AI Adaption within SMEs: Analysis of Impedances and Suggested Approaches

Celeste Chudyk, Damian Läufer, Simone Braun, and Tobias Hagen

IMLA – Institute of Machine Learning and Analytics
Offenburg University of Applied Sciences
{celeste.chudyk|damian.laeufer|simone.braun|tobias.hagen}@hs-offenburg.de

Abstract. In this paper, we present the main obstacles faced by small and medium-sized enterprises (SMEs) when implementing artificial intelligence (AI), and suggest a novel "plug and play" guided approach for further integration. In order to identify the relevant barriers, we first compile results from recent literature reviews that address challenges specific to SMEs and AI. Then, based on the AI maturity model for SMEs by Schuster et al. [1], we analyze the current status of AI in local German SMEs with which we have worked in the context of the "KI-Labor Südbaden"[2] project. Based on the results of the analysis, we detail a structured approach utilizing pre-identified successful AI implementations as the basis for further technological development. By structuring their AI integration on known successful use cases, SMEs have the chance to leapfrog their AI development and remain competitive in today's landscape.

1 Introduction

Due to the recent rapid progress in generative AI and in the continuous steady progress in traditional machine learning methods, there has been unprecedented opportunity for the application of AI to assist or even transform local economies [3,4]. However, adoption is so far spread unevenly, with German SMEs adopting AI at a slower pace than larger industry[5].

Although the field of AI dates back to the 1950s [6,7], the first decades of progress were slow due to limited computational resources and data. The pace of development accelerated with the advent of deep learning, and with the launch of ChatGPT in November of 2022, AI suddenly entered the mainstream lexicon. Interest in using AI for business applications also boomed at the same time.

However, AI adoption has not been evenly distributed. As with previous generations of technological advancement such as basic digitization, SMEs have been slower to onboard AI technologies [8,9,10,11,12]. As of 2023, only 12% of German companies have reported that they have implemented AI[5], compared to 55% internationally[13].

Integration of AI tools in the workforce generally results in a modest revenue increase, with McKinsey reporting additional revenue gains of 3 to 15 percent, and sales ROI gains of 10 to 20 percent [14] . However, AI adoption is forecasted not just to marginally increase profitability but to potentially enable radical economic transformation. Rather than simply a means of faster production, it is a technology that enables new innovation itself [15]. "This is where AI's true potential will emerge: not in doing the same thing better, faster, and cheaper but by doing new things altogether." [16] Although larger firms have higher rates of AI adoption, SMEs make up the majority of both German and European companies (99.3% and 99.8% respectively)[17,18]. Therefore, it is essential that

AI adoption within SMEs can be accelerated, so that they can retain their competitive standing and remain a core component of the European economy in the long term.

In order to facilitate local AI implementation, the state of Baden-Württemberg initiated the "KI-Labor" (AI Lab) network [19]. The "KI-Labor Südbaden"[2] is one of 16 state-funded AI labs in Baden-Württemberg that offer advice and support to local companies (including events, workshops, and individual consulting). Based on our experiences at this AI Lab, in this paper we summarize the challenges of AI implementation in SMEs as well as advocate for suggested solutions, in order to expedite future AI adoption. First, we analyze current research on the barriers and challenges SMEs face in adopting AI, then we apply an AI maturity model to evaluate the current level of AI adoption amongst the local consulted organizations. Based on these analyzes, we design a systematic approach that would further facilitate the adoption of AI in SMEs within future projects.

2 Challenges for SMEs in the Adoption of AI

In order to review the main barriers for adoption of AI within SMEs in general, we conducted a literature review in August and October 2024 using Google Scholar. The search term was as follows:
allintitle: ("challenge" OR "challenges" OR "obstacle" OR "obstacles" OR "difficulty" OR "difficulties" OR "hurdle" OR "hurdles" OR "test" OR "tests" OR "trial" OR "trials" OR "problem" OR "problems" OR "complication" OR "complications" OR "barrier" OR "barriers" OR "struggle" OR "struggles") AND ("AI" OR "artificial intelligence") AND ("SME" OR "SMEs" OR "MSME" OR "MSMEs" OR "small and medium enterprise" OR "small and medium enterprises") AND ("review" OR "study" OR "overview" OR "survey"). Only well-structured literature reviews and comprehensive surveys that specifically addressed AI within SMEs and that were published between 2022 and 2024 were included. This was to ensure that the results were representative and reflected the current situation in 2024. The search yielded 42 results. After excluding articles due to qualitative concerns, eight articles remained for analysis. The most common challenges of AI integration for SMEs that were addressed in the literature reviews were tabulated, with an overview presented in Table 1.

As shown in the table, most studies listed similar challenges. A lack of knowledge and skills was described in every review as a major challenge. Specifically, the reviews cited lack of AI experts in SMEs [11,20,21,22,23,24,25,26] and a general lack of understanding and awareness of the technology among their employees [11,20,21,24,25]. All analyzed reviews also mentioned financial barriers, such as a general lack of avail-

Table 1. Main Challenges in AI adoption for SMEs

Challenge	Source
Lack of knowledge / skills	[11,20,21,22,23,24,25,26]
High costs and financial risks	[11,20,21,22,23,24,25,26]
Lack of data (quality, quantity and availability)	[11,20,21,23,24,25]
Lack of management awareness and strategy	[11,20,21,22,24,25,26]
Complexity and individuality of potential AI solutions	[11,20,21,24,25]
Inadequate IT-infrastructure	[11,20,21,22,23,24,25]
Data privacy, security, and regulations	[11,20,23,24,25,26]
Ethical and social concerns	[11,20,23,24,25,26]

able budget [20,21,23,24,25], perceived high cost of implementation and maintenance [11,20,21,22,23,24,26], uncertainties in cost-benefit assessment [11,21,22], the avoidance of a possible bad investment [11,24], and the pursuit of short-term profit [25]. In various SMEs, data was limited to small quantities and/or had low quality [11,20,21,23,24,25]. Without sufficient data, individual AI projects were often not feasible. The challenge of the lack of awareness of AI could also be observed in management [11,20,21,22,24,26]. A limited understanding of AI led to avoidance of its use and impeded development of comprehensive AI strategies [11,20,21,25]. The complexity of modern AI approaches and the individuality of possible AI solutions was another barrier for many SMEs [11,20,21,24]. The IT infrastructure was often limited and not suitable for AI use [11,20,21,22,24,25]. Some processes were not (or not sufficiently) digitized. This in turn prevented adequate data collection, which was reflected in the problem of data availability described above. In terms of data security, many SMEs feared that the use of AI would increase the attack surface [20,25,26]. Complex and evolving policies in this area further detered SMEs [24,25,26]. Ethical issues were also a barrier, including concerns about job security [23,26], fairness and transparency [20,24], and potential lost of trust from customers [24,25].

3 Experience and Maturity levels

In order to assess the current level of AI adoption within the SMEs that were assisted locally through the AI Lab, we used the AI maturity model by Schuster et al. [1]. From several such models available, the Schuster model was selected due to its intentional development for SME use, its structured approach, and its comprehensive scope, which included ethics and privacy (dimensions often not present in other approaches). The model rates organizations along five levels (Novice, Explorer, User, Translator and Pioneer) for the categories listed in Table 3. The AI Lab has advised and supported numerous companies from various sectors in AI projects; representative of the full spectrum of companies we have supported (see Table 2), five organizations are assessed below for their level of AI maturity, with results shown in Table 3. [1] All companies were graded as falling within in the lower two maturity levels in all dimensions.

In October 2024, we also asked nine SMEs from the southern Black Forest region to self-assess their AI maturity. An overview of the self-assessments can be found in Figure 1. The self-assessments confirmed our experience, that local SMEs remained mostly at the "Novice" or "Explorer" level. All but two companies gave a self-evaluated rating below the "User" level in all categories. Below, we summarize the state of AI adoption for each dimension in the consulted organizations.

Table 2. Considered organizations and related AI projects

Organization	**Sector**	**AI Project**
Org 1	Service	Chatbot
Org 2	Engineering	Predictive Maintenance
Org 3	Engineering	Predictive Maintenance
Org 4	Sales	Churn Prediction
Org 5	Consulting and Assessment	AI workshops

[1] Not all organizations analyzed here meet the full EU definition of an SME. Nevertheless, we assume that the results are transferable to local SMEs due to the sectors and business models of the organizations.

Table 3. Maturity ratings of the five considered companies

Category	Org 1	Org 2	Org 3	Org 4	Org 5
Culture/mindset	Explorer	Explorer	Explorer	Novice / Explorer	Explorer / User
Data	unknown	Novice	Novice	Explorer	Novice
Ethics	Novice	Novice	Novice	Novice	Novice / Explorer
Organization	Explorer	Novice	Novice	Novice	Novice
Privacy	Novice	Novice	Novice	Explorer	Explorer
Strategy	Novice/Explorer	Novice	Novice	Novice	Novice / Explorer
Technology	Novice	Novice	Novice	Novice / Explorer	Novice / Explorer

Culture and Mindset: The majority of managers in all companies surveyed show a strong interest in AI, as evidenced by their cooperation with the AI Lab. Companies saw potential in the use of AI, and in some cases considered it a necessity to remain competitive. However, the organizations lacked any noticeable AI culture that promoted innovation.

Data: The data provided by companies often had qualitative and quantitative shortcomings. The data were never collected explicitly for AI usage, resulting in low temporal resolution and imprecise output values. Additionally, there were often factual contradictions between related data sets and other inconsistencies. In other cases, high-quality data were only available for a limited time period or for a small sample size.

Ethics: Most organizations had no AI-specific ethics policy. However, in multiple cases, an active knowledge of consumer privacy laws (regarding General Data Protection Regulation – GDPR [27]) was demonstrated.

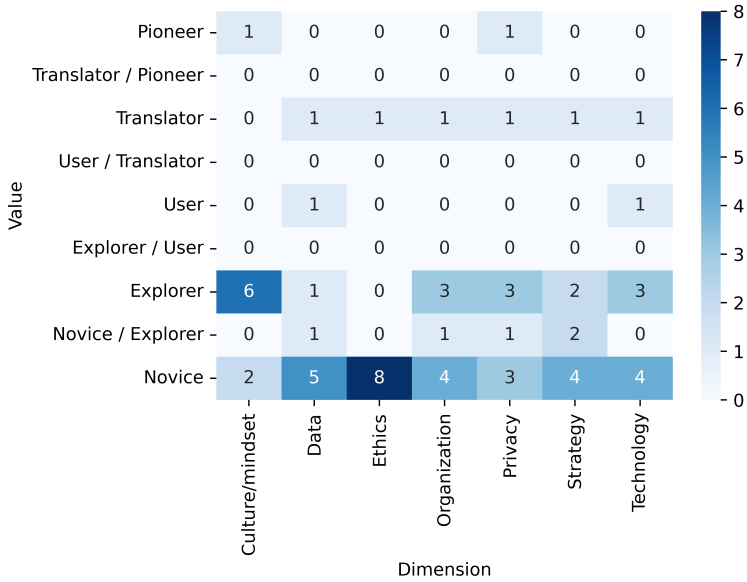

Fig. 1. Overview of the self-assessed AI maturity levels of nine SMEs from the southern Black Forest region.

Organization: In terms of organizational structures, companies were not ready for AI integration. The available resources (in particular: data, computing power, and personnel) were not yet adequate.

Privacy: The topic of data privacy was not initially prioritized by most of the companies surveyed, however they did show awareness of basic concepts, having worked with GDPR regulations previously.

Strategy: Although many managers were interested in incorporating AI technologies into a future strategy, and also had ideas for their first AI projects, these ideas were not yet part of official company policy.

Technology: Despite interest, AI applications were still rarely used in production. There was a lack of understanding about the technology along with its possibilities and limitations. In some cases, there were unrealistic ideas of AI, and uncertainty of when applying AI would be appropriate.

Overall AI Maturity of SMEs: The companies surveyed were still in the early stages of AI adoption. Despite a strong interest and a generally positive attitude towards AI, there was a lack of practical education concerning the technology along with a lack of necessary data. Working on building an understanding of the basics would be essential to progressing further on the maturity model.

4 Structured Approach for the Introduction of AI projects

In order to overcome the barriers to AI adoption listed in Table 1, and in consideration of feedback from managers of local SMEs, we have developed a suggested "plug and play" approach for quickly prototyping and integrating AI solutions for SMEs new to AI. Where continuing education resources already exist, they have been well received [28]. To expand on the concept of educational AI workshops, we propose a hands-on approach consisting of not only explanations of fundamental AI concepts, but also of guided implementation of a predetermined sample AI project. Industry leader Andrew Ng advises companies "to work on a *concrete idea*, meaning a specific product envisioned in enough detail" rather than following the typical design-thinking approach of brainstorming and developing strategy first [29]. Developing "plug-and-play" solutions that could be easily applicable to most companies would ensure faster implementation as well as a faster learning process to identify the company's challenges regarding the onboarding of AI technologies. These quick implementations could then be used as building blocks on which to foster wider AI adoption within the whole business. This would allow for an experiential education process that addresses all eight key challenge areas during project implementation. This approach would include:

- structured workshops / introduction to AI
- a list of specific predefined use cases that organizations can adapt as part of the project
- accompanying prerequisites and suggestions for when each use case is appropriate
- lists of suggested software frameworks to use for each case and instructions on how to use them (with more than one option for each functionality so that there is room for individualized choices based on requirements)
- guidance through the first implementation steps of the selected use case, with details of these steps shown in Figure 2.

This approach would not only serve as a foundation for the company's understanding of AI technology, but also act as the first stepping stone for developing the capacity for the

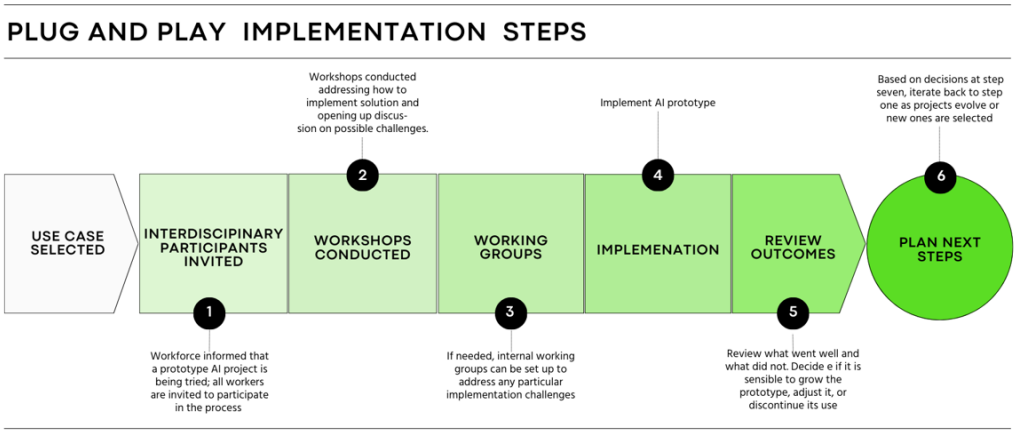

Fig. 2. Suggested Implementation Steps

organization to identify, select, and run AI projects more independently in the future, without (or with less) reliance on third parties.

A guided implementation of an already mostly-finished solution would address the eight challenges in Table 1 in the following way:

- **Lack of knowledge / skills:** Workshops included along with the solutions would both introduce basic AI concepts as well as link the theoretical concepts to their real-life counterparts.
- **High costs and financial risks:** Because the solution would be either free or have minimal costs (depending on the exact implementation details the company chooses i.e., are they combining the project with a cloud service), it would mitigate financial risk.
- **Lack of data:** Through either the implementation of using pretrained models as a solution, or using a limited machine learning solution, what data is needed would be limited, using only a predefined set of data (based on what has been found to be the minimum data necessary to solve the problem).
- **Lack of management awareness and strategy:** Similar to the first issue, the accompanying workshops will address management awareness. The development of a comprehensive AI strategy for the company can be delayed until after the plug and play prototype launch, at which point management will be better prepared through the first-hand experience to development an appropriate strategy.
- **Complexity and individuality of potential AI solutions:** By using a predefined prototype, the complexity is greatly reduced. Although the underlying technology remains complex, the implementation steps are clear and the uncertainty of which AI project to start with is removed.
- **Inadequate IT-infrastructure:** By starting with a relatively simple AI example, IT-infrastructure problems are minimized. By working from a predetermined list of possible solutions, which would include the use of software as a service solutions that are chosen for user-friendliness, there are no complicated IT decisions to be made upfront.
- **Data privacy, security, and regulations:** Data privacy, security, and regulation concerns are preemptively considered within the possible use cases. How these issues are addressed within the prototype can act as a useful reference for future projects.

– **Ethical and social concerns:** Ethical and social concerns are addressed throughout the project by maintaining transparency within the organization. Moreover, the process acts as a continuing education opportunity.

This structured approach could significantly mitigate overall risk of the implementation failing. Although larger industry players have demonstrated faster adoption rates of newer technology over time, studies estimate over an 80% failure rate of data science and AI projects [30,31,32]. The rates of success for purely generative AI applications are not yet clear; Gartner estimates a 30% failure rate by 2026 [33]. Therefore, we can look to research to find examples that have already demonstrated a successful track record, and select those examples as first implementations. Based on a McKinsey study, the top three use cases with the greatest financial success are: 1. Sales, 2. Software engineering, and 3. Marketing [4]. Considering their demonstrated success, plug and play solutions based in these areas can be used in SMEs as their first AI prototypes, with use cases as follow:

– **Sales**: Automated churn prediction, customer lead prioritization, chatbot integration for product recommendation
– **Software engineering**: Augmented software development through the use of LLMs or products such as GitHub Copilot. [2]
– **Marketing**: Generative AI can be used for the expedited creation of marketing materials such as landing pages and social media posts.

It is possible that later AI adoption could even be advantageous, in that initial R&D investments and trial and error of testing various methodologies can be entirely skipped over, following the economic development concept of leapfrogging. New adopters also have the advantage of avoiding the technical debt of older implemented systems. In the most ideal situations, these leapfroggers "not only jump over some phases of technological development but also create new paths to follow." [34]

5 Conclusion

Recent rapid AI technological progress has great economic potential, with a bare minimum effect of productivity gains in the near-term, along with the more long-term potential of fundamental industry transformation. However, deployment of AI solutions has been uneven according to business resources. In order for SMEs not to fall behind, we advocate for an assisted approach, providing guidance through the implementation of a first AI prototype. By implementing manageable, already tested solutions, SMEs could leapfrog past the need for local R&D, and instead implement current state-of-the-art solutions, meanwhile gaining the knowledge and experience necessary for further independent AI integration and innovation.

References

1. Schuster, T., Waidelich, L., Volz, R.: Maturity models for the assessment of artificial intelligence in small and medium-sized enterprises. In: Digital Transformation, Cham, Springer International Publishing (2021) 22–36

[2] AI augmented code generation is relevant for more than firms selling software solutions. Examples include AI-assisted G-Code generation for CNC machines in the manufacturing sector, and AI-assisted HTML editing for homepages.

2. KI-Labor Südbaden: Hochschule Offenburg KI-Labor Südbaden. https://ki-suedbaden.de/ (2024) [Accessed 10-09-2024].
3. Acemoglu, D.: The simple macroeconomics of ai. Technical report, National Bureau of Economic Research (2024)
4. Chui, M., Hazan, E., Roberts, R., Singla, A., Smaje, K., Sukharevsky, A., Yee, L., Zemmel, R.: The economic potential of generative ai: The next productivity frontier. Technical report, McKinsey (2023)
5. Rammer, C., Doherr, T., Kinne, J., Lenz, D.: Ki-einsatz in unternehmen in deutschland. Technical report, Bundesministerium für Wirtschaft und Klimaschutz (2024)
6. Turing, A.M.: Computing machinery and intelligence. Mind **59**(236) (1950) 433–460
7. McCarthy, J., Minsky, M.L., Rochester, N., Shannon, C.E.: A proposal for the dartmouth summer research project on artificial intelligence, august 31, 1955. AI Magazine **27**(4) (2006)
8. Barton, M., Budjac, R., Tanuska, P., Gaspar, G., Schreiber, P.: Identification overview of industry 4.0 essential attributes and resource-limited embedded artificial-intelligence-of-things devices for small and medium-sized enterprises. Applied Sciences **12**(11) (2022)
9. Cotrino, A., Sebastián, M.A., González-Gaya, C.: Industry 4.0 roadmap: Implementation for small and medium-sized enterprises. Applied Sciences **10**(23) (2020)
10. Bauer, M., van Dinther, C., Kiefer, D.W.: Machine learning in sme: An empirical study on enablers and success factors. In: Americas Conference on Information Systems. (2020)
11. Oldemeyer, L., Jede, A., Teuteberg, F.: Investigation of artificial intelligence in smes: a systematic review of the state of the art and the main implementation challenges. Management Review Quarterly (2024)
12. Tominc, P., Oreški, D., Čančer, V., Rožman, M.: Statistically significant differences in ai support levels for project management between smes and large enterprises. AI **5**(1) (2024) 136–157
13. Chui, M., Hall, B., Singla, A., Sukharevsky, A., Yee, L.: The state of ai in 2023: Generative ai's breakout year. Technical report, McKinsey (2023)
14. Deveau, R., Griffin, S.J., Reis, S.: Ai-powered marketing and sales reach new heights with generative ai. Technical report, McKinsey (2023)
15. Cockburn, I.M., Henderson, R., Stern, S.: The impact of artificial intelligence on innovation. Working Paper 24449, National Bureau of Economic Research (2018)
16. Ransbotham, S., Khodabandeh, S., Fehling, R., LaFountain, B., Kiron, D.: Winning with ai. MIT Sloan Management Review (2019)
17. Statistisches Bundesamt: 55% in kleinen und mittleren unternehmen tätig. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Unternehmen/Kleine-Unternehmen-Mittlere-Unternehmen/aktuell-beschaeftigte.html (2024) [Accessed 14-10-2024].
18. GROW.A.2: 2024 sme fact sheet. Technical report, European Commission (2024)
19. Ministerium für Wirtschaft, Arbeit und Tourismus: Regionale Labore für Künstliche Intelligenz in Baden-Württemberg. https://www.wirtschaft-digital-bw.de/ki-made-in-bw/regionale-ki-labs/standorte-der-regionalen-ki-labs (2024) [Accessed 10-09-2024].
20. Lu, X., Wijayaratna, K., Huang, Y., Qiu, A.: Ai-enabled opportunities and transformation challenges for smes in the post-pandemic era: a review and research agenda. Frontiers in Public Health **10** (2022)
21. De Simone, V., Pasquale, V.D., Miranda, S.: An overview on the use of ai/ml in manufacturing msmes: solved issues, limits, and challenges. Procedia Computer Science **217** (2023) 1820–1829
22. Govori, A., Sejdija, Q.: Future prospects and challenges of integrating artificial intelligence within the business practices of small and medium enterprises. Journal of Governance and Regulation **12**(2) (2023) 176 – 183
23. Schönberger, M.: Artificial intelligence for small and medium-sized enterprises: Identifying key applications and challenges. Journal of Business Management **21** (2023) 89–112

24. Yusuf, S.O., Durodola, R.L., Ocran, G., Abubakar, J.E., Echere, A.Z., Paul-Adeleye, A.H.: Challenges and opportunities in ai and digital transformation for smes: A cross-continental perspective. World Journal of Advanced Research and Reviews **23**(3) (2024) 668–678
25. Grünbichler, R., Salimbeni, S.: Artificial intelligence in small and medium-sized enterprises: Requirements and barriers. In: Latest Advancements in Mechanical Engineering, Springer Nature Switzerland (2024) 173–184
26. Iyelolu, T.V., Agu, E.E., Idemudia, C., Ijomah, T.I.: Driving sme innovation with ai solutions: overcoming adoption barriers and future growth opportunities. International Journal of Science and Technology Research Archive **7**(1) (2024) 036–054
27. Council of European Union: Regulation (eu) 2016/679 of the european parliament and of the council. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L:2016:119:FULL (2016)
28. Reyes, C.C., Eisele, O., Lennings, F., Sandrock, S., Schüth, N.J., Terstegen, S.: Künstliche intelligenz erkennen, bewerten und einführen. Technical report, ifaa (2023)
29. Ng, A.: OpenAI Shrinks GPT-4o, Meta Withholds Models From Europe, and more — deeplearning.ai. https://www.deeplearning.ai/the-batch/issue-259/ (2024) [Accessed 29-07-2024].
30. VentureBeat: Why do 87% of data science projects never make it into production? https://venturebeat.com/ai/why-do-87-of-data-science-projects-never-make-it-into-production/ (2019) [Accessed 01-10-2024].
31. Ryseff, J., Bruhl, B.F.D., Newberry, S.J.: The root causes of failure for artificial intelligence projects and how they can succeed: Avoiding the anti-patterns of ai. Technical report, RAND Corporation (2024)
32. Bojinov, I.: Keep your ai projects on track. Harvard Business Review **11** (2023)
33. Gartner Inc.: Gartner predicts 30 https://www.gartner.com/en/newsroom/press-releases/2024-07-29-gartner-predicts-30-percent-of-generative-ai-projects-will-be-abandoned-after-proof-of-concept-by-end-of-2025 (2024) [Accessed 08-10-2024].
34. Kopka, A., Fornahl, D.: Artificial intelligence and firm growth — catch-up processes of smes through integrating ai into their knowledge bases. Small Business Economics **62**(1) (2024) 63 – 85