Journal of the Knowledge Economy (2023) 14:3551–3569
https://doi.org/10.1007/s13132-022-01003-z

Design Framework for the Implementation of AI-based (Service) Business Models for Small and Medium-sized Manufacturing Enterprises

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Received: 31 May 2021 / Accepted: 4 March 2022 / Published online: 26 March 2022

Abstract
In a globalized world, small- and medium-sized manufacturing enterprises (manufacturing SME) face the challenge of keeping up with global competition. Although AI is ascribed the potential to fundamentally change entire markets, industries, and general business activities, the question remains how SME can implement AI in their operation effectively and efficiently, and therefore build up potential (service) business models. The aim of this paper is to reveal the innovation potential of these systems and to provide instructions on how they can be used by SME. Through these resources can be used more efficiently and new business models can be created. The causes for the little use of AI are numerous and solutions were sought in this work. The result is a socio-technical framework that allows manufacturing SME to build up AI-based (service) business models for themselves.

Keywords Business model · Business model design · Artificial intelligence · Small and medium-sized manufacturing enterprises (manufacturing SME) · Socio-technical design framework

Introduction

The working world is currently in a state of upheaval. As a result, many intense debates are being held about the future of work, focusing on the opportunities and implications of new technologies, especially artificial intelligence (AI) (e.g.,

This article is part of the Topical Collection on *Digital Transformation and Disruption*

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Hirsch-Kreinsen & ten Hompel, 2017). Because of these technologies, new development potentials are opening up for manufacturing SME. In particular to those with regard to process innovations (intelligent monitoring, controlling, and managing of processes, making them more flexible to lift Industry 4.0 to a new level) and/or product innovations according to AI-based (service) business models (industrial products with digital services and AI applications to augment innovative business models) (Mishra & Tripathi, 2021).

The "Industry 4.0" initiative aims to make the entire value-added chain more efficient by way of digitalized and automated or autonomous processing steps (Kagermann et al., 2013; Lepore et al., 2021). The focus of the initiative is therefore primarily on digital process innovations and their implementation–even due to domain knowledge of production processes of manufacturing SME (Obermaier, 2019).

Crucial for the competitiveness of SME in global markets is that companies focus not only on efficiency and thus improving internal processes but also on the effectiveness, i.e., developing (service) business models[1] (Abu-Rumman et al., 2021; Adrodegari & Saccani, 2017; Baines & Lightfoot, 2013; Kowalkowski et al., 2017). Although there is a consensus that the use of digital technologies has the ability to accelerate the progress and therefore enables complex and new services, their role is often overlooked (Ardolino et al., 2018). These could provide the possibility to improve the services offered through digital technologies or even completely change them. At this point, new (service) business models could be created (Adrodegari & Saccani, 2017; Ardolino et al., 2018; Paschou et al., 2020). Although in this context, AI is ascribed the potential to fundamentally change entire markets, industries, and general business activities (Pfau & Rimpp, 2021); the question remains how businesses can implement AI in their operation effectively and efficiently, and therefore build up potential (service) business models, which have been used rarely (Paschou et al., 2020).

More and more companies are recognizing the potentials of AI; however, they lack the knowledge of how to integrate it into their existing business (Dowling et al., 2021; Hanussek et al., 2021; Laperche & Liu, 2013; Zimmermann, 2021). One of the greatest challenge in the coming era of artificial intelligence is reflected in the correct implementation and management of AI, to establish a sustainable business (Boll-Westermann et al., 2019). Indeed, many SME have some competitive advantages due to their unique, technological (industry) knowledge (Falk et al., 2020). However, due to their limited financial and staff/human resources (Abu-Rumman et al., 2021), they seldom avail of further necessary knowledge domains to introduce and operate data- and AI-based (service) business models effectively and efficiently (Andrade et al., 2022; Coreynen et al., 2017).

[1] This phenomenon of focus shifting in production is investigated in research under the term "servitization" (Baines & Lightfoot, 2013; Brax & Visintin, 2017). Other synonyms for this are among others "service transition," "service transformation," "service strategy," "service infusion," "product-service systems," or sometimes "hybrid offering" (Adrodegari & Saccani, 2017; Brax & Visintin, 2017; Fliess & Lexutt, 2019; Kowalkowski et al., 2017; Paiola & Gebauer, 2020).

Multinational enterprises have already integrated big data as one of the most important resources in their business models successfully (Zimmermann, 2021). However, manufacturing SME require suitable concepts and support in the development of AI-based (service) business models (Queiroz et al., 2020).

Therefore, this article aims to describe the implications, which are induced from the use of artificial intelligence, for business models and how they evolve, to then create a socio-technical framework for manufacturing SME. First, the term business model, its elements, as well as the process of business model development, will be illuminated. Following this, the features of artificial intelligence will be portrayed. Based on these remarks, the implications that arise for AI-based (service) business model development in the manufacturing sector will be presented. Afterwards, a framework for the development of AI-based (service) business models will be derived. The significant results will be concluded in combination with an outlook in the end of the article.

Theoretical Basis

Business Model

In science and in practice the term "Business Model" steadily gains traction (Baden-Fuller & Mangematin, 2013; Kilintzis et al., 2020; Müller-Stewens & Lechner, 2016). Reasons for this are the rising stress of competition, globalization, introduction of new technologies, blurred industrial boundaries as well as changing market and competition premises (Huikkola & Kohtamäki, 2018). The development of new and the transformation of existing business models[2] can be viewed/seen as core competences to stay competitive now and in the future to be and stay competitive in the long term[3] (Gassmann et al., 2017; Kohtamäki et al., 2019).

There is no uniform definition of what exactly characterizes a business model (see Adrodegari & Saccani, 2017; Bouwman et al., 2018; Carayannis et al., 2017; Joenssen & Müllerleile, 2020; Paiola & Gebauer, 2020). Nonetheless, the multitude of definitions are a unity when it comes to describe the requirement of a business model, of how enterprises generate values and delivers them (Adrodegari & Saccani, 2017; Arnold et al., 2016; Osterwalder & Pigneur, 2010).Business models can (explicitly) help to analyze the business logic, as well as the net value creation and monetization mechanisms and generate a better understanding of these (Adrodegari

[2] While the first type of building new business models internally, in addition to existing business models, is to be regarded as business model innovation, the second type addresses the change of existing business models in the sense of a business model transformation. To circumvent any misunderstanding, the notion has to be made, that there is no uniform interpretation of both these terms (Arnold et al., 2016; Bouwman et al., 2018; Grijalvo Martín et al., 2021). As part of this article both terms will be summarized in the single term business model development.

[3] Gassmann et al. clarify this in the following way: "In the future competition will not be between products and processes, but instead between business models" (Gassmann et al., 2017, p. 5).

Fig. 1 Business model design process (adapted from from Osterwalder & Pigneur, 2010, S. 249)

& Saccani, 2017; Baden-Fuller & Mangematin, 2013; Osterwalder & Pigneur, 2010).

Due to the large number and heterogeneity of existing definitions of business models, their content layout does not follow an explicit procedure. Exemplarily, because of their popularity and their essential contribution to science, the Business Model Canvas from Osterwalder and Pigneur (2010), the magic triangle from Gassmann et al. (2017), as well as the V^4-Modell from Al-Debei and Avison (2010) will be highlighted. Based on an extensive literature study about business model frameworks, Adrodegari and Saccani (2017) have identified business model traits which are widely agreed upon. Those can be–in the style of Paiola and Gebauercompiled into the following four components (Paiola & Gebauer, 2020).

- Value proposition: The value proposition aims to satisfy customer problems and needs, by providing unique products, services or a combination of both, which fulfill the demands and expectations of their customer segment.
- Value delivery: The centerpiece of every business model are the customers. To serve their needs in the best possible way, this element aims at an effective and efficient design of customer segments, relationships, and channels.
- Value creation: With the key resources, activities, and key collaborations, this element contains central elements for realizing the value proposition and represents all internal and external resources that are required to offer the value proposition.
- Value capture: These describe how companies monetize their value proposition and realize values from the individual customer segments.

Business Model Development

In order to carry out a targeted (further) development of the logic of a business model, there are different concepts and models (Carayannis et al., 2014). Examples–again due to their popularity and their significant contribution to practice and research—are the Business Model Design Process (by Osterwalder & Pigneur, 2010), the St. Gallen Business Model Navigator (Gassmann et al., 2017), or approach for business model innovation (Schallmo, 2013).

In practice, the “Business Model Design Process” developed by Osterwalder and Pigneur (2010) has prevailed. The five-step process lays a basis for companies to develop their business models in a specific context. The 5 Phases of the Business Model Design Process can be seen in Fig. 1.

In the “**Mobilize**” phase, the course is first laid for the project of business model development. In particular, it is about creating an awareness of the necessity of the project, to define the specific project goals and scope, putting together the project team and the first ideas to the test in advance The subsequent "**Understand**" phase is primarily devoted to extensive research and analysis in order to gain knowledge about the corresponding elements of the business model. In the course of this, information about relevant technologies, trends, competing companies as well as potential customers and their problems and needs are collected. In order to ask critically the current status quo and to be open to new assumptions and paradigms, Osterwalder and Pigneur (2010) recommend a mix of activities. In addition to classic methods such as market research, expert interviews, customer surveys or observations early prototyping can be helpful in this phase in order to collect timely feedback for ideas. The knowledge and ideas from this phase are prototypically implemented as business models in the "**Design**" step and, among other things, tested and validated for their feasibility and profitability with internal stakeholders as well as external experts and potential customers. In addition, it is clarified whether the old and new business model should be separated from one another or integrated into each other. In this phase, it is very important/crucial to research many different, often daring ideas, to experiment with them and obtain them as much feedback as possible from a wide variety of people and groups of people develop and optimize the business model. The goal/aim is to select the most promising business model design at the end of this phase in order to actually implement it in the company in the subsequent phase ("**implement**"). Ultimately, it is important to establish dedicated structures and processes in the company in order to continuously monitor and evaluate the market and the performance of the business model and to make adjustments in order to remain competitive in the long term if it is necessary ("**Manage**").

In the rarest of cases, however, the process of business model development is linear. For example, the "Understand" and "Design" phases can often run simultaneously. This can be attributed in particular to the exploratory nature of the business model development in which new possibilities are continuously explored, tested, or discarded (Osterwalder & Pigneur, 2010).

AI as Enabler of (Service) Business Models

For a long time, the industrial production was characterized by transactional sales with a rather low number of customer interaction points and a strong focus on cost efficiency. Nowadays the industry is becoming more and more flexible towards customer-specific product-service solutions (Qvist-Sørensen, 2020). Former product-centric success factors in traditional industry, such as "new materials and technologies, faster and more reliable automation, machining with more precision, waste reduction programs, smoother flow of parts, employee engagement, and closer coupling within the supply chain" (Baines & Lightfoot, 2013, S. 2) are not enough to keep up with the competition. Rather, it is important to meet the needs of customers instead of just selling them a product (Gaiardelli et al., 2021). In this context, digitization offers diverse potentials for business model developments in the direction of (service) business models (Boehmer et al., 2020; Coreynen et al., 2020; Frank et al., 2019; Kohtamäki et al., 2019; Paiola & Gebauer, 2020; Vendrell-Herrero et al., 2017). Technologies such as IoT, AI, Big Data, or Cloud Computing give manufacturing companies, among other things, insights into where their products are and how they are used, as well as information about their status and performance in real time (Ardolino et al., 2018; Baines & Lightfoot, 2013; Boehmer et al., 2020; Frank et al., 2019; Lu, 2019; Paiola & Gebauer, 2020; Paschou et al., 2020). Therefore, the ability to react, for example, in the event of impending machine breakdowns, can be significantly increased (Baines & Lightfoot, 2013). Digital technologies also enable new forms of customer interaction (Coreynen et al., 2017).[4]

In this context, specifically artificial intelligence[5] as a key technology (Ahlborn et al., 2019; Dowling et al., 2021; Zimmermann, 2021) can significantly change entire value chains, business models, markets, and industries through the use of intelligent systems (Brynjolfsson & Mcafee, 2017; Dowling et al., 2021; Pfau & Rimpp, 2021; Zimmermann, 2021).

In a simplified understanding of AI, according to Beins et al. (2017), four core skills of modern AI can be identified: perception, understanding, acting, and learning. AI extends the logical basis of common IT systems that rely on the input, processing and output of data to include the components of learning and understanding. By expanding the processing component, the system is trained for continuous self-optimization (Beins et al., 2017). These learning effects mean that AI systems offer far greater opportunities and possibilities, especially for tasks that require a high level of adaptability and problem-solving skills, compared to clearly defined and rigid if–then-rule-based systems (Ahlborn et al., 2019; Beins et al., 2017). With regard to the increasing number and variety of data types and quantities that serve input in the first step ("**perception**"), it is possible to read almost any form of data and process it ("**understand**").[6] In principle, the processing component uses clearly defined case decisions, if it is possible. But it can also be complemented with learning or training properties (Beins et al., 2017).[7] After processing the data, decisions are made or actions are triggered ("**action**"). For example, the system can draw conclusions based on the data in order to identify any anomalies (VDMA Bayern, 2020). Insights gained from this can support certain problems and decision-making, derive suggestions for action and, if necessary, even initiate subsequent processes

[4] A more comprehensive overview of the role of digital technologies in service transformation is provided by Ardolino et al. (2018).

[5] AI describes methods, processes, and technologies that enable IT systems–such as machines, robots, or software systems—to interpret large amounts of data and to learn from this data in order to reproduce or imitate certain human-cognitive abilities (Di Vaio et al., 2020; Lee et al., 2019; Metelskaia et al., 2018; Paschou et al., 2020; VDMA Bayern, 2020). This means that tasks that require visual perception, language or strategic thinking and planning, for example, can be carried out independently and efficiently by machines (Ahlborn et al., 2019; Dowling et al., 2021; Metelskaia et al., 2018; VDMA Bayern, 2020; Keding, 2021).

[6] The quality and relevance of the data play a decisive role here, since possible latent or openly immoral patterns in earlier decisions, for example, in the area of racism or sexism, may later be reproduced by the AI under certain circumstances (Keding, 2021).

[7] Special methods are used for this, such as language understanding or machine or deep learning (Beins et al., 2017).

autonomously (Beins et al., 2017; VDMA Bayern, 2020).[8] In the subsequent training phase ("**learning/training**"), but also during operation, the AI system uses feedback to learn to understand the cause-effect relationships of the operations and to differentiate between correct and incorrect actions (Beins et al., 2017; VDMA Bayern, 2020). As a result, the AI system can access an ever-increasing amount of data and knowledge and also learn from this experience and continuously develop itself (Ahlborn et al., 2019; VDMA Bayern, 2020). It is not uncommon for the algorithms[9] used in decision-making and problem-solving situations to exceed the cognitive abilities of real people and therefore be faster, more precise, and more efficient (Ahlborn et al., 2019; Di Vaio et al., 2020; Keding, 2021). This applies in particular to cases that are characterized by a high degree of dynamism, uncertainty and complexity. Especially if those also require a high degree of objectivity and the multitude of decision-relevant parameters and data would exceed human processing capacity (Ahlborn et al., 2019; Keding, 2021; VDMA Bayern, 2020).[10]

However, the possibilities of AI are also technically limited. Up to now, AI systems have been limited to solving individual, specific use cases within certain system boundaries (Ahlborn et al., 2019; Beins et al., 2017; Bundesregierung der Bundesrepublik Deutschland, 2018; Boll-Westermann et al., 2019; VDMA Bayern, 2020; Zimmermann, 2021). Moreover, the predictability of self-learning systems decreases over time and can no longer be guaranteed sooner or later (Seifert et al., 2018). In addition, ML-based methods in particular are often of the black box type. This means that results, which are generated by AI systems are no longer traceable or just traceable with a disproportionately high effort. Therefore, they are often perceived as non-transparent (Bitkom & DFKI, 2017). These properties of AI have led to "serious fears of parts of the population [note of the author] of becoming victims of an unstoppable mechanization process. The Keywords are data collection madness, transparent customers, rationalization of workplaces etc." (Bitkom & DFKI, 2017, p. 37). These emotions towards AI systems can also be identified in the operational context. When it comes to implementing and operating AI systems in the organizational context, the most important factors are trust and acceptance (Jung & von Garrel, 2021).

[8] With reference to the example of anomaly detection, this information could be used, for example, to identify relationships between sensor values and quality assurance results in order to anticipate potential production errors and ideally to arrive at dedicated recommendations for action for machine operation (VDMA Bayern, 2020) This enables tasks that require, for example, visual perception, language, or strategic thinking and planning to be carried out independently and efficiently by machines (Ahlborn et al., 2019; Dowling et al., 2021; Metelskaia et al., 2018; VDMA Bayern, 2020; Keding, 2021).

[9] Artificial intelligence is based on mathematical-statistical models, so-called algorithms (Beins et al., 2017; Joenssen & Müllerleile, 2020). Based on a specific problem and the underlying data model, algorithms are able to autonomously identify different solutions, gain new knowledge, optimize processes, and support decisions (Beins et al., 2017; VDMA Bayern, 2020).

[10] As a result, it can be expected that the future role of people will be to focus more on topics and tasks that require strong judgment, intuition, creativity, flexibility, empathy, and tacit knowledge (Keding, 2021).

Implications for Manufacturing SME

Business Models and AI

Formerly successful business models and their individual elements may become ineffective and obsolete (Paiola & Gebauer, 2020). Manufacturing companies are called upon to reflect critically on their business models and, if necessary, to reconfigure/redesign them in order to be able to survive in the changed competitive environment (Boll-Westermann et al., 2019). The role of a company is transforming "from being owners of competencies and resources into integrators of skills, resources and technologies able to realize complex value creation processes" (Gaiardelli et al., 2021, p. 177). The possible impacts arising in relation to the individual elements of the business model can be significant.

The use of AI opens up new opportunities and possibilities for manufacturing companies to innovate their **value proposition**. AI solutions, especially in combination with the increasing linking of production, can support companies in responding more specifically to specific customer needs and in stronger individualization of their range of services). In particular, through integrated sensors in the machines, information about the utilization, use, and condition of an object can be obtained and evaluated in real time. Through this, conclusions and insights can be drawn for new, innovative, and customer-centered value propositions (Ahlborn et al., 2019; Dowling et al., 2021; Keding, 2021; Metelskaia et al., 2018; Zimmermann, 2021). It should be emphasized that the value proposition of an AI-based solution depends heavily on the solution itself. Examples of generic value propositions could be as follows:

- ***Making data usable:*** One of the greatest potentials of AI arises from the networking of production-related systems in Industry 4.0. Networked production makes it possible to obtain and evaluate different data and information in order to derive and take meaningful measures (Ahlborn et al., 2019).
- ***Relieve employees and strengthen focus on core business:*** The algorithms on which the AI is based can support employees in relieving them of repetitive or highly process-related work, which in turn frees up resources to strengthen the core business (Ahlborn et al., 2019; Keding, 2021).
- ***Support and optimization of customer processes, as well as the creation of new service offers:*** Data can also be analyzed in real time using AI in order to provide customers with valuable knowledge for optimizing their planning and production. The data obtained from this can in turn be used to design new types of products and services (Dowling et al., 2021; Keding, 2021; Zimmermann, 2021).

The fact that the focus of the value proposition of a service-centered business model is primarily on intangible goods, such as certain skills, knowledge, and processes, and that the demand for individual solutions rises, a customer-centered value-adding process within the scope of value delivery is of eminent significance (Coreynen et al., 2017; Culot et al., 2020; Kohtamäki et al., 2019). Furthermore, Coreynen et al. explained it further as follows: "learning from customers, being adaptive to their individual and dynamic needs and co-creation are essential" (2017, p. 50). This allows ideas for the future value proposition or other elements of the business model to be validated early on in their conception and development (Boll-Westermann et al., 2019). Depending on which specific AI-based solution a company offers its customers, the type of collaboration can also change. In this way, companies can gradually integrate more deeply into their customers' value adding through the increasing delivery of relevant and tailor-made services (Baines & Lightfoot, 2013; Qvist-Sørensen, 2020). As a result, the cooperation and the relationship with the customers intensifies. An important point is the topic of trust and acceptance. Since the topic of artificial intelligence is very complex and can lead to fears and reservations among customers, especially when it comes to sharing data, it is essential to gain the trust of customers (Boll-Westermann et al., 2019).

The **value creation** activities of traditional manufacturing companies are primarily focused on the construction, production, and distribution of physical goods (Boll-Westermann et al., 2019). In principle, the development of complex AI-based solutions requires dedicated internal and external processes as well as activities dealing with the design, engineering, operation and maintenance of products, services, and IT systems (software and hardware) (Metelskaia et al., 2018). During the development phase and the operation of AI-based (service) business models, the management of internal and external data, information, and knowledge domains are central (Boll-Westermann et al., 2019; Metelskaia et al., 2018). As companies integrate more and more into the added value of their customers, it is important to create a trusting cooperation Employees, especially those with direct customer contact, are required to understand their customers 'businesses and their challenges in every detail and to do everything necessary and possible to solve their customers' problems. At the same time, they should have in-depth knowledge of their own products, technologies, and systems in order to be able to make realistic and targeted offers to customers. A high degree of commitment, empathy, authenticity, technical understanding, customer orientation as well as flexibility and resilience are therefore required (Baines & Lightfoot, 2013). In addition, it is important to develop and expand appropriate marketing and sales skills in order to convey the value of the new solutions to customers and to convince them of the offers (Adrodegari & Saccani, 2017; Baines & Lightfoot, 2013). The introduction of AI-based solutions does not only affect the key activities of a manufacturing SME, but also usually presents it with a number of challenges with regard to its key resources and collaborations. Often, SME lack the necessary core competencies and resources. Qualified specialists are indispensable for the successful introduction and management of the AI offering (Metelskaia et al., 2018). In addition, it must be ensured that the respective company has the necessary technical resources (Boll-Westermann et al., 2019), such as adequate access to qualitative and comprehensive data sets[11] from

[11] The installed base is therefore very important, because as a general rule, the larger it is, the larger is the available database. A large number of products in circulation and a broad base of existing customers make it possible to generate valuable data, which in turn can provide insights for optimizing your own offers and business model (Adrodegari & Saccani, 2017; Baines & Lightfoot, 2013).

different sources with which the corresponding AI models can be trained, or general know-how on topics such as artificial intelligence or data science (Falk et al., 2020).[12]

In contrast to physical products, AI-based (service) business models as digital service offerings are primarily based on data, which can usually be copied and reused at almost no cost. Traditional pricing mechanisms, such as the classic overhead calculation, usually fall short of the element of value capture in the context of (service) business models and are simply ineffective. Rather, it is important to determine the benefits of the services for customers in order to draw conclusions about their willingness to pay, as well as with regard to adequate payment models. In connection with AI-based solutions, "as-a-service" subscription models, such as software-as-a-service or AI-as-a-service, are particularly widespread and recognized. In these models, for example, products equipped with AI are not offered as capital goods, but as a service. Service agreements can ensure more stable payment flows, which can be particularly advantageous in times of strong economic fluctuations (Baines & Lightfoot, 2013; Brax & Visintin, 2017; Fliess & Lexutt, 2019). However, values do not have to be measured solely in monetary terms. In particular, in a digitized, post-industrial world, data represent an important, often critical to success, source for generating values. In this sense, AI-based solutions translate the input data into valuable insights, which in turn generate additional values (Boll-Westermann et al., 2019).

On the cost side, it is to be expected that the introduction of AI will be associated with corresponding investments. Typically, a significant part of the costs is likely be incurred in recruiting and qualifying the necessary specialist staff, on setting up an appropriate IT infrastructure, and in developing, marketing, and selling innovative AI-based products, services or product-service combinations (Metelskaia et al., 2018).

Business Model Development and AI

The development of AI-based (service) business models by manufacturing SME is a complex process in which the interaction between physical products and services changes significantly (Brax & Visintin, 2017). In this context, it is not enough to open up new technological possibilities through AI, but these must be made sustainable and economical in AI-based (service) business models (Paiola & Gebauer,

[12] Companies that want to offer their customers AI solutions do not necessarily have to develop them in-house (Pfau & Rimpp, 2021). It often makes more sense to use services that are already available on the market and, if necessary, to customize them (Pfau & Rimpp, 2021). In particular, if the AI applications are expected to have only a weak to moderate influence on the business model, outsourcing can be a worthwhile alternative (Pfau & Rimpp, 2021). For example, if a manufacturing enterprise wants to offer predictive maintenance services in addition to its existing business, i.e., the sale of production goods, it must be considered whether the investment in building up the necessary know-how and the necessary technical and organizational infrastructure would be profitable. In addition, it must be ensured that the respective company has the necessary technical resources. AI systems usually place high demands on computing power (Boll-Westermann et al., 2019). This can be remedied, for example, by special platforms that are offered in the cloud, on-premise or as edge computing (Falk et al., 2020).

2020). This fact can lead to fundamental changes in the business model that can question the reasoning of the existing business model. It is therefore important to approach the development of new business models in a targeted and structured manner (Adrodegari & Saccani, 2017; Qvist-Sørensen, 2020; Kohtamäki, 2019).

Due to the characteristics of AI which were described above, but also against the background of a lack of financial and human resources (Dowling et al., 2021; Hanussek et al., 2021; Zimmermann, 2021), it seems to make sense, especially for manufacturing SME that have had little or no experience with AI, to adapt classic business model development processes: Since the development of innovative, AI-based (service) business models is a complex project, the specific effort and scope is sometimes not yet clearly defined, especially at the beginning of the project, and often becomes apparent in the course of the project. An agile and interactive approach, in which certain ideas are continuously tested and, if necessary, validated with the customers, can therefore be useful in the development of an AI-based business model in order to gain gradual clarity about the project scope and goals to develop customer-optimized solutions. Osterwalder and Pigneur (2010) already make it clear that breaking the linearity of the process may be necessary due to the exploratory nature of the business model development. In order to visualize, test and, if necessary, discard ideas as quick as possible, it may be advisable to use rapid prototyping methods. But the design of user journeys can also provide information on how processes, including potential touch points, pain points and moments of truth, i.e., particularly memorable, decisive moments, can be designed (Corves & Schön, 2020).

In order to ensure that the design of the business model is consistent with potential AI-based solutions as well as in harmony with the employees, it is advisable to closely coordinate the development of these perspectives, i.e., the economic, technological and social dimensions (Carayannis & Campbell, 2010). This allows dependencies to be taken into account and actions to be compared with each other.

From a social perspective, it seems logical to “demystify” the topic of AI in companies as a first step, especially against the background of the emotional approach to artificial intelligence. By dealing with the topic and communicating transparently, it is possible to create a clear and shared understanding of the potential, requirements, and challenges of AI and also to generate awareness in the company (Jung & von Garrel, 2021).

Since artificial intelligence processes, systems, and related technologies are constantly evolving (Boll-Westermann et al., 2019), it seems advisable, to continuously monitor and reflect on such developments throughout the process of business model development and after implementation. This sharpens the focus on translating or monetizing technological potentials into economic values. At this point, it is particularly important to critically question your own assumptions and, if necessary, to have the courage and willingness to reiterate them in the process. It is unlikely that a company with an AI-based solution will be successful in the medium to long term if the solution itself and the associated business model are not continuously developed. In order to justify the implications of AI-based business model development in SME, it is therefore advisable to adapt the business model development process at the processual level according to these implications (Fig. 2).

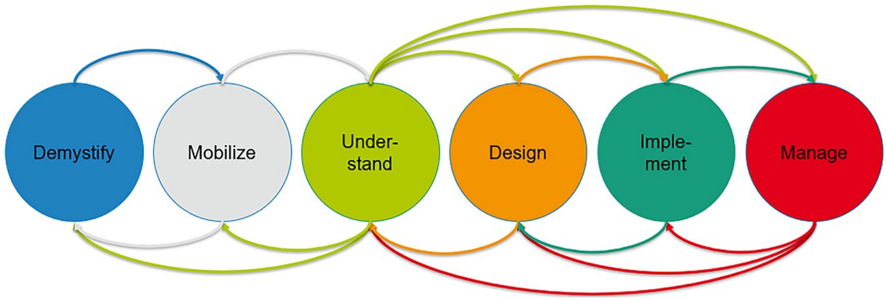

Fig. 2 Development process for AI-based business models (adapted from Osterwalder & Pigneur, 2010, S. 249)

AI-based (Service) Business Models of SME

As already shown, the development of new and innovative business models is increasingly becoming a core competence for companies in order to be competitive in the long term (Paiola & Gebauer, 2020). Once successful business models and their individual elements can become ineffective and obsolete (Paiola & Gebauer,

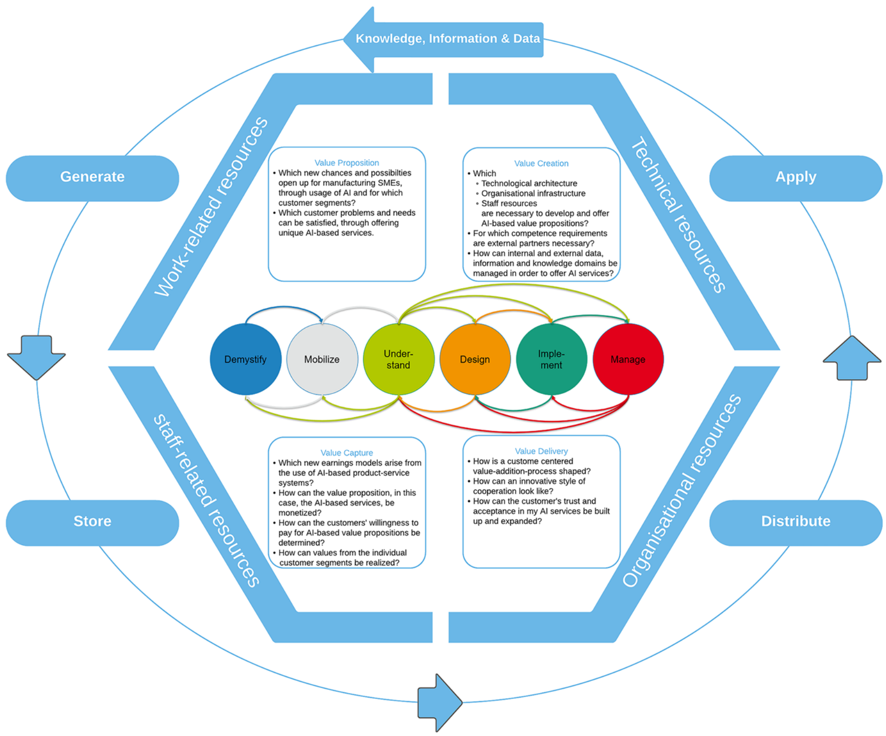

Fig. 3 Design framework for the Implementation of AI-based (service) business models for manufacturing SME

2020). Manufacturing companies are therefore required to critically reflect on their business models and, if necessary, reconfigure them in order to survive in the changed competitive environment (Boll-Westermann et al., 2019). Due to its disruptive character, artificial intelligence in particular has the potential to redefine or even destroy established industries (Ehret & Wirtz, 2017).

But "[…] many small and medium-sized companies are just at the beginning of digitization" (Dowling et al., 2021, p. 7). In addition to financially limited resources, personnel restrictions also pose great challenges for SME. SME often see little reason to break new ground and therefore concentrate their resources in order to carry out their core business, especially when the workload and demand of their products or services is high (Dowling et al., 2021). Furthermore, SME often lack qualified specialist staff and the necessary expertise about the potentials and specific applications of AI, which are, however, necessary to advance such topics (Dowling et al., 2021; Hanussek et al., 2021; Zimmermann, 2021).

AI technologies for (service) business models are always developed by people (AI experts) and implemented for specific corporate contexts (with technical experts) and process data into information. This requires, especially in the industrial context, people with the knowledge to act on the basis of this information (service employees/users). In order for such models to work, all existing technological organizational, human, process, and labor resources must be included in addition to customer needs. In this sense, AI-based (service) business models are socio-technical systems and the result of the interaction of people or groups and intelligent systems based on their unique data, information, and knowledge domains (North & Varvakis, 2016).

For this reason, it can be helpful, especially for SME, to link heterogeneous data, information, and knowledge domains and to make previously non-existent knowledge available in order to develop AI-based (service) business models (Koch & Windsperger, 2017).

Different methods and tools can act as "enablers" here, systematically generating, applying, distributing, and storing data, information, and knowledge domains from a socio-technical perspective (i.e., taking into account technological, organizational, personnel, procedural, and work-related design options) for the development of AI-based (service) business models (Mertins et al., 2016). The use of these methods must not only be characterized by the management of existing knowledge domains with a focus on its documentation, but must support the development of dynamic resources and capabilities of organizations in order to develop, reconfigure, realigning, or integrate core competencies using external resources and skills (including integrated data and information platform, wiki, digital knowledge communities (Al-Gharaibeh & Ali, 2021; North & Maier, 2018).

Conclusion and Outlook: Socio-Technical Design Framework

Manufacturing enterprises are facing a multitude of challenges nowadays. Due to globalization and the increased use of technologies, the competitive environment is intensifying considerably, while at the same time the expectations and demands of customers are increasing. Manufactured goods are being imitated at continuously lower costs and are increasingly interchangeable, so that more and more production companies are starting to enrich or even replace their previously goods-centric offers with service-oriented, integrated solutions and to develop service-based business models. Especially, AI–as a key technology–offers great potential through service or product innovations, as customer or process data combined with AI methods form the basis for the development of new (service) business models.

If one sees AI-based (service) business models in this context as socio-technical systems, whose outcomes is the interaction of people or groups and intelligent systems on the basis of their unique data, information, and knowledge domains, then an arrangement of these domains, taking into account the technological, organizational, personnel, procedural, and work-related design options, appears to be a promising approach. However, especially manufacturing SMEs, whose competitive advantages are in particular due to their unique technological domain knowledge, rarely possess the other necessary knowledge domains to effectively and efficiently introduce and operate data- and AI-based (service) business models.

Summarizing the challenges and insights–based on the implications abstracted by artificial intelligence for (1) individual elements of business models, (2) the process of business model development, and (3) the development of (service) business models by SME–a design framework–referring to research activities relating the digital transformation (e.g., Rêgo et al., 2021) or customer-driven innovation (Sindakis, 2015)–for SME for the development of AI-based (service) business models can be established (Fig. 3).

This approach is justified by the knowledge that it is of strategic importance, especially for small- and medium-sized companies, to develop AI-based (service) business models, to network heterogeneous knowledge domains—both on an organizational and individual level–and to provide and spread,which has been so far, non-existent knowledge.

But at this point, it should be emphasized that the challenges presented in this article for the development of AI-based service business models as well as the developed solution approach in the form of a framework can only provide initial indications. Only through the concrete, organization-specific design of this framework do the specific challenges that organizations have to face when developing new business models become clear (i.e., Corallo et al., 2019). In this context, the implementation of an agile and interactive development process, which is only briefly described and recommended, is an example. To what extent, such an agile process influences the shape of a business model or what relationships exist between the resources and how these affect the development process has not been sufficiently researched so far. In addition, the introduction of agile methods requires transformations at all levels of an organization, which not only have to involve procedural but also cultural change processes in a company. Such a process requires, among other things, a change in the mindset of the employees and is of a long-term nature.

Furthermore, it is also possible to convert this organization-related design framework into a cross-organizational framework and thus promote the development of cross-organizational platform resources ("platform boundary resources") (i.e., Zhao, 2022), and thus a broad knowledge community for the development of AI-based products and services together. in this context, in the business model context, a lot of time is often spent addressing the actual customer problem in order to overcome the so-called "problem–solution hurdle"–that means ensuring that the desired solution addresses an actual customer problem. By opening up the framework, customers of the manufacturing companies (or their customers) can be integrated directly. Making their ideas or everyday problems in the execution of a process or the processing of a task available to the company in the sense of an open innovation platform.

Funding Open Access funding enabled and organized by Projekt DEAL. This research and development project is funded by the German Federal Ministry of Education and Research (BMBF) within the "Innovations for Tomorrow's Production, Services, and Work" Program (Funding Number: 02L20C034) and implemented by the Project Management Agency Karlsruhe (PTKA). The author is responsible for the content of this publication.

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