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# Technologies for Digital Transformation

## Moving Towards the Future of Organisations

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# Contents

# Technologies for Digital Transformation. Towards the Future of Organisations


**Alessio Maria Braccini, Jessie Pallud, and Ferdinando Pennarola**

**Abstract** Digital technologies have a profound influence on organisations, continuously producing transformative impacts. Unlike conventional technologies, digital counterparts extend beyond specific functions, permeating the entirety of organizational dynamics, especially influencing core processes like sense-making and decision-making. The forefront of technological development is characterised by emerging digital technologies like blockchain, artificial intelligence, robotics, and the Internet of Things. These technologies, while promising innovation, introduce uncertainties in organizations' digital transformation paths, with impacts difficult to predict. The chapters within this exploration summarise the varied insights—empirical, conceptual, and theoretical—offering a comprehensive perspective on the intricate implications and roles of emerging digital technologies within the realm of digital transformation.

**Keywords** Digital transformation · Emerging digital technologies · Artificial intelligence · Blockchain · Internet of things

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## 1 Digital Technologies and Digital Transformation

Technology has consistently been a strong driver of transformation in the processes of organising production and economic activities in history. Innovation and continuous change of technologies afforded long-lasting cycles of development of economies and organisations. The benefits of technology innovation frequently spilt out of the focal setting of adoption, with cross-industry and economy-wide impacts [1, 2]. Indeed, continuous, and generalised development of technology brought improved work and life conditions, larger distributed welfare, scientific and economic breakthroughs and provided continued support for further technological development. Such phenomena are even more visible when *technology* is *digital technology*, which besides producing all the above-mentioned outcomes, turned out to be the strongest transformative agent for organising and organisations [3].

But digital technology is not just a diver of change. It is also an entity in continuous change, whose evolution and adoption trigger many implications for individuals, organisations, and societies. Digital technologies automate data and information processing, touching the foundations of the cognitive and intellectual processes—such as communication, information, and decision-making—that characterise human agency as individuals, and in institutions. Hence, digital technologies change the fabric of organising [3, 4].

Unlike traditional technologies that organisations have managed with waves of incremental or radical innovation and contributed to the development of processes, functions, or units, digital technologies' transformative power encompasses the entire organisation [5]. Digital technologies present in the form of interconnected systems of entities that offer action possibilities to individuals, teams, and organisations. They are applicable to the fundamental processes of organising sense-making, decision-making, and knowing, and are no longer confined within the boundaries of specialised IT departments but span across all functional areas in organisations.

In this landscape, emerging digital technologies are at the current frontier of technology development and pose significant challenges [6]. These digital technologies are on the rise, part of organisations' rapid and exploratory process of adoption. These emerging technologies trigger new affordances for organising, with opportunities and implications yet to be explored. Exploring emerging technologies and their role in the digital transformation of organisations is at the frontier of research on digital transformation, and it is the rationale that binds the chapters of this book.

## 2 Emerging Digital Technologies and Organisations

What do we mean by emerging digital technologies? The concept was first formulated in the EU debate on the regulation of a set of technologies that may sit on the brink of another leap forward in progress and prosperity with significant industrial and societal changes [6, 7]. In this book, we consider them as a set of digital technologies that promise significant innovation breakthroughs. At the same time, they are also not

already sedimented and follow uncertain and risky evolution patterns. In spite of that, they have the potential to fundamentally shape all aspects of organising [8].

Emerging digital technologies are the result of recent innovation. Yet they are already out of laboratories. Organisations are using, exploring, and integrating them in processes and activities. The impact these technologies will have on organisations depends on the development trajectories of the technologies themselves, and on the characteristics of the organisational context in which they will be adopted, with trajectories hard to predict.

The most significant emerging technologies at the time of writing are blockchain, artificial intelligence, robotics, and internet of things. They necessarily go along with traditional digital technologies, but they all show peculiar characteristics that make them unique compared to other digital technologies, such as information systems.

Artificial intelligence, for instance, has the characteristics of autonomy. Designed to leverage the mass size of data being produced in decades by digital systems, artificial intelligence can now learn, summarise, predict, generate content, and make decisions autonomously. If artificial intelligence may empower human and organisational agency, improving decision-making, it poses a threat to potential lack of control by human agency, biased action, and arbitrary evolution.

Blockchain promotes decentralised, secure information storage and sharing among multiple actors. If blockchain promises secure and effective inter-organisational collaboration platforms and may constitute the digital backbone of mass-distributed systems, it may also potentially disrupt existing institutions leveraging on centralised control authorities.

Finally, more on the same line of thought, the internet of things and robotics promote a healthier and safer life for workers and people in general, enabling smart objects, smart cities and smart factories to warrant good production and quality of life [9, 10]. At the same time, they raise concerns of surveillance and privacy, they throw to the desk the long-standing conflict between labour versus capital and suggest implications on the future of labour in production [11].

Studying emerging digital technologies, and their implications for organisational digital transformation, along with the contextual conditions in which they are used, has merit and is necessary. In this regard, the chapters of the book tackle emerging digital technologies, or the phenomena developing around them, from different angles, and contribute with empirical, conceptual, and theoretical knowledge on exploring the implications and role of emerging digital technologies for digital transformation.

## 3 Researching Technologies for Digital Transformation

The chapters of these books were selected among the best papers presented at the 2022 edition of the Italian Chapter of AIS and collected on this topical book to provide an up-to-date overview of the research performed by scholars attending the Italian community of AIS on emerging technologies. The chapters underwent a double-blind review process and were included in this book to provide an interdisciplinary and multifocal perspective over technologies for digital transformation. In

total 18 different papers are collected in this book, and they face technologies for digital transformation from two different points of view: the first group of chapters explore specific focal emerging technologies, both from an empirical and a conceptual point of view; the second group of chapters explore instead implications of emerging technologies for individuals, organisations, and industries.

## *3.1 Exploring Emerging Technologies*

Chapters "Manufacturing SMEs and Artificial Intelligence: Between Promises and Paradoxes", "Investigating the Artificial Intelligence Debate in Organisation and Management Studies", "Do Forecasting Algorithms Need a Crisis-Mode? Machine Learning Based Sales Forecasting in Times of COVID-19", "Artificial Intelligence in Information Systems Research: A Socio-technical Perspective", "Blockchain and Lending Process Efficiency in the Banking Industry", and "Under Pressure: Strategic Choices and Contextual Trade-Offs of SMEs Facing Industry 4.0 Implementation" explore three specific emerging technologies: artificial intelligence, blockchain and Industry 4.0. Out of the three, artificial intelligence has got most of the attention from researchers as several chapters explore different dimensions of artificial intelligence applications.

In chapter "Manufacturing SMEs and Artificial Intelligence: Between Promises and Paradoxes", Ravarini, Zaghloul and Strada [in this volume] focus on the adoption of artificial intelligence by small and medium enterprises in the manufacturing sector, an area of research that has received relatively little attention by the IS discipline. Based on a multiple case study of three SMEs, their work highlights an articulated picture of AI adoption that differs from the profile traced by mainstream literature. They also identify a struggle of SMEs between the objectives of realizing the benefits of the investments and the actual capability of building the necessary organizational context for realizing the prospected benefits.

Chapter "Investigating the Artificial Intelligence Debate in Organisation and Management Studies" by Smacchia and Za [in this volume] still insists on the manufacturing sector, and particularly investigates artificial intelligence within the Industry 4.0 domain. They address the current academic debate on AI in the organization and management scientific literature. By way of a bibliometric analysis of 1102 articles published in academic journals, they map trends and topics of research as a starting point to deepen the knowledge of AI. Their results indicate a fervent and developing debate on the implications and on the issues related to the use of artificial intelligence.

In chapter "Do Forecasting Algorithms Need a Crisis-Mode? Machine Learning Based Sales Forecasting in Times of COVID-19" Fahse [in this volume] reflect on the forecasting capability of machine learning algorithms. Considering the importance that effective forecasting capabilities play for the management of organisations, Fahse focuses on the reliability of forecasts in uncertain times produced by the pandemic. By focusing on the performance of a sales forecast machine learning

system for baked goods ad Covid-19 times, Fahse suggests adding variables to sales forecast models informing models on restrictive measures to contrast covid disease spreading, providing evidence of the improved forecast.

In chapter "Artificial Intelligence in Information Systems Research: A Socio-technical Perspective", Safei, Haki and Morin [in this volume] focus on the interdisciplinarity characteristics of AI research. They recall the organisational and socio-technical nature of information systems research, and they look at the IS literature to explore to what extent the study of AI is contributing to deepening the socio-technical understanding of AI-related phenomena. They conduct a systematic literature review informed by a socio-technical framework analysing work published in flagship IS journals. Their results reveal research focuses more on technology, tasks, and actors, leaving behind the environment and structural components, and not fully considering the interactions among all the components of a socio-technical view of AI.

Chapter "Blockchain and Lending Process Efficiency in the Banking Industry" focuses on the blockchain, while chapter "Under Pressure: Strategic Choices and Contextual Trade-Offs of SMEs Facing Industry 4.0 Implementation" on Industry 4.0.

In chapter "Blockchain and Lending Process Efficiency in the Banking Industry", Bruno and Iacoviello [in this volume] explore blockchain technology in the banking sector, addressing the dual perspective of innovation trigger and disruptive agent of this technology in this specific industry. Using a qualitative research approach that combines a literature review and a case study, they highlight innovation and improved effectiveness potential in banking processes, products, and services, particularly focusing on the potential tension between a distributed technology, and an industry that prefers centralised data storage and processing technologies.

Finally Zabudkina, Lisein and Pichault [in this volume] focus on Industry 4.0 in chapter "Under Pressure: Strategic Choices and Contextual Trade-Offs of SMEs Facing Industry 4.0 Implementation", addressing the implementation of these technologies by small and medium enterprises. They proposed a narrative literature review focusing on contextual enablers and barriers influencing SMEs strategic choices concerning Industry 4.0 implementation. Adopting an institutional approach, they propose a framework showing the division between environmental and organisational triggers leading SMEs to trade-offs regarding five dimensions of strategic choices for Industry 4.0 implementation.

## *3.2 Exploring Implications of Emerging Technologies*

Chapters "The Context Sets the Tone: A Literature Review on Emotion Recognition from Speech Using AI", "Understanding the Links Between Neuroscience, Physiological Tools and Stress, with the Eventual Neuroscientific Impact of Culture, in Organizational, Managerial and Information Systems (IS) Fields Through a Social Network Analysis", "Digitalize Thy Place: Benefits and Challenges in the

Development of Smart Destinations", "Digital Transformation and Dysfunctions: Case Study of a Japanese Leading Technology Company, Analysis from Socio-technical Approach", "Digitalization, Online Services, and Entrepreneurial Environment in the Italian Smart Cities' Transition", "Exploring the Evolution of Digital Transformation Research in Non-profit Organisations: A Bibliometric Analysis", "How to Unlock the Value of Your Data: Six Design Guidelines for Implementing Data Strategies", "Data-Driven Failure Management: An Ontology-Based Speech Recognition App for Failure Capturing in Manufacturing Processes", "Evaluation of Innovativeness as the Success Factor of Innovative Start-Ups. Evidence from Literature", "A Bibliometric Analysis of Fab Labs Research", "The Metaverse: Digital Innovation in the Fashion Industry. A Systematic Literature Review", and ""Look! This Is the Future of Cardiology": Institutional Work and the Making of Telemedicine in Healthcare" focus instead on implications of emerging technologies integration covering the different aspects of new affordances and action possibilities of digital technologies (chapters "The Context Sets the Tone: A Literature Review on Emotion Recognition from Speech Using AI" and "Understanding the Links Between Neuroscience, Physiological Tools and Stress, with the Eventual Neuroscientific Impact of Culture, in Organizational, Managerial and Information Systems (IS) Fields Through a Social Network Analysis"), changes and transformations consequent to digitalisation (chapters "Digitalize Thy Place: Benefits and Challenges in the Development of Smart Destinations", "Digital Transformation and Dysfunctions: Case Study of a Japanese Leading Technology Company, Analysis from Socio-technical Approach", "Digitalization, Online Services, and Entrepreneurial Environment in the Italian Smart Cities' Transition", and "Exploring the Evolution of Digital Transformation Research in Non-profit Organisations: A Bibliometric Analysis"), value generated by digital technologies and digital data (chapters "How to Unlock the Value of Your Data: Six Design Guidelines for Implementing Data Strategies" and "Data-Driven Failure Management: An Ontology-Based Speech Recognition App for Failure Capturing in Manufacturing Processes"), innovations for organisations, markets and professions (chapters "Evaluation of Innovativeness as the Success Factor of Innovative Start-Ups. Evidence from Literature", "A Bibliometric Analysis of Fab Labs Research", "The Metaverse: Digital Innovation in the Fashion Industry. A Systematic Literature Review", and ""Look! This Is the Future of Cardiology": Institutional Work and the Making of Telemedicine in Healthcare").

Two chapters focus on new affordances and action possibilities of digital technologies.

In chapter "The Context Sets the Tone: A Literature Review on Emotion Recognition from Speech Using AI", Thaler, Haung, Gewald and Brune [in this volume] explore the literature on emotion recognition from speech using artificial intelligence, considering the crucial role that customers' emotions play in the service industry. They intend to focus on identifying feature types and emotion dimensions for emotional speech analysis. Their results show that these dimensions are not adequately covered in the articles they have analysed. Therefore, they develop three guidelines for future design-oriented research addressing emotion recognition.

In chapter "Understanding the Links Between Neuroscience, Physiological Tools and Stress, with the Eventual Neuroscientific Impact of Culture, in Organizational, Managerial and Information Systems (IS) Fields Through a Social Network Analysis", Silvestre and Romanelli [in this volume] perform a literature review to deepen the link between neuroscience, physiological tools, and stress in organisation, management, and information systems literature motivated by the fact that modern information and communication digital technologies can afford to collect and analyse neuroscientific data with the potential of improving research on organisational phenomena such as technostress.

Four papers explore changes and transformations consequent to digitalisation and integration of digital technologies in organisations.

In chapter "Digitalize Thy Place: Benefits and Challenges in the Development of Smart Destinations", Nicoletti, Capo and D'Agostino [in this volume] focus on digital transformation of the tourism industry and investigate how firms and territories may leverage digital transformation for the creation of smart destinations. Adopting a qualitative research design based on interviews of ten key informants, they explore the adoption of a hospitality data and intelligence platform, and how it can promote the development of the tourist destination. In their analysis, they reflect both on benefits—in terms of improved forecasting and decision-making possibilities, and increased partnership opportunities—and challenges for the tourism industry, especially referring to the lack of critical digital infrastructures, or digital competencies.

Chapter "Digital Transformation and Dysfunctions: Case Study of a Japanese Leading Technology Company, Analysis from Socio-technical Approach" by Hayashi [in this volume] focuses on failures of digital transformation process related to contextual organizational issues. The chapter explores a case study from a socio-technological point of view combining the theories of the socio-economic approach to management and the sociotechnical approach. The result of the work identifies organizational dysfunctions in terms of work fragmentation, lack of communication, and lack of coordination among team members due to a vertical and compartmentalized organizational structure. They also trace these dysfunctions to social and technical factors in play in the case unit.

In chapter "Digitalization, Online Services, and Entrepreneurial Environment in the Italian Smart Cities' Transition", Marchesani and Ceci [in this volume] focus on smart cities investigating the evolution of online services implementation in cities over the years, and the impact on the entrepreneurial environment. Using panel data based on twenty Italian cities over a period of 11 years, the chapter identifies two clusters of online services implementation: in transition and developed. The two clusters are then related to the characteristics of the entrepreneurial environment. The results of the work show that the digitalization of services in smart cities is essential to create a favourable local environment for the development of entrepreneurial opportunities.

In chapter "Exploring the Evolution of Digital Transformation Research in Nonprofit Organisations: A Bibliometric Analysis", Cipriano and Za [in this volume] focus on the trends of the digital transformation research, and identify a neglected

area, that of non-profit organisations, in which they target their research efforts by performing a bibliometric analysis of the literature. They analyse 586 research articles selected from SCOUPS and published from 1983 to 2022 and identify trends and topics in this area of research. Their results show that most of the attention on digital transformation of non-profit organisations is concentrated in the past 4 years where 50% of the research papers they identified were published, and that the literature samples contains five clusters of papers addressing specific topics of digital transformation in non-profit organisations.

Two papers explore value generated by digital technologies and by digital data.

In chapter "How to Unlock the Value of Your Data: Six Design Guidelines for Implementing Data Strategies", Mayer, Lanzerath, Wutzler, Quick and Peruscha [in this volume] explore design principles to unlock the value out of data. Their work starts from the observation that organisations struggle to exploit the value of their data, and as such they shall define strategies and roadmaps for managing organisational related data. Leveraging on the results of experts' interviews, the authors propose six design guidelines for helping organisations implementing data strategies, applicable across industries and at all levels or the managerial hierarchy.

In chapter "Data-Driven Failure Management: An Ontology-Based Speech Recognition App for Failure Capturing in Manufacturing Processes", Scharef, Ludwig, Bley, Wiener, and Schmidt [in this volume] address the complexity of the manufacturing process, and their potential failures, focusing on data-drive failure management. They highlight the difficulties for many small and medium enterprises to leverage data-drive failure management due to the lack of relevant failure data. Adopting a design science research approach, they develop and evaluate a novel ontology-based speech recognition app that addresses key shortcomings of currently available solutions. Their work contributes with the identification of the design requirements and principles, and with the instantiation of these principles in an app prototype to collect failure data in the context of manufacturing processes.

Finally, four papers explore innovations for organisations, markets consequent to adopting and integrating digital technologies.

In chapter "Evaluation of Innovativeness as the Success Factor of Innovative Start-Ups. Evidence from Literature", Bellini, D'Ascenzo, Gorelova, Fabbri and Ventrice [in this volume] focus on innovative start-ups, specifically on measuring their innovativeness level. With a preliminary study, they aim at developing a framework that could be useful for assessing the innovativeness capabilities of start-ups.

Still on the side of innovation, Agrifoglio, Metallo, Oppedisano and Ferrara [in this volume] explore Fab Labs research in chapter "A Bibliometric Analysis of Fab Labs Research". They conduct an online literature search using the SCOPUS database to explore the literature on community-based workshops and fabrication labs. They identify a dataset of 148 publications and perform a bibliometric co-occurrence analysis to identify clusters of research papers and discussion topics. They identify three clusters of literature, and per each cluster, they identify the topics discussed by the literature.

The work of Grillo and Bonomi [in this volume] in chapter "The Metaverse: Digital Innovation in the Fashion Industry. A Systematic Literature Review"

explores digital innovation in the fashion industry, focusing on the metaverse. Relying on a systematic literature review, they explore the use of virtual world technologies in this specific industry. Their results unveil a plethora of industry interests, intersecting many enabling technologies, including virtual reality, augmented reality, blockchain, and non-fungible tokens.

Finally, in chapter ""Look! This Is the Future of Cardiology": Institutional Work and the Making of Telemedicine in Healthcare", Zanutto, Piras, and Ponte [in this volume] focus on the telemonitoring capabilities of digital technologies for telemedicine in the healthcare industry. Their work adopts a qualitative research design exploring the process that led from the first experimental adoptions to the final codification of a clinical service, unveiling a complex ecology of actors, knowledge, and practices that are necessary to institutionalise telemonitoring in healthcare organisations. Their findings highlight how the institutionalisation of change requires continuous tuning and transformation of everyday practices.

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# Part I
# Exploring Emerging Technologies

# Manufacturing SMEs and Artificial Intelligence: Between Promises and Paradoxes

**Aurelio Ravarini, Fatema Zaghloul, and Emanuele Strada**

**Abstract** Driven by the growing availability and accessibility of data and processing power, businesses across all sectors are developing and implementing increasingly "intelligent" systems that are empowered by a wave of artificial intelligence (AI) technologies. This paper examines the state of AI adoption in small and medium-sized enterprises (SMEs) in the manufacturing sector, an area of research that has received relatively little attention. Three SMEs, whose main offices are located in Northern Italy, have been studied to understand how they deal with the issue of AI adoption and what problems they typically encounter. An articulated picture emerges where SMEs struggle between the desire to realize the promises of innovation and the ability to build the appropriate organizational setting to pursue it.

**Keywords** Artificial intelligence · Manufacturing · SMEs

## 1 Introduction

Research and applications that fall under the name of Artificial Intelligence (AI) are certainly not a novelty in the panorama of digital technologies. Due to the increasing availability of data, accompanied by technological advancements in computing power and data storage, AI is becoming a sought-after technology for the development and competitiveness of companies operating in various industries [1–3].

In a recent international survey, more than 75% of respondents reported that AI will revolutionize their organization over the next 3 years, and more than 60%

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believed that, in no more than 3 years, AI will transform the industry in which they operate [4]. Another recent study highlighted that, in Italy, 88% of managers believed that investing in AI enables them achieve their growth objectives and almost all consider AI as a strategic factor [5].

The manufacturing sector is facing numerous challenges in which emerging technology plays an essential role: the growing importance of the production of products with added value, the sustainability of production processes, adapting to individual customer requirements, and responding quickly to market demands [1]. It is a context characterized by increasing product and process complexity, high variability of demand and customer preferences, and continuous pressure to remain competitive [6]. Research indicates that AI-based innovations are able to gather large amounts of data, obtained from numerous sources, and assist machines in making autonomous decisions, enhancing the flexibility of processes and circularity capabilities, in addition to addressing demand planning, inventory management, and quality control [7, 8]. Despite this recognition, most studies focus primarily on AI technologies implemented in the manufacturing industry (e.g. [1]), rather than on enablers and pre-requisites for adoption at a firm-level [6].

In addition, most studies on AI adoption are based on the context of large enterprises, which have a much easier access to financial resources and up-to-date managerial and technological skills. On the other hand, it is well-known that small and medium sized enterprises (SMEs) represent an essential and prevalent strength of many economies. The so-called "coming of the AI era" might, therefore, be an inappropriate generalization of a phenomenon which is, instead, constrained to a limited portion of the worldwide economy.

Therefore, this study explores the current landscape of AI adoption in a relatively less understood and examined research area: SMEs in the manufacturing sector. Adopting a multiple case study approach consisting of three SMEs, whose main offices are located in Northern Italy, we address the following research question: *What is the state of AI adoption in manufacturing SMEs?*

The remainder of the paper is structured as follows: the next section presents a brief background into digital technology implementation and SMEs in the Italian context, followed by literature on AI in the manufacturing sector, outlining the current discourse in this area and why the Italian context is chosen. Next, we outline the methodology. In the final sections, a synopsis of our initial findings are presented and discussed. We close with some discussion on the implications and concluding remarks.

## 2 Digital Technology and SMEs in Italy

SMEs (defined by the European Commission as having less than 250 persons employed, an annual turnover of up to EUR 50 million, or a balance sheet total of no more than EUR 43 million) are considered the backbone of the EU and, in particular, the Italian economy [9, 10].

The adoption of digital technology by Italian SMEs has developed at different speeds over the last few years. The Italian Institute of Statistics [10] reports that between 2016 and 2018, more than half of the companies with at least 10 employees made a decision to invest in technology. However, these investments were primarily aimed at the acquisition of infrastructures (such as cloud solutions, broadband access, etc.). The Covid-19 pandemic and the consequent lockdowns of 2020 forced companies to conduct all activities that did not strictly require in-person presence remotely, which resulted in (in Italy, like elsewhere) a massive and sudden (thus, unplanned) adoption of digital tools, mainly intended to support remote work. The period between the end of the toughest lockdown to today is recognized as a 'transition' phase, characterized by a degree of ambiguity and uncertainty regarding the impact of the pandemic on work and, consequently, on the digital tools that support it. With respect to infrastructure, in 2021 just over 60% of Italian SMEs had at least a basic level of digital intensity, placing them slightly above the EU27 average (equal to 56%). In the adoption of IoT systems, Italian SMEs are eighth in Europe, while in digital skills, Italy ranks third from last [10].

## 3 AI Applications in Manufacturing

In this section, a short overview of AI in the manufacturing industry is provided to present the research context, along with the primary application areas, and challenges associated with their adoption.

AI refers to the technologies that allow computers and machines to accomplish tasks that would ordinarily require human intelligence [11], essentially reproducing *what* humans can do and not *how* they do it. Early developments in AI, such as knowledge management systems [12, 13], and decision support systems [14], had limitations in terms of autonomy and learning capacity. With advances in processing, data availability, and technical methodologies, AI is now being used to create advanced innovations like cognitive robots [15], algorithmic intelligence [16], and autonomous agents [17]. IS scholars have studied the impact of emerging AI technologies in a variety of organizational settings to understand how they impact (1) process efficiency and decision-making quality (in terms of assisting/supporting human decision-makers, or replacing them) (e.g. [13, 18, 19]), and (2) the development of novel and innovative data-driven services and products (e.g. [16, 20]). However, the phenomena of AI adoption in SMEs is less well understood.

### *3.1 AI in the Manufacturing Industry*

The significance of AI as one of the technologies underpinning the concept of smart manufacturing has been recognised by scholars (e.g. [1, 21]). In principle, an AI-based system can enhance organizational processes and efficiency, as well as

existing products and services. According to Mittal et al. [4], two thirds of AI project implementations involve the automation and optimization of business processes. Furthermore, the use of AI in smart factories facilitates prompt decision-making based on historical and real-time data, with minimal human involvement.

A research study conducted by the Politecnico di Milano Observatory illustrates that the value of the Italian AI market in 2020 was worth 300 million €, of which 23% was destined for the banking and finance sector, followed by 14% in the energy/utility sector, 13% for manufacturing, 12% telco/media, and 11% insurance [22].

Lu [23] provides a comprehensive overview of the development and application of AI in various fields, but AI in manufacturing is only mentioned briefly. Furthermore, there is limited research concerning the adoption and impact of AI in SMEs and exploring this phenomenon at a firm-level [6]. While it is plausible that there is a significant gap with large companies, as is normally the case for the adoption of digital technologies, SMEs have different characteristics, including limitations in financial resources, skills and pre-existing digital technologies, which determine an adoption gap at least in terms of time and often also in terms of the benefits realized.

### *3.2 AI Applications in Manufacturing: The Main Use Cases*

Reviewing the literature revealed that the most widespread applications of AI in manufacturing are in the context of maintenance, quality control, demand forecasting and production process optimization processes [6, 24]. It is in these areas that companies have a good availability of data necessary for algorithms. Furthermore, it is argued that the corresponding AI projects require relatively less in-depth expertise, are simple to implement and generate substantial benefits (including in financial terms) and are relatively easy to estimate in the feasibility study phase.

AI applications in other areas of manufacturing require greater effort, both in terms of economic and physical resources, which are recognized as difficult to implement in SMEs, and therefore, in general, are not widespread in this context.

**Predictive Maintenance** Predictive maintenance and its subdomain, i.e. the prediction of the remaining life of a machine, are the most common use case of AI in manufacturing, and are often also cited as prime examples of digitization via AI.

The implementation of AI in this process is a relatively easy application case due to the availability of optimal data already present in companies. In particular, the most widespread and used Machine Learning (ML) technique are linear regression models, to predict the residual life of a machine and classification algorithms to predict a failure in a defined period of time.

The analysis of the data collected by the sensors placed on the machinery enables the prediction of potential downtime and malfunctions and subsequently plan timely interventions [25]. In addition to minimizing downtime, there is also the possibility

of reducing the costs associated with maintenance, consequently optimizing the frequency of maintenance interventions and increasing productivity.

**Quality Control** AI systems are able to detect anomalies in products compared to optimal results, using computer vision technologies. When a product is categorized as defective, the AI systems activate a signal so that the item is identified to make changes or to be discarded [6].

Applications in this area are widespread both to (a) reduce risks: non-compliance in products can lead to dissatisfied customers and/or fines, and (b) contain costs: diffusion of high-resolution cameras, together with visual recognition technologies, reduces inspection costs despite a high degree of precision in detecting defects throughout the production process.

**Other Application Areas** Among other various areas of application include demand forecasting and the optimization of production processes.

Demand forecasting using ML allows companies to predict consumer demand as accurately as possible. Applications in this area can generate cascading benefits in planning and coordinating areas such as sales, marketing, supply chain, customer management and finance.

The optimization of production processes is promising with respect to the achievement of sustainability objectives. In this context, process mining applications based on AI algorithms are spreading, aimed at identifying and removing bottlenecks within processes. The monitoring of the critical parameters of the production processes also allows the creation of high-quality products at moderate costs [26].

## *3.3 Barriers to AI Implementation*

Despite the potential benefits that justify the implementation of AI-based systems, there are numerous elements that can jeopardize the success of an AI project in manufacturing.

With respect to Italy, studies indicate that most companies have not yet adopted AI initiatives [27], and of those that have, half were merely conducting proof-of-concept experiments, applying them to a few well-defined business processes [28]. Other studies demonstrated the difficulty, or at least organizations' mistrust, in translating AI promises into reality. For example, 77% of Italian C-level executives claim to encounter issues with AI adoption [5]. Claims of efficiency and transformation are usually not substantiated by measurable empirical evidence, making it difficult to determine to what extent, how, and why AI systems are being used, their impact on organizational and individual decision-making, and their ability to transform organizational processes. This poses a problem in determining how to evaluate the short- and long-term impact of AI from a social, economic, and political perspective [13].

Furthermore, a recent survey revealed that only 20% of Italian companies successfully completed AI projects. Despite having made progress in the management of their information assets, a precondition for the implementation of AI projects, it appears that Italian companies have room for improvement in the development of skills in the creation of a corporate culture that favors the growth and dissemination of such projects and in preparing the customer for new products and services [29].

From an organizational perspective, the main obstacles are represented by the persistent difficulties in managing data and integrating AI into existing business processes [4]. In fact, most companies continue to use "silo" structures, and the IT that supports them ends up being used to optimize individual organizational units. To effectively implement AI, however, an integration of business units is required; therefore, organizations need to redesign their operating model, taking into account the digital core that requires a transformation of organizational structure, culture, and power and control [30].

Other critical issues are related to the organizational implications of AI, to the human aspects that AI modifies. In applications where AI is a tool that does not replace, but supports the decision-making process [13], an obstacle is linked to change management: people with a more rigid mentality tend to resist accepting advice suggested by a machine. In other cases, AI technologies usually maximize the efficiency of operations by automating repetitive tasks [31], and consequently, the likelihood of jobs being lost or replaced is high [22, 24, 32]. This illustrates that the acceptance and adoption of AI applications can be affected by different cultures and personal values.

Another barrier appears to be related to the fact that the intention to adopt AI solutions is not accompanied by the definition of a well-defined path and objectives, such as the adoption of standardized execution processes to exploit the scalability of the AI, and management agreement regarding the AI strategy that should be adopted.

## 4 Methodology

Given the dearth of existing studies, we explore the current landscape of AI adoption in SME manufacturing companies in Northern Italy. This study adopts an interpretivist multiple case study approach [33], which is well-suited to exploring and understanding information systems (IS) adoption in organizations, as well as enabling cross-case comparisons to identify whether the findings can be applied to several cases or are idiosyncratic.

To facilitate the comparability of the case study findings, companies with similar characteristics were sought. Three SMEs were identified: two companies (one small, while the other medium-sized) in the taps sector, both located in the Cusio-Valsesia industrial district, and a small company in the personal protective equipment (PPE) sector. All three companies have a typical family management, even if the medium-sized company consists of a higher degree of structured organizational characteristics.

We interviewed five stakeholders across these three organizations. Drawing on multiple organizations allowed us to explore the phenomenon from diverse and multi-layered perspectives. To find knowledgeable informants, we adopted a purposeful sampling technique, followed by the snowballing technique [34].

The interviews were conducted with key figures within the company, including the Chief Executive Officer (CEO)/entrepreneur, to obtain an insight into the general vision of the company, the production manager as they are directly involved with the production processes, and the operators as they work closely with the processes analyzed. Each interview lasted approximately 45–60 min, was audio-recorded, transcribed and annotated. The research team met frequently during data collection for debriefings to evaluate the key themes that emerged from the data in order to assure trustworthiness and rigor and to create a contextually specific understanding.

A semi-structured interview schedule was followed which focused on aspects such as the organization's culture, technological capability, goals, and processes. The guide was developed and organized according to a structure derived from the analysis of the literature in the field of 'readiness'[1] in the adoption of digital technologies, and particularly that of AI readiness. Each section of the interview referred to a factor, consisting of a set of variables, as presented in Table 1. Given the diversity of participants, the interview guide consisted of slightly different sections that were specific and tailored to the participants' role and knowledgeability.

We complemented the interview data with secondary data such as internal documents (e.g. reports, business cases) to better understand activities and previous technology adoption and implementation within the organization.

Data collection and analysis were conducted simultaneously so understanding could emerge from the theoretical concepts and empirical content. Our coding procedure followed the logic of open coding, axial coding, and selective coding. Two authors independently analysed each transcript to ensure a reliable and systematic coding process. Following this, we contrasted and compared the codes to come up with a unified, yet evolving, code-book.

## 5 Initial Findings

**Company X**

Company X S.p.a is part of the Cusio-Valsesia district of taps. In this sector, it is the only European company with a fully integrated production cycle. The interview was conducted with two organizational roles: the Chief Information Officer (CIO) and the Chief Operation Officer (COO).

[1] Readiness indicates the state required to engage in a particular activity (i.e. the adoption of a specific innovation)

**Table 1** The factors and the variables subject of the empirical study

| Factor | Variable |
|---|---|
| Goal of the project | Company vision<br>IT vision |
| Corporate culture | Change management<br>Top-management support<br>AI-Awareness<br>Team |
| Task | Processes<br>Requirements<br>Documentation |
| Technology | Hardware capability<br>Algorithm<br>Software Capability<br>Cloud<br>Compatibility |
| Data | Identification<br>Availability<br>Finding<br>Quality<br>Management<br>Privacy |
| Resources | Financial<br>People<br>Time |
| External Environment | Government<br>Data |

Adapted from [35–37]

It is a family-run company, established in the 1950s and now in its third generation, employing roughly 250 people, and an annual turnover, as of 2020, of over 76 million €, up 3.8% compared to 2019. It has an export of 78%, is present in 90 countries: Germany is the main market, followed by France, Australia and South Africa (BPER). The company is at the top of the category in terms of research activity and the degree of innovation of production equipment: 452 work centers, for a total of 2.8 million items sold per year.

The third generation has given an imprint strongly linked to technological innovation, but with an eye on specific characteristics of the work environment: "*in an AI project it is essential to consider the specific characteristics of the tasks and the individuals involved*" (COO)

Consistent with this approach, the company is conducting an AI-based pilot project in the field of demand forecasting, with the medium-term objective of increasing the efficiency of its business processes, enhancing the quality of the products offered and, hence, improving brand reputation. Another project involves the application of AI to enhance quality control, achieved by integrating computer vision technologies into existing processes. The company has not yet been able to make this second project operational due to technical problems, including the complexity of