

# Adopting Artificial Intelligence in Danish SMEs: Barriers to Become a Data Driven Company, Its Solutions and Benefits

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**Abstract:** Artificial intelligence allows small and medium-sized enterprises (SMEs) in the manufacturing sector to improve performance, reduce downtime and increase productivity. SMEs in Denmark are still struggling to implement artificial intelligence based strategies since they face a range of challenges, such as business applications, data availability, organizational culture towards the acceptance of new technologies, investment in new technologies, skills gap, development process and effective strategy. In the beginning, the paper describes the challenges faced by SMEs in adopting artificial intelligence. Then, the paper suggests solutions to overcome these challenges and discusses the importance of artificial intelligence as well as the opportunities it offers to SMEs.

## 1 INTRODUCTION

Industry 4.0, also called fourth industrial revolution, is the integration of IT and production systems. The IT systems comprise of artificial intelligence, industrial robots, sensors, alarms, IoT, cloud computing, image analysis, inventory management, data analysis and mood/behaviour analysis. The production systems include but not limited to enterprise resource planning (ERP), manufacturing execution system (MES), control and hardware. The integration of IT systems with production systems provides new insights from previously hidden information and allows for better decision making. Further, since 5G reduces response times from minutes to milliseconds, artificial intelligence (AI) has become the main driving force behind this industrial revolution in order to help enterprises to improve yield, quality, performance, efficiency and to decrease product waste, downtime, production and maintenance cost. AI is a broader term that covers a wide range of concepts and technologies, including machine learning (ML) and deep learning (DL). A survey of more than 500 Danish companies (Colotla et al., 2016) concluded that most of the companies are willing to change their business models to adopt AI in order to become more productive and to improve customer as well as product services. In spite of that most of the SMEs are left be-


hind in this race of embracing AI due to numerous obstacles, just as, lack of expert knowledge, capabilities and funds. Aiming to be a front-runner in the use of AI, Denmark has formulated a *National Strategy for Artificial Intelligence*<sup>1</sup> to boost research and development in AI. The main aims of this strategy is to establish better collaboration between researchers and businesses, start new education programmes on AI and raise an investment pool of DKK 1.5 (€ 0.2) billion based on public-private partnership to help enterprises adopt AI (O'Dwyer, 2019).

To summarize, the main contributions of this paper are as follow:

- Discussing the main barriers for adopting AI.
- Suggesting the activities to be performed before adopting AI and investigating what needs to be done to prepare SMEs for AI adoption.
- Presenting the values of AI for SMEs.

The paper is structured as follows. Section 2 explains the motivation behind this paper. Section 3 introduces the research methodology. Section 4 presents the challenges for successfully implementing AI in SMEs. Section 5 suggests the solutions to deal with these challenges. Section 6 presents the benefits of AI for SMEs. Section 7 concludes the paper and points to the future directions.

<sup>1</sup><https://en.digst.dk/policy-and-strategy/denmark-national-strategy-for-artificial-intelligence>

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## 2 MOTIVATION

The European Commission defines SMEs as those enterprises employing fewer than 250 employees (Matt et al., 2020), have an annual turnover of less than DKK 375 (€ 50) million and/or a total balance sheet of less than DKK 320 (€ 43 million). According to a survey conducted of European enterprises (Jäger et al., 2015), only one-third of SMEs have adopted the fourth industrial revolution compared to more than two-thirds of large enterprises. The main challenges for the European SMEs to adopt AI appear to be limited funding, changing business models, data accessibility, legal and intellectual property issues, lack of industrial standards and shortage of skilled workers (Matt et al., 2020). Denmark's industry structure is centered around SMEs – there are currently more than 300,000 SMEs in Denmark, corresponding to more than 98% of Danish companies. Out of the total SMEs, just 5% SMEs in Denmark currently work with AI (Lindberg et al., 2019). Further, only 20% large enterprises have included AI in the core part of their corporate strategy (Wagner, 2018). Denmark ranks globally 25<sup>th</sup> on investment in AI and 65<sup>th</sup> as an AI eco-system, total (% of GDP). Similarly like European SMEs, most of Danish enterprises also agree that lack of skills and talent, access to funding, clear strategy, data availability, ownership and commitment are the biggest challenges to AI adoption. Adoption of AI in Denmark will have a huge impact on Danish enterprises and economy. It will be a game changer for the enterprises in order to help them to increase productivity and open the doors for new as well as innovative products and business models. It is estimated that AI may offers Danish enterprises between DKK 100 (€ 13.5) to DKK 160 (€ 21) billion of value potential. Similarly, the impact potential of AI may bring up to additional DKK 35 (€ 4.7) billion annually by 2030, total (% of GDP).

Nonetheless, adopting AI will be costly, however, its overall impact on the Danish economy will be positive. AI will make a positive difference to the Danish job market by creating jobs up to 80,000 people with AI skills by 2030 (Lindberg et al., 2019).

## 3 METHODOLOGICAL APPROACH

The methodological approach used in this paper is known as the systematic literature review (Kitchenham et al., 2009). This approach deals with collecting, checking and analysing data from the existing literature based on information found in journals, con-

ferences, books, academic dissertations, reports and news articles with specific search questions in mind. Some of the questions are as follow:

- What are the challenges of adopting AI in manufacturing SMEs in Denmark/Nordic countries?
- What solutions are most commonly associated with AI adoption in SMEs?
- Does AI produce beneficial outcomes for SMEs?

## 4 CHALLENGES FOR ADOPTING AI IN SMEs

### 4.1 Overview

Small and medium-sized enterprises are far behind in deploying AI-based technologies when compared with large enterprises. The common challenges faced by SMEs in Denmark as well as SMEs in neighbouring Nordic countries and in Germany are: lack of support and commitment for AI within organization, high degree of restraint over return on investment (ROI), shortfall of right skills/competences, absence of digital standards, data security/privacy issues, inadequate funding and shortage of right tools/technologies (Colotla et al., 2016), (Wuest et al., 2016), (Stentoft et al., 2019), (El-Jawhari et al., 2020), (Bauer et al., 2020), (Sjøberg, 2019), (Yu and Schweisfurth, 2020), (Schröder, 2016), (Rauch et al., 2019), (Bianchini and Michalkova, 2019), (Truvé et al., 2019), (Aarstad and Saidl, 2019), (Kim et al., 2018). Furthermore, it can be observed in the radar chart (Fig. 1) with number of quantitative variables that lack of organizational readiness for change, skilled labour shortages and shortage of funds are the three main obstacles to AI adoption. As, the focus of this paper is to suggest the activities that must be considered before implementing AI in SMEs. Thus, in addition to these three above mentioned challenges some of the other SME specific challenges posed by AI adoption that must be addressed are also discussed further in Section 5.

## 5 WAYS OF OVERCOMING THE CHALLENGES

### 5.1 Overview

In order to overcome some of the challenges associated with the adoption of AI, *AI Denmark*<sup>2</sup> has

<sup>2</sup><https://aidenmark.dk>

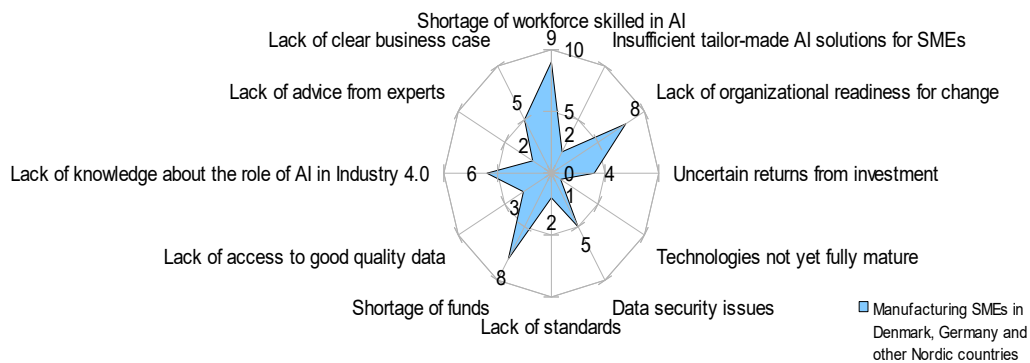


Figure 1: Barriers to AI adoption for SMEs.

launched an innovative project to help Danish SMEs to increase their competitiveness with AI. The project is financed by *The Danish Industry Foundation*<sup>3</sup>. The total project budget is DKK 34.5 (€ 4.6) million and the project will run for the next three years from 2021 to 2023. About 120 Danish SMEs will participate in the project for a period of next six months in order to gain competitive advantage. The main goals of the project is to launch tailor-made/company-specific AI-based pilot projects, provide training to its workforce on the utilization of AI-based tools/technologies and support successful process of organizational change. In addition, the following initiatives will strengthen the adoption of AI in Manufacturing SMEs in Denmark.

## 5.2 Business Strategy

### 5.2.1 Involvement of Top Management

The involvement of senior leadership in the implementation of Industry 4.0 and AI is one the most critical success factors even more important than the technical ability and AI technology (Dhasarathy et al., 2020). Those SMEs, whose senior management has basic understanding of AI-related technologies/tools, their applications in SMEs and associated benefits, are more likely to succeed in adopting AI (Iftikhar and Nordbjerg, 2021). Hence, it is recommended that the top management should have a clear strategy of how to generate most value with AI by investing in AI skill development, good quality data and organizational cultural enhancement. Moreover, the AI strategy should be an integral part of their overall business strategy.

### 5.2.2 Organizational Change Process and Cultural Enhancement

Top management needs to enable a data and AI-driven culture within the organization (Jöhnk et al., 2021). In order to meet this challenge, it is recommended that the top management must create AI knowledge/awareness among its employees and educate the employees about the capabilities and value of AI, in addition to the risks and limitations associated with AI. At the same time, they need to address the ethical and moral implication of AI by generating trust between human-robot interaction tasks and countering the fears of AI replacing their jobs.

### 5.2.3 Returns from AI Investment

To measure returns from AI investment, it is necessary to calculate all possible costs such as, changing the overall business process and mindset, training employees, data collection, technology investment as well as forecast the business value that AI will bring to the enterprise. In this way, the enterprise's top management can make the decision on returns from AI investment.

### 5.2.4 Crash Courses in AI for Everyone

The lack of AI knowledge within SMEs can prevent them from adopting AI. Enterprise employees might not know how to start/use or even which AI technology exists and how it can be used for their benefit (Hansen and Bøgh, 2021). To tackle this issue, it is suggested that Denmark might also follow Finland's model to launch free online crash courses in *Elements of AI*<sup>4</sup> with the aim of educating not only the enterprise employees but also the general population about this new technology. Similarly, enterprises should commit and invest in the skill development

<sup>3</sup><https://www.industriensfond.dk>

<sup>4</sup><https://www.elementsofai.com>

programs of their work force. In addition, AI awareness should be generated by establishing partnership with other non-competing enterprises as well as educational institutions, especially the university colleges for the reason that Danish university colleges have already close ties with SMEs. Basic to advanced level AI courses should be offered with public-private partnerships for enterprises that are thinking about adopting AI as well as the enterprises that are already working with AI.

### 5.2.5 Business Case

Clearly defining the ultimate project/business goals is very crucial for the success of any AI-driven project. It is suggested that the AI-driven project should start with the identification of a problem. The project should have a specific and a clear business case. In this regard, some of the most common questions that should be answered are:

- What is this project going to achieve with respect to business value?
- What is the problem that needs a solution?
- Why is the problem important?
- Are there any hypotheses?
- What is the preferred outcome?
- What are the expected benefits for the business?
- Will the solution be actually implemented?
- What are the constraints with relation to the implementation?

Further, once the scope of the to-do-list to achieve the goals has been finalized. Assembling the right project team, selecting the core functionalities and preparing a prototype as early as possible, can form the basis for a clear business case.

## 5.3 SME Collaborations

For Denmark to accelerate in AI adoption, a joint alliance among SMEs, non-profit organizations/associations, universities and startup companies is necessary (Lindberg et al., 2019).

In this regard, an experimental learning facility “small Industry 4.0 factory” has been established at Aalborg University, Denmark. The main aim of the learning factory is to create a platform for developing Industry 4.0 technologies to satisfy future manufacturing requirements as well as demonstrating their value to SMEs in a production-like environment (Nardello et al., 2017). Similarly, *Manu-*

*facturing Academy of Denmark*<sup>5</sup> and *Norwegian Artificial Intelligence Research Consortium*<sup>6</sup> has also taken initiatives for the development of strategic partnerships between universities/university colleges, research and technology organisations, start-up companies and SMEs.

Moreover, alliances among non-competing SMEs, universities/university colleges and start-up companies are highly recommended. Through these alliances, partners can not only share their experiences but also help in narrowing the talent gap by offering expert help and contributing to the fund by sharing the budget, for example due to similar business/use cases.

### 5.3.1 Narrow the Talent Gap in AI

The number of graduates in AI-related fields must be increased by providing more AI-related educational programs at Danish universities and university colleges as well as by attracting international talent. In addition, to meet industry’s increasing need for AI skills *Denmark sets out to overcome the AI talent shortage*<sup>7</sup> by launching a large initiative called the Danish Technology Pact (TP) to increase the number of Science, Technology, Engineering and Mathematics (STEM) professionals with 20% by 2025.

### 5.3.2 AI Project Funding

SMEs should take proactive approach, partner with other non-competing enterprises, start-up companies as well as universities/university colleges in Denmark and internationally, and look for expert help, for example, Manufacturing Academy of Denmark (MADE) for funding their projects. Further, SMEs can get funding help from Innobooster, which is a funding programme within *Innovation Fund Denmark*<sup>8</sup>. Innobooster invests in promising ideas from SMEs and start-ups. Innobooster covers 33% of project expenses and invests up to DKK 5 (€ 0.65) million in projects that demonstrate innovative thinking and significant market potential.

Furthermore, it is recommended that flexible loans and tax incentives/credits should be offered to SMEs carrying out AI-related projects. Cash awards should be given for AI solutions that demonstrates best business values. Similarly, SMEs should be offered grants for private consultations, participation in training workshops and any opportunities to strengthen AI skills of their work force.

<sup>5</sup><https://www.made.dk>

<sup>6</sup><https://www.nora.ai>

<sup>7</sup><https://investindk.com/insights/denmark-sets-out-to-overcome-the-ai-talent-shortage>

<sup>8</sup><https://innovationsfonden.dk>

## 6 BENEFITS OF ADOPTING AI IN SMES

### 6.1 Overview

The introduction of AI comes with many benefits that can help SMEs to gain valuable insight into their usual operations and maintenance strategies, thus reducing maintenance cost. SMEs can perform their tasks in more efficient way by improving operational efficiency, production process and *Overall Equipment Effectiveness (OEE)*<sup>9</sup>. Further, AI can assist SMEs in raising human-robot collaboration, enhancing product quality, minimizing downtime, increasing productivity, boosting revenue and exploring new business opportunities (Colotla et al., 2016), (Lindberg et al., 2019).

Furthermore, one of the direct benefits of AI in manufacturing SMEs is fault detection, prediction/predictive maintenance and prevention, which is described below.

#### 6.1.1 Fault Detection, Prediction and Prevention

Fault detection or diagnosis identifies a fault after it occurred as well as the cause or location of the fault and/or what needs to be adjusted in order to fix the fault. Fault diagnosis based systems monitor data in real-time and provide an alert or alarm when an anomaly has occurred (Iftikhar et al., 2020). On the other hand, fault prediction or prognosis helps to predict when and where a fault might occur, so that necessary corrective actions can be taken. It is useful to identify the remaining useful life of a machine or when a equipment will fail (Angelopoulos et al., 2020). Moreover, fault prevention takes fault prediction a step further. In addition to predict the threats of potential equipment failure, it also suggests what actions should be taken in order to avoid the failure.

Additionally, a concrete example of the benefits of AI in a real-world medium-sized manufacturing company in Denmark is presented in (Iftikhar et al., 2019). One of the main goals of the example “is to find patterns at real-time in sensor data using AI that can help to predict and ultimately prevent equipment/production line sudden failure”. Equipment/production line failure is one of the most common causes of unplanned downtime that costs global manufacturing sector an estimated DKK 315 (€ 42) billion annually. Analyzing sensor data from a production environment is complicated because the data is often high dimensional and it is nearly impossible

to find patterns across dozens or even hundreds of sensors, manually. AI has the ability to analyze the complex relationships of the sensor data in real-time in order to predict any upcoming errors in advance by raising a warning flag to keep production operations running smoothly.

## 7 CONCLUSIONS

This paper underlines the importance of Industry 4.0 for SMEs that provides the opportunity to improve their productivity and competitiveness by optimizing their production processes. The paper also highlights the Danish national strategies aim to reduce obstacles for SMEs in order to adopt industry 4.0 and AI-related technologies. Further, motivated by the impact of AI on Danish economy in future, this paper aims at emphasizing the benefits of AI that can help SMEs to gain valuable insights from operational/process data for better decision making.

Future research should validate and examine the impact as well as measure the success of solutions/activities suggested on AI adoption for SMEs.

## REFERENCES

- Aarstad, A. and Saidl, M. (2019). Barriers to adopting ai technology in smes. Master’s Thesis, Copenhagen Business School, Denmark.
- Angelopoulos, A., Michailidis, E. T., Nomikos, N., Trakadas, P., Hatziefremidis, A., Voliotis, S., and Zahariadis, T. (2020). Tackling faults in the industry 4.0 era—a survey of machine-learning solutions and key aspects. *Sensors*, 20(1):109.
- Bauer, M., van Dinther, C., and Kiefer, D. (2020). Machine learning in sme: An empirical study on enablers and success factors. In *Americas Conference on Information Systems*. AIS eLibrary.
- Bianchini, M. and Michalkova, V. (2019). Data analytics in smes: Trends and policies. *OECD SME and Entrepreneurship Papers*, 14.
- Colotla, I., Fæste, A., Heidemann, A., Winther, A., Andersen, P. H., Duvold, T., and Hansen, M. (2016). Winning the industry 4.0 race: How ready are danish manufacturers? Available online at: <https://innovationsfonden.dk/sites/default/files/2018-07/bcg-winning-the-industry-40-race-dec-2016.pdf>.
- Dhasarathy, A., Gill, I., and Khan, N. (2020). *The CIO Challenge: Modern Business Needs a New Kind of Tech Leader*. McKinsey Digital.
- El-Jawhari, B., Halbe, S., Whyte, M., Cobbaert, K., and Odenkirchen, A. (2020). An introduction to implementing ai in manufacturing. Available

<sup>9</sup><https://www.oeec.com>

- online at: <https://www.pwc.com/gx/en/industrial-manufacturing/pdf/intro-implementing-ai-manufacturing.pdf>.
- Hansen, E. B. and Bøgh, S. (2021). Artificial intelligence and internet of things in small and medium-sized enterprises: A survey. *Journal of Manufacturing Systems*, 58:362–372.
- Iftikhar, N., Lachowicz, B. P., Madarasz, A., Nordbjerg, F. E., Baattrup-Andersen, T., and Jeppesen, K. (2020). Real-time visualization of sensor data in smart manufacturing using lambda architecture. In *9th International Conference on Data Science, Technology and Applications*, pages 215–222. Scitepress.
- Iftikhar, N. and Nordbjerg, F. E. (2021). Implementing machine learning in small and medium-sized manufacturing enterprises. In *8th International Conference on Changeable, Agile, Reconfigurable and Virtual Production (forthcoming)*. Springer.
- Iftikhar, N., Nordbjerg, F. E., Baattrup-Andersen, T., and Jeppesen, K. (2019). Industry 4.0: Sensor data analysis using machine learning. In *International Conference on Data Management Technologies and Applications*, pages 37–58. Springer.
- Jäger, A., Moll, C., Som, O., Zanker, C., Kinkel, S., and Lichtner, R. (2015). *Analysis of the Impact of Robotic Systems on Employment in the European Union. Final Report*. Publications Office of the European Union, Luxembourg.
- Jöhnk, J., Weißbert, M., and Wyrтки, K. (2021). Ready or not, ai comes—an interview study of organizational ai readiness factors. *Business & Information Systems Engineering*, 63(1):5–20.
- Kim, A. S., DiPlacido, M. P., Kerns, M. C., and Darnley, R. E. (2018). Industry 4.0: Digitization in danish industry. Available online at: <https://core.ac.uk/download/pdf/212982545.pdf>.
- Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J., and Linkman, S. (2009). Systematic literature reviews in software engineering—a systematic literature review. *Information and Software Technology*, 51(1):7–15.
- Lindberg, B., Andersen, J. R., Hansen, M. A. E., Frandsen, S., Krause, S., and Duvold, T. (2019). An ai nation? harnessing the opportunity of artificial intelligence in denmark. Available online at: <https://innovationsfonden.dk/sites/default/files/2019-09/an-ai-nation-harnessing-the-opportunity-of-ai-in-denmark.pdf>.
- Matt, D. T., Modrák, V., and Zsifkovits, H. (2020). *Industry 4.0 for SMEs: Challenges, Opportunities and Requirements*. Springer Nature, Cham.
- Nardello, M., Madsen, O., and Møller, C. (2017). The smart production laboratory: A learning factory for industry 4.0 concepts. In *CEUR Workshop Proceedings (Vol. 1898)*.
- O’Dwyer, G. (2019). Danish government injects 200 million euro into ai r&d. Available online at: <https://www.computerweekly.com/news/252466718/Danish-government-injects-200m-into-AI-RD>.
- Rauch, E., Dallasega, P., and Unterhofer, M. (2019). Requirements and barriers for introducing smart manufacturing in small and medium-sized enterprises. *IEEE Engineering Management Review*, 47(3):87–94.
- Schröder, C. (2016). The challenges of industry 4.0 for small and medium-sized enterprises. Available online at: <https://library.fes.de/pdf-files/wiso/12683.pdf>.
- Sjøberg, M. (2019). Artificial intelligence in norwegian organizations: An exploratory study of challenges in ai adoption. Master’s Thesis, University of Agder, Norway.
- Stentoft, J., Rajkumar, C., and Madsen, E. S. (2019). Drivers and barriers for industry 4.0 readiness and practice: a sme perspective with empirical evidence. In *52nd Hawaii International Conference on System Sciences*. HICSS - University of Hawaii.
- Truvé, T., Wallin, W., and Ryfors, D. (2019). Swedish manufacturing smes readiness for industry 4.0: what factors influence an implementation of artificial intelligence and how ready are manufacturing smes in sweden? Bachelor’s Thesis, Jönköping University, Sweden.
- Wagner, B. (2018). Get started with the iiot & industry 4.0. Available online at: <https://forcetechnology.com/en/articles/industry-4-0-iiot-iiot-servitization>.
- Wuest, T., Weimer, D., Irgens, C., and Thoben, K. D. (2016). Machine learning in manufacturing: advantages, challenges, and applications. *Production & Manufacturing Research*, 4(1):23–45.
- Yu, F. and Schweisfurth, T. (2020). Industry 4.0 technology implementation in smes—a survey in the danish-german border region. *International Journal of Innovation Studies*, 4(3):76–84.