ADOPTION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN GERMAN SMES — RESULTS FROM AN EMPIRICAL STUDY

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Abstract

Artificial intelligence (AI) is globally regarded as one of the most important technologies of the future. Germany is not considered a pioneer in the field of AI in the international context, and the implementation of AI technologies is rather sluggish. As the German economy is mainly driven by small and medium-sized enterprises (SMEs), the implementation of AI in SMEs is the main success factor. This study discusses the implementation perspectives of AI in German SMEs based on an empirical study from the year 2020 among 283 companies.

1. INTRODUCTION

Artificial intelligence (AI) is on everyone's lips and will — many authors in theory and practice agree — dominate the coming years of business (Helm et al., 2020). This is true not only, but also in the context of the global COVID-19 pandemic (Vaishya, Javaid, Khan, & Haleem, 2020). Despite the potential of technologies such as machine learning (Alpaydin, 2020), deep learning (Goodfellow, Bengio, & Courville, 2016), neural networks (Yegnanarayana, 2009), and others, implementation in enterprise practice is not as advanced in itself as one would hope.

This is particularly the case in Germany, which has been rather late in providing political support for AI technologies and implementing them

in corporate practice by international comparison (Harhoff, Heumann, Jentzsch, & Lorenz, 2018).

The global success of the German economy is mainly due to SMEs, so the following questions are of interest from a research perspective:

• Do German SMEs know artificial intelligence as well as related technologies?

• What is the level of digitization in German SMEs in general and in which areas could AI be used?

• Who is responsible for the introduction of AI in SMEs?

• What barriers to introduction exist?

• Are there already ongoing pilot projects and experiences?

These and other questions were explored in a quantitative-exploratory study of 283 German SMEs in 2020, the approach and initial findings of which are presented in this research-in-progress.

2. LITERATURE REVIEW

A literature review is necessary to build a deeper understanding of the topic under discussion. For this purpose, literary works, especially empirical papers on the topic of AI, the implementation status of AI in companies and especially in medium-sized companies, were examined. A variety of definitions have already been made for artificial intelligence, as the term has many scientific and technological overlaps (Floridi, 2019). Floridi defines the term AI broadly "as a reservoir of smart agency on tap" (2019, p. 3). In literature, the term AI, which includes broad technological categories, is often used as a synonym for cognitive technology and as well as cognitive computing (Kokina & Davenport, 2017). A popular standard definition that is supposed to cover the essential facets of AI goes back to 1955, in which McCarthy, Minsky, Rochester, and Shannon defined AI as "making a machine behave in ways that would be called intelligent if a human were so behaving" (Floridi, 2019; McCarthy, Minsky, Rochester, & Shannon, 1955, p. 11). In general branches of AI include natural language processing, robotics, cognitive modelling, machine learning, expert systems, knowledge representation and heuristic problem solving (Weber, 2020).

Based on a representative special assessment of the German Innovation Survey from 2019, the German Federal Ministry for Economic Affairs and Energy examined the current state of AI use in German companies. In addition, a supplementary survey was conducted with 368 companies that have already implemented AI in their corporate processes. The study indicates that only 5.8% of all businesses in the review area have applied AI, whereas only a small number have developed the AI-solutions in-house. The majority fall back on developments by third partners. It should be noted that machine learning and machine proofing are particularly used in the areas of

products, process automation and services. From a staffing perspective, filling AI positions is a major challenge due to requirements such as software programming: Just under one-third of companies using AI were looking for additional staff, with only 47 percent of positions actually filled (Bundesministerium für Wirtschaft und Energie, 2020).

Based on a study in 2019, the Fraunhofer IAO investigated the impacts of AI in companies and the influence on the environment of working in the future. The main part of the investigation constitutes a written survey attended by 309 companies. Among them, 49 companies have already implemented AI in their company. The study shows that AI becomes an essential topic for companies in the future. The ones, which already have implemented AI in certain processes, report a high benefit. In addition, the study highlights that companies with fewer than 250 employees are significantly behind in the implementation of AI. This is due, on the one hand, to the large volumes of data required for the use of AI and, on the other, to the high financial and personnel expenditure that would have to be made (Dukino et al., 2020). The present study examines the application of AI in SMEs in more detail, which is why a definition of the term is provided first.

Various definitions of SMEs cause confusion in practice and literature about this very term. As a variety of synonyms such as medium-sized and family businesses are used to describe the sector, a distinction between the definitions is often difficult and has so far been applied inconsistently (Becker, Ulrich Fibitz, Schuhknecht, & Reitelshöfer, 2019). However, in general, the definition can be carried out based on qualitative characteristics, quantitative limits and a combination of those (Arentz & Münstermann, 2013). Known thresholds provide the IfM Bonn and the Commission of the European Communities: according to IfM Bonn, SMEs are all companies with fewer than 500 employees and less than or equal to €50 million in sales (IfM Bonn, n.d.). The quantitative limits in the definition of the European Commission are 250 employees, a balance sheet total of €43 million or €50 million in sales (European Commission, 2003).

SMEs are particularly important for the German economy. How relevant the implementation and use of AI applications are for SMEs in this context was investigated by the Scientific Institute for Infrastructure and Communication Services in 2019. The study indicates that AI has a high potential for SMEs in almost all segments. Logistics, procurement, purchasing, and production indicate the most opportunities for AI-solutions. However, the need for cloud-based AI-offerings is high, as many SMEs have insufficient specialists or data to develop AI-solutions autonomously. As AI continues to become more important in both the domestic and international markets, 70 percent of experts said technology implementation in SMEs is necessary in order to maintain competitiveness in the long term (Lundborg & Märkel, 2019).

The opportunities of AI lie particularly in the area of supply chain optimization as well as higher process efficiency and improved customer service. It is striking that personnel reduction is named as the lowest opportunity. In addition to a lack of expertise and a small database, obstacles also include concerns about data protection and the company's lack of digital maturity (Lundborg & Märkel, 2019).

Even at the European level, SMEs are still not very involved with AI. A study by Saarland University shows that 43 percent of the respondents have not yet dealt with AI. Thus, the majority of SMEs also do not offer any further training opportunities in this area. AI is currently used primarily in business processes to save costs and increase asset efficiency. In this study, too, a clear shortage of AI specialists crystallizes as a problem that can lead to competitive disadvantages on the international market in particular (Kaul, Schieler, & Hans, 2019).

3. METHODOLOGY

The data was collected with the aid of a standardized online questionnaire containing both open and closed questions. The questionnaire was initially checked by a pre-test with several test persons. For the survey, e-mail addresses of German companies were randomly generated using the Nexis database. Finally, the survey period ranged from October 22 to November 11, 2020. A total of 12,360 companies were contacted by e-mail, whereby 1,112 e-mails could not be delivered. Thus, 11,248 companies received the link to the online survey. The online questionnaire was answered 283 times during the survey period, corresponding to a participation rate of 2.5 percent.

The questionnaire contained a total of 33 questions divided into five topics. First, specifications regarding the company and the respondent were asked. This was followed by questions on the general conditions of AI, such as the relevance of AI in the company and for SMEs in general. The following section addressed the technological basis of AI, while the third section represented the relationship between AI and the corporate strategy as well as the business model. The last section was made up of questions that essentially focused on the impact of AI on the success of SMEs.

4. SAMPLE DESCRIPTION

According to the respondents, 54 percent of the companies have the legal form of a GmbH (private limited company). 16 percent of the participants wear the legal dress of an AG (public limited company). 14 percent state that they have another legal form and 13 percent of the respondents state that the legal form of their company is a GmbH & Co. KG. Only 1 percent state that their company is a GmbH & KGaA, and   percent of the respondents are registered as a general partnership. The industry

affiliation of the companies is as follows: 38 percent of the companies are active in the service sector, 11 percent each in mechanical and analogue engineering and in the automotive industry. 6 percent of the companies are active in logistics and another 4 percent in medical technology. 36 percent belong to other sectors, such as health care, trade and the energy industry. 41 percent of the respondents are employed in information technology. 23 percent state that they belong to the management. Furthermore, 8 percent work in HR, 6 percent in controlling and another 3 percent work in production. 24 percent work in other areas of the company, such as marketing & sales and distribution.

5. INITIAL EMPIRICAL RESULTS

5.1. Relevance of technologies for companies

The survey shows that for the respondents, only rule-based systems (45 percent: 19 percent very high and 26 percent high) and machine learning (40 percent: 19 percent very high and 21 percent high) have high relevance in the company. For more than half of the respondents, collaborative robots (72 percent: 57 percent very low and 15 percent low), computer vision (66 percent: 46 percent very low and 20 percent low), chatbots (63 percent: 46 percent very low and 17 percent low) as well as natural language processing (57 percent: 44 percent very low and 13 percent low) and robotic process automation (51 percent: 42 percent very low and 9 percent low) have a low to very low relevance. The companies also attribute low importance to deep learning (49 percent: 36 percent very low and 13 percent low) and process mining (49 percent: 39 percent very low and 10 percent low).

Figure 1. Relevance of technologies for companies
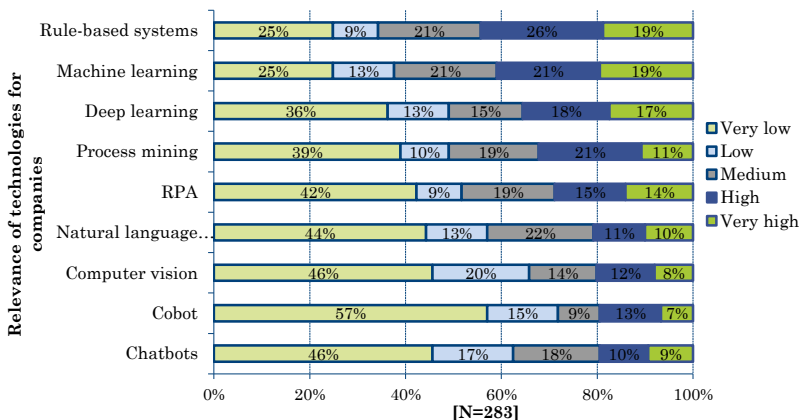
5.2. Opportunities through AI in SMEs

77 percent of the respondents see the greatest opportunities through AI in SMEs in the automation of processes and 72 percent see great opportunities in the efficient use of data. 66 percent cite the acceleration of processes and 55 percent see an advantage through potential savings through artificial intelligence. 53 percent see an advantage for their company in the streamlining of processes. Another 53 percent of respondents cite the possibility of making better decisions. Less than half see an improvement through AI in the development of new business models (43 percent), the improvement of risk management (31 percent) and the improvement of working capital management (19 percent). 1 percent mention other opportunities, such as new product developments.

Figure 2. Opportunities through AI in SMEs

[N=283] (Multiple answers possible)
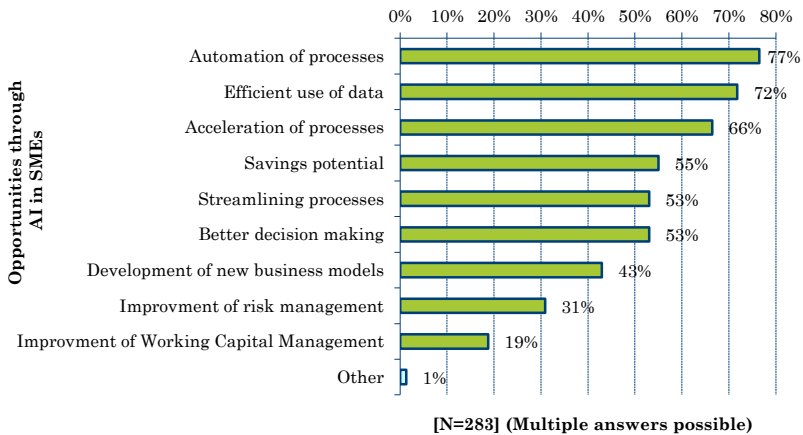
5.3. Assessment of barriers to AI in SMEs

When asked what barriers they see to AI, 65 percent of the companies identify a lack of competence as a barrier. Obstacles at implementation are seen as a challenge by 52 percent of the companies surveyed. Data problems are seen as a hurdle for the use of AI in SMEs by another 52 percent of the survey participants. 46 percent say deficiencies in the IT infrastructure would be an obstacle in their view. 39 percent of respondents cite financial barriers. Further obstacles are seen by 32 percent of respondents in the lack of commitment from top management, 32 percent through regulatory hurdles, not having a business case with 28 percent, as well as 13 percent in cyber attacks

and 7 percent see no value added through AI. Another 7 percent cite the displacement of the human component, for example, as other obstacles.

Figure 3. Barriers to AI

[N=283] (Multiple answers possible)
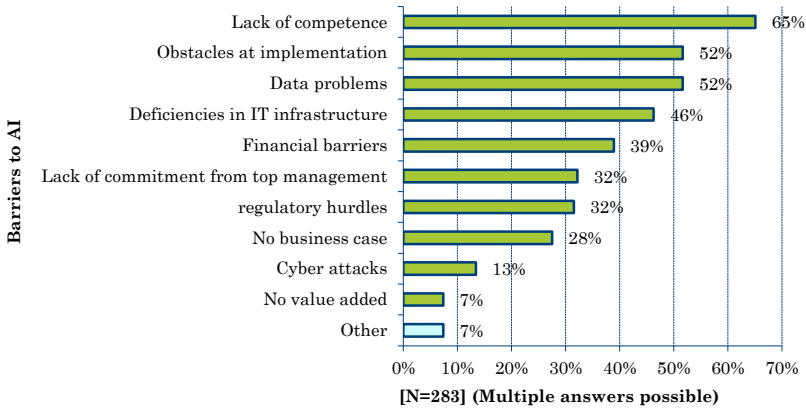
5.4. Suitability of individual company divisions for AI

In addition, the companies were asked to provide information on the suitability of the use of AI in the following company areas: top management, materials & production management, finance, marketing & sales, human resources, logistics, controlling, accounting, IT, research & development. 65 percent of the respondents state that IT is very suitable for the use of AI (34 percent very strongly and 31 strongly). This also includes the area of logistics with 59 percent (28 percent very strongly and 31 percent strongly). More than half also see materials and production management (21 percent very strongly and 31 percent strongly) and finance as very suitable (18 percent very strongly and 34 percent strongly), each with 52 percent. Marketing and sales are strongly suited to AI according to 48 percent of the companies (25 percent very strongly and 23 percent strongly). 46 percent consider research and development (27 percent very strongly and 19 percent strongly) and controlling (45 percent very strongly and 26 percent strongly) to be strongly suited to the use of AI. A further 38 percent say that accounting is strongly suitable for AI (14 percent very strongly and 24 percent strongly). 67 percent of respondents consider top management (33 percent very weak and 34 percent weak) to be weakly to very weakly suitable. HR is also rated as less suitable (47 percent: 23 percent very weak and 24 percent weak).

Figure 4. Suitability of individual company divisions for AI

[N=283]
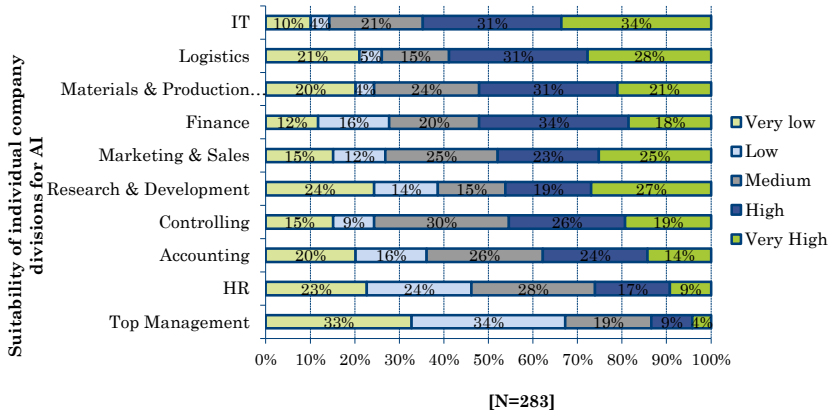
6. OUTLOOK

The initial empirical results of this study show that German SMEs are not yet fully aware of the relevance and potential of AI technologies. They mainly use classic technologies that have been known for a long time, such as rule-based systems.

Contextual factors such as company size, industry and the general level of digitization of the company as well as the potential influence of an entrepreneurial family and a capital market orientation were also queried in the study, but not yet evaluated. It is assumed that these contextual factors have a significant influence on the fundamental importance, the assessment of opportunities and risks, organizational responsibility and ultimately also the budget for AI implementation.

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