reflect similar findings documented in previous studies. The expected benefits of AI integration, such as improving business processes (Szedlak *et al.*, 2021), increasing efficiency and productivity (Szedlak *et al.*, 2021), and developing new products and services (Tikkanen *et al.*, 2022; Szedlak *et al.*, 2021), are reflected in several research papers. This overlap confirms the consistency of the findings and suggests that the trends and patterns identified are relevant across different contexts and regions. The similarities in findings underscore the relevance of the present study in the wider academic discourse and provide additional confirmation of the significance of the conclusions and recommendations.

LIMITATIONS AND RECOMMENDATIONS

Although the author of this paper has endeavoured to achieve a high degree of objectivity, accuracy and validity, there are several limitations to this research. First, the survey sample was drawn from a specific geographical region, namely Germany, which may limit the generalisability of the findings to other countries or regions with different technological landscapes, business cultures and regulatory environments. Although the survey covered a wide range of industries and company sizes, the sample

of respondents may not fully reflect the entire SME landscape. Future research could include a more diverse range of countries to provide a broader perspective on the challenges and opportunities faced by SMEs in different contexts.

Second, the survey data rely on self-reported responses, which can introduce response bias and potential inaccuracies (Podsakoff *et al.*, 2003). Despite efforts to ensure the validity and reliability of the survey instrument, participants' interpretations of the questions and their own experiences may vary, leading to potential discrepancies between reported and actual behaviour. To mitigate this limitation, a mixed-methods approach combining survey data with qualitative interviews or case studies could provide a more comprehensive understanding of the complexities surrounding AI adoption in SMEs. In addition, the data collected were not checked using statistical tests to control for non-response bias or common method bias, such as Harman's single factor test or a chi-squared test (Podsakoff *et al.*, 2003; Sekaran and Bougie, 2016).

A third limitation relates to the cross-sectional nature of the study, which captures a snapshot of SMEs' AI adoption and perceptions at a particular point in time. As the AI landscape is rapidly evolving, longitudinal studies could provide insights into how SMEs' attitudes and experiences with AI change over time, shedding light on the dynamics of AI adoption and integration.

Despite these limitations, this study lays foundations for further research and future developments in the field of AI in SMEs. One promising perspective is to target the barriers to AI integration in order to promote wider adoption in this category of firms. Identified concerns about lack of expertise and integration issues could be addressed through educational initiatives and advisory services. This could help fill knowledge gaps and support companies in successfully integrating AI technologies. Given the varying levels of AI adoption among SMEs and the recognised challenges, efforts should be directed towards the development of targeted training and education programmes. These initiatives could improve SMEs' understanding of the potential benefits of AI, foster the development of the necessary skills, and address concerns related to data security and privacy. Collaboration between SMEs and external AI experts could facilitate the sharing of knowledge, resources, and best practices, further supporting successful AI integration. In addition, policy and regulatory frameworks should be designed to encourage the adoption of AI while addressing potential ethical, legal, and social implications. Policymakers can play a key role in creating an environment conducive to AI innovation by providing incentives, reducing barriers, and promoting responsible AI practices.

In conclusion, this study has illuminated the multi-faceted landscape of AI adoption and perceptions among SMEs. Despite the limitations identified, the findings provide a valuable foundation for future research and practical interventions aimed at fostering AI integration and enhancing competitiveness within the SME sector. As AI continues to shape the future of business and technology, ongoing efforts to address the challenges and harness the benefits of AI in SMEs are essential to drive innovation and sustainable growth in the digital age.

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APPENDIX 1

Demographics of the sample

Variable	Dimension	Early respondents				Late respondents				N	%
		N	%	Mean	SD	N	%	Mean	SD		
Gender	Male	32	37.2	2.105	0.915	2	11.1	2.444	0.685	34	32.7
	Female	13	15.1			6	33.3			19	18.3
	Not specified	41	47.7			10	55.6			51	49.0
Age	25 and under	1	1.2	3.860	1.173	0	0.0	4.000	1.202	1	1.0
	26 to 35	11	12.8			3	16.7			14	13.5
	36 to 45	27	31.4			4	22.2			31	29.8
	46 to 55	7	8.1			1	5.6			8	7.7
	Not specified	40	46.5			10	55.6			50	48.1
Work experience	Less than 5 years	14	16.3	3.407	1.609	2	11.1	3.667	1.563	16	15.4
	Less than 10 years	19	22.1			4	22.2			23	22.1
	Less than 15 years	11	12.8			2	11.1			13	12.5
	Over 20 years	2	2.3			0	0.0			2	1.9
	Not specified	40	46.5			10	55.6			50	48.1
Years employed	Less than 5 years	12	14.0	3.384	1.601	2	11.1	3.667	1.563	14	13.5
	Less than 10 years	24	27.9			4	22.2			28	26.9
	Less than 15 years	9	10.5			2	11.1			11	10.6
	Over 20 years	1	1.2			0	0			1	1.0
	Not specified	40	46.5			10	55.6			50	48.1
Department	Management	13	15.1	7.535	3.923	2	11.1	7.667	4.150	15	14.4
	Finance	3	3.5			2	11.1			5	4.8
	Sales	3	3.5			2	11.1			5	4.8
	Marketing	2	2.3			0	0.0			2	1.9
	IT	10	11.6			0	0.0			10	9.6
	Quality management	3	3.5			0	0.0			3	2.9
	Customer service	3	3.5			1	5.6			4	3.8
	Production	3	3.5			0	0.0			3	2.9
	Development	3	3.5			1	5.6			4	3.8
	Other	1	1.2			0	0.0			1	1.0
	Not specified	42	48.8			10	55.6			52	50.0
Industry	Energy and the Environment	4	4.7	5.302	1.868	1	5.6	5.556	1.892	5	4.8
	Finance and Insurance	3	3.5			1	5.6			4	3.8
	Healthcare	10	11.6			1	5.6			11	10.6
	Education and Training	13	15.1			1	5.6			14	13.5
	Trade and Retail	6	7.0			2	11.1			8	7.7
	IT and Communications	22	25.6			6	33.3			28	26.9
	Manufacturing and Trade	22	25.6			4	22.2			26	25.0
	Other	6	7.0			2	11.1			8	7.7
	Not specified	0	0.0			0	0.0			0	0.0

Variable	Dimension	Early respondents				Late respondents				N	%
		N	%	Mean	SD	N	%	Mean	SD		
Number of employees	Fewer than 10	11	12.8	2.663	0.830	3	16.7	2.611	0.826	14	13.5
	Fewer than 50	15	17.4			2	11.1			17	16.3
	Fewer than 250	53	61.6			12	66.7			65	62.5
	More than 250	6	7.0			1	5.6			7	6.7
	Not specified	1	1.2			0	0.0			1	1.0
Turnover	Below €2 million	18	20.9	2.442	1.207	7	38.9	2.167	1.258	25	24.0
	Below €10 million	35	40.7			5	27.8			40	38.5
	Below €50 million	21	24.4			4	22.2			25	24.0
	Above €50 million	1	1.2			0	0.0			1	1.0
	Not specified	11	12.8			2	11.1			13	12.5

Source: Developed by the author. Note: "SD" = standard deviation.