Platform-based support for AI uptake by SMEs: guidelines to design service bundles

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Abstract

Purpose – Manufacturing small and medium-sized enterprises (SMEs) have already noticed the tangible benefits offered by artificial intelligence (AI). Several approaches have been proposed with a view to support them in the processes entailed in this innovation path. These include multisided platforms created to enable the connection between SMEs and AI developers, making it easier for them to network each other. While such platforms are complex, they facilitate simultaneous interaction with several stakeholders and reaching out to new potential users (both SMEs and AI developers), through a collaboration with supporting ecosystems such as digital innovation hubs (DIHs).

Design/methodology/approach – Mixed methods were used. The literature review was performed to identify the existing approaches within and outside the manufacturing domain. Computer-assisted telephonic (in-depth) interviewing , was conducted to include perspectives of AI platform stakeholders and collect primary data from various European countries.

Findings – Several challenges and barriers for AI platform stakeholders were identified alongside the corresponding best practices and guidelines on how to address them.

Originality/value – An effective approach was proposed to provide support to the industrial platform managers in this field, by developing guidelines and best practices on how a platform should build its services to support the ecosystem.

Keywords Artificial intelligence, Small and medium-sized enterprises, AI developers, AI platform guidelines, Digital innovation hubs

Paper type Research paper

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1. Introduction

No organization can afford to sit back and ignore the potential of artificial intelligence (AI; Floridi, 2019). Rushing to adopt AI just because the technology exists and offers potentially enormous benefits can be dangerous for any type of business, especially for small and medium-sized enterprises (SMEs) that do not have the spare economic availability or time for a trial-and-error approach. To fully utilize the potential of AI in manufacturing, AI implementation programs (like any disruptive technology) need to be smooth, affordable, scalable and capable of avoiding derailing issues (Pessot *et al.*, 2020). Companies need to approach AI implementation with a clear business goal and be aware of opportunities that AI will create for them. For an effective integration of AI into a company, cutting-edge technology is important but so is the alignment of the company's culture, structure and work methods (Fountaine, McCarthy, & Saleh, 2019). Otherwise, it is unlikely to yield the desired benefits (Martínez-Caro, Cegarra-Navarro, & Alfonso-Ruiz, 2020). Accenture (2020) emphasizes that organizations need to reengineer the experiences that bring technology and people together in a human-centric manner and address the ethical and cultural issues intrinsically associated with AI.

While scholars often consider manufacturing to be at the forefront of the application of new technologies, AI's impact on manufacturing remains low across all use cases (Villalonga *et al.*, 2021). Although AI technologies are in continuous evolution, the process of introducing AI is still highly complex, time-consuming, capital and skill-intensive, and requires a comprehensive, systematic approach if it is to prove successful (BeyondMinds, 2021). Very few companies can fully rely on internal expertise to manage the overall process from AI selection to implementation (Bettoni, Matteri, Montini, Gładysz, & Carpanzano, 2021). This is even more challenging for manufacturing SMEs that, typically, have more resource constraints than large enterprises. Thus, the role of external providers is essential to create an ecosystem in which service providers or AI developers can create AI software and applications that suit the business needs of specific SMEs, based on the collected and analyzed data (Haber, Alique, Alique, Hernández, & Uribe-Etxebarria, 2003). Moreover, a possible option is to rely on the expertise of the industrial associations, chambers and digital innovation hubs (DIHs; EU, 2019), or similar initiatives outside the EU which help companies to become more competitive by leveraging their networks (Hervas-Oliver, Gonzalez-Alcaide, Rojas-Alvarado, & Monto-Mompo, 2020). In this ecosystem, a significant role belongs to the platforms created to bring together companies and AI developers and facilitate their cooperation (Mucha & Seppala, 2020). They are brokers that connect stakeholders such as end users (e.g. manufacturing SMEs), service providers and DIHs, each one with different needs, requirements and expectations. Thus, the platforms need to be capable of supporting the different actors within the ecosystem.

Through this article, we intend to encourage studies aimed at developing guidelines for AI platform managers regarding the structure of their services. Currently, such guidelines tend to come in a fragmented way, from a perspective of a single stakeholder. We attempted to develop a generic approach considering all the key stakeholders focusing on the perspective of European companies by gathering data from various European countries. We prepared the article within the framework of the EU-funded project "Platform-enabled kits of Artificial Intelligence for easy uptake by SMEs" (KITT4SME – https://kitt4sme.eu). KITT4SME aims to provide scope-tailored and industry-ready hardware, software and organizational kits as a modularly customizable digital platform that seamlessly introduces AI in the production systems of European SMEs and mid-caps. The novelty of our study stems primarily from the synergetic nature of the presented guidelines. Figure 1 summarizes the adopted methodology.

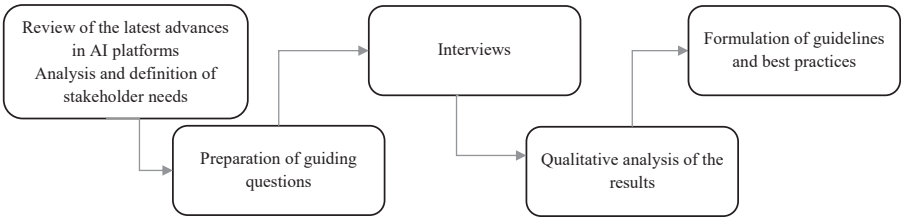
The article will continue as follows: section *Characteristics of AI Platforms and Their Stakeholders* will discuss the state-of-the-art advances relevant to AI platforms. Section

Methodology will aim to determine which actors we can consider the main stakeholders of such platforms and analyze their needs in terms of platform services. Section *Empirical Evidence* will describe the approach used to prepare and administer the questionnaires for the different stakeholders from various European countries. In section *Discussion: Good Practices and Guidelines*, we will qualitatively analyze the obtained survey results and compare them to the stakeholders' needs, identified in the state-of-the-art analysis. Section *Conclusions* will offer a set of guidelines for stakeholders.

2. Characteristics of AI platforms and their stakeholders

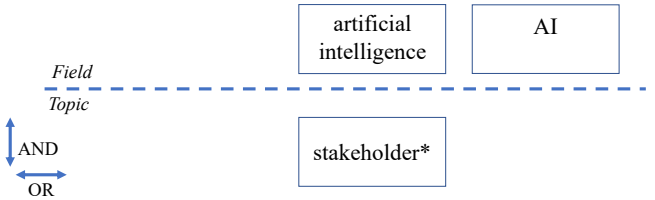
We decided against using the available bibliometrics and an in-depth systematic review, because we aimed to identify categories relevant from the perspective of this study, rather than providing an exhaustive landscape or arrive at any new findings in this regard. Hence, we selected the most common and readily available search engine. We conducted the review using Google Scholar available without subscription requirements. Moreover, information about AI adoption exists not only in scientific articles but also in grey literature. While Google Scholar does not cover all the issues concerning grey literature analysis, it is better suited to our purposes than purely scientific databases. We conducted the review on February 28, 2021. Figure 2 shows the keyword matrix. Google Scholar provides a de facto unlimited list of results. For the study, we considered only the first 50 results in the screening of titles and abstracts. The most prominent articles related to the topic should emerge in these results. Two experts were involved in the screening of the respective abstracts. Whenever they disagreed about the text's relevance, we invited the third expert to decide on the relevance. Everyone involved agreed on the final selection.

We did not assume any exclusion criterion for the publishing date, but we considered only papers in English, which yielded only ten relevant papers (Ejsmont, Gladysz, Kozlowski, & Krystosiak, 2021, p. 27). We may categorize the stakeholders of AI platforms into four groups, i.e. 1/AI end users (ready for the applications, not yet having capabilities), 2/(leading) AI developers (i.e. technology/solution providers and brokers, competing/supporting/



Source(s): Own elaboration

Figure 1.
The methodology



Source(s): Own elaboration

Figure 2.
Keyword matrix

complementary technology platforms, industrial associations), 3/DIHs (or analogous actors outside the EU) and 4/AI supporters (e.g. consultancy firms, R&D centers/institutes, the academia). We excluded the authorities because there is no potential impact that platform developers could have on the authorities. All regulatory requirements are necessary conditions with which every platform must comply.

End users are all the companies searching for AI-based applications to resolve their operational problems, but lacking the necessary skills, investment potential or facing other challenges related to AI adoption. SMEs are an important category of potential end users (Hansen & Bøgh, 2021). Only 56% of SMEs in the EU achieved at least a basic level of digital intensity (EU, 2022). SMEs are struggling with the introduction of AI (Watney & Auer, 2021). Although the digital revolution creates opportunities for all companies, many still struggle to figure out which technologies to invest in and how to secure funding for their digital transformation. Companies are increasingly coming to realize that a combination of IT skills, AI skills and solid business knowledge is required if a positive economic result is to be produced (Albukhitan, 2020). The ability to innovate and acquire the necessary human capital skills is among the most important enablers (McKinsey, 2020), yet nearly 50% of the companies surveyed indicate the lack of AI skills in the job market as a key obstacle to AI implementation (EY, 2018). Moreover, company managers need to understand where, when and how to best deploy new technologies, because each scenario and use case requires careful planning. Before taking any measures, companies should devise a strategic plan for the use of the technology to better analyze the possible impact and to have a representation of all the steps for the implementation of the technology. Companies find it difficult to approach the integration of new technologies "alone." Supporting actors such as external advisors, consultants, developers and integrators are instrumental in maximizing the efficiency of AI integration. Furthermore, we may consider DIHs a bridge facilitating this implementation process. Interviews conducted in this study showed that interviewed SMEs did not recognize the existence of the DIHs ecosystem. "Not-invented-here" is a negative attitude toward external knowledge which results in a low level of trust toward external ideas, while "not-sold-here" refers to the fear of losing competitive advantage when transferring a company's internal knowledge resources to outsiders (Amann, Granström, Frishammar, & Elfsberg, 2022). When either of those syndromes is present, organizations that collaborate through a DIH are not able to take full advantage of their partnership and the DIH fails to achieve its mission.

AI developers are responsible for developing and distributing AI software with features that depend on the company's needs determined, thanks to the collected and analyzed data. AI is developing rapidly and the demand for AI developers is growing rapidly. However, even though many entities fall under the AI developer category, scholars have devoted little attention to this group in the literature (Nascimento, Nguyen-Duc, Sundbø, & Conte, 2020).

Policymakers recognize the need to support and formalize the AI support ecosystem (EU, 2019; Beckmann *et al.*, 2016). DIHs are a key pillar in the European Commission's Digitising European Industry initiative (EU, 2019). Nothing inhibits development as much as the passive attitude of entrepreneurs toward the ongoing digital revolution and DIHs can support the diffusion of the most effective solutions throughout the EU by establishing a network of connections. DIHs can support any company, regardless of its technological advancement, in taking advantage of digital opportunities, by providing access to technical knowledge on new digital technologies, including in terms of software, hardware and business models, so that companies can understand new opportunities and potential returns on investments. Moreover, DIHs provide demonstration facilities and project piloting. Despite the enormous contributions of DIHs and other AI supporters in promoting AI among organizations, scholars devote relatively little attention to this group of stakeholders in the literature as summarized by Ejsmont *et al.* (2021, p. 32). There is a shortage of studies on the role of DIHs in

the development and propagation of AI. Collaboration with a platform offering AI solutions can prove very fruitful for DIHs as it allows them to expand their scope, by reaching out to small enterprises. There is a need to share best practices among DIHs and ensure efficient knowledge exchange. To successfully engage with SMEs and the industry, DIHs need to provide services that are relevant and establish relationships based on trust. They should use language that SMEs understand and implement procedures that keep bureaucracy to a minimum. Most DIHs offer a fixed range of services, but at the same time a DIH should be flexible, experiment and co-create, but they lack the skill. Partnerships with external experts specializing in advanced topics could help provide the necessary competences and increase the range of DIH services. Currently, few DIHs are ready to help companies with the actual implementation of AI, even though DIHs are planning to do it in the best way (internal training or external support; Hervas-Oliver *et al.*, 2020). Any AI supporter needs to work on improving the visibility of its offer using both online and offline strategies, e.g. including a dedicated webpage, social media channels and newsletters. It can also be helpful to prepare some multimedia content. Offline marketing can include printed presentation materials, participation in tech events, trade shows and conferences. Many hubs use their networks, such as clusters and chambers of commerce, as communication channels.

Artificial intelligence platform-as-a-service (AI PaaS) is a form of cloud computing service that enables customers to provide, instantiate, run and manage a modular bundle comprising a computing platform and one or more applications, without the complexity of building and maintaining the infrastructure typically associated with developing and launching the applications. Moreover, it allows developers to create, develop and package such software bundles (Villalonga *et al.*, 2021). It is possible to consider the concept of AI PaaS from the perspective of the classic PaaS model. Platform as a service usually includes two components required for application development: hardware (computing power, data storage, networking infrastructure, virtual machines) and software (tools and services). The key hurdle to adopting this general approach to AI PaaS architecture is that a general model for AI PaaS is yet to be developed. Vendors offer different services under the same umbrella term. Nonetheless, several elements are common to the majority of today's platforms: infrastructure, data storage, pre-trained machine learning (ML) models and AI application programming interfaces (APIs).

Artificial-intelligence-as-a-service (AIaaS; Elger & Shanaghy, 2020) enables experimenting with AI without excessive initial investment or risk. AI providers offer several ML methods and AI-based computational techniques. Respective entities need to evaluate the features and pricing offered to see what works for them (TechTarget, 2022). The topic of AIaaS appears mainly in grey literature. To date, we have found no guidelines on how to design and tailor AIaaS to specific stakeholders. Only one book explores utilizing existing platforms (Amazon Web Services; AWS) from the perspective of a software developer (Elger & Shanaghy, 2020). The leading platforms offering ready-to-use AI solutions and tools for AI developers and data scientists include AWS, IBM's Watson, Microsoft's Azure AI and Google's Vertex AI (Pierleoni, Concetti, Belli, & Palma, 2020). However, these are not designed for manufacturing. The AI solutions they offer do not really meet the needs of manufacturing SMEs. We may classify such platforms under two types according to their offer: facilitation of coding and development of AI programs, enabling creating and configuring applications through a graphical interface; and providing complete ready-to-use packages deployed/implemented without the need for advanced technical and IT skills. Given we focused primarily on SMEs, the former type of platform was less interesting to us since very few SMEs have the necessary in-house competencies (data scientists, analysts and developers) or a team capable of effectively modeling AI programs usage. It is the second group of platforms that provides a marketplace, where businesses can make their services available side-by-side with their competitors and customers can choose the option that best fits their needs.

3. Methodology

To define a shortlist of AI platform stakeholders, we conducted a literature review – also in non-manufacturing domains – as there is a shortage of papers focusing specifically on manufacturing SMEs. We had to corroborate its validity in relation to a multisided AI platform dedicated to manufacturing SMEs through the workshop. The KITT4SME consortium members delegated all 51 workshop participants to the workshop. We then divided the participants into seven groups of seven to eight people, including experts and decision-makers, representing stakeholder groups identified during the review (the academia, AI providers and developers, DIHs, industrial associations, research institutes and SMEs). The KITT4SME consortium conducted the workshops remotely (https://conceptboard.com) during the kickoff meeting held on 15 October 2020. The aim was to identify all the individuals, groups or organizations that can enable the uptake of artificial intelligence by SMEs through the KITT4SME platform. We adopted the power-interest matrix as the proven effective method to systemize the identified stakeholder portfolio (Nguyen, Mohamed, & Panuwatwanich, 2018). The workshop finished with the identification of entities that can facilitate the uptake of AI by SMEs via the AI platform (Ejsmont *et al.*, 2021, pp. 13–20).

We employed direct in-depth interviews using a structured online questionnaire to discover phenomena impacting the needs of the key stakeholders. We applied the CATI technique and videoconferencing. The interview oscillated around 90 minutes per respondent. We shared the questionnaire with the respondents, who had control over the collected data. We divided the structure of questionnaires (metrics, general questions on I4.0, detailed questions on AI and the AI platform) into generally applicable and stakeholder-specific questions (Survey, 2022a, b, c) and derived it from the literature review (Ejsmont *et al.*, 2021). Convenience and purposive sampling is a limitation of the research constrained by resources. This is to overcome in the future by seeking a wider coverage of European economies and then possibly going beyond Europe. Every KITT4SME consortium member contacted European manufacturing SMEs from its own business network. The selection was grounded on the KITT4SME members' subjective assessment of the strength and quality of their longstanding business relations and cooperation with SMEs as the criterion for convenience sampling. Interviews aimed to identify the issues that European manufacturing SMEs face when approaching digitization as a prerequisite for the adoption of AI systems and the steps necessary to allow wider digitalization and AI adoption. Moreover, interviews aimed to analyze the role of DIHs, their barriers and obstacles and conditions for collaboration with an AI platform to understand what the needs of DIHs are, and what services the platform could offer to attract them. Similarly, the secondary aim was to analyze barriers and obstacles faced by AI developers in delivering AI solutions, to understand how AI platforms could support them to ensure high-quality deliveries to the AI platform and, hence, to the final user.

4. Empirical evidence

The three key stakeholder types that require more in-depth analysis include SMEs, AI developers and DIHs. The participants understood DIHs as AI supporters and facilitators. Therefore, we coined one additional category to include other AI supporters who were not DIHs per se. All workshop groups mentioned these particular stakeholder classes. Furthermore, these stakeholders appeared in key quarters of the power-interest matrix. The workshop results were consistent with data reported in the literature (Ejsmont *et al.*, 2021). Literature sources described users more specifically as AI end users. While the workshop participants settled on a more general category of user, the meaning of AI end-user was implied by the default given in the scope of this study. The other category that the literature mentions is technology providers. In this regard, the workshops ended with an

analogous category of leading AI developers. Finally, the two groups of innovation/service facilitators and knowledge providers mentioned in the literature as primary AI stakeholders jointly constituted an obvious analogy to DIHs and other AI supporters. The results (four groups of main stakeholders) obtained from the workshop and review aligned (Table 1).

Some publications point to the general categories of stakeholders (Meske, Bunde, Schneider, & Gersch, 2022) such as AI managers, AI users, AI developers, AI regulators and individuals, affected by AI-based decisions. Several articles focus on stakeholders in the context of explainable AI (Preece, Harborne, Braines, Tomsett, & Chakraborty, 2018) and propose a framework that binds all stakeholders and involves all stakeholders in the development of AI with responsibility for their systems (Lima & Cha, 2020). However, it is very rare to find publications that define stakeholder categories in a specific sector. Puaschunder (2019) describes perspectives in terms of AI in healthcare, but we found no such analysis pertaining specifically to manufacturing. The added value of the article is the precise definition of AI stakeholder groups in relation to the specific sector of manufacturing SMEs.

The analyses allowed us to determine the importance of individual stakeholder groups in the context of their potential impact on the success of an AI platform (Figure 3). Moreover, the power-interest matrix allowed us to develop strategies to effectively manage all stakeholders in the engagement phase.

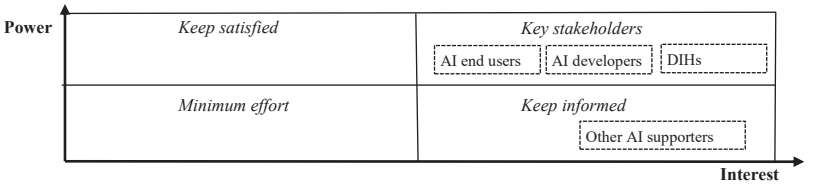
The survey for key stakeholders provided broader and more in-depth information about the problems, needs and expectations formulated and identified during the workshop. We conducted 31 interviews from 1 February 2021 to 11 March 2021. The sample (31 respondents out of 40 contacted) ensured coverage of several European countries per each type of stakeholder: ten SMEs (five Italian, three Polish and two Spanish), eight DIHs (three Italian, two Polish, one Spanish, one Croatian and one Swiss) and 13 AI developers (five Italian, two Polish, two Spanish, one German, one Romanian, one Greek and one Serbian).

The responses of the SMEs determined the companies' readiness for the implementation of AI – more generally Industry 4.0 (I4.0). All but one respondent confirmed the ongoing implementation of technologies in the company, especially the Internet of Things (IoT) as a crucial concept for the future of manufacturing. Seven companies declared implementation of these new technologies in cooperation with other parties. That emphasized the important role of platforms, DIHs and consulting companies in this transition. The average awareness of AI technology in the manufacturing sector was lower than the previous result, with almost a

Research		Workshop
1. AI end users	→←	Users
2. AI leading developers	→←	Technology providers
3. DIHs	}→←{	Innovation and service facilitators
4. Other AI supporters		Knowledge providers

Source(s): Own elaboration

Table 1. Stakeholders' categorization: state of the art vs workshop



Source(s): Own elaboration

Figure 3. Interest-power matrix

uniform distribution on all the levels proposed to the users. Respondents were not entirely aware of the possible opportunities that AI can bring to their companies. The gap between the current and future alignment of AI implementation with the companies' strategic objectives also confirmed it. Half of the interviewees stated that AI would play a major role in their organizations in the coming years in operations, logistics, production and marketing, and thus in gaining a permanent strategic advantage over the competitors, improving the quality, creating new business opportunities or reducing costs. The interviewees agreed that workers would cooperate with AI so that they can complement each other allowing for better decisions and maximized joint potential. The companies that declared collaboration readiness in terms of introducing I4.0 were also ready to collaborate on AI, strengthening the concept of an aggregator of organizations such as DIHs, AI platforms and consultants. Within a two-year horizon, the interviewees expected to improve their knowledge of AI to make up for the lack of experience. As new use cases continue to be developed, more companies will be able to decide if AI could be useful for them and worth integrating it into their processes. The consensus was optimistic, indicating that the respondents were planning to implement AI solutions in their plants in the near future. The potential areas of AI platform implementation included quality and planning improvement ("faster data processing, faster anomaly detection, preventive and predictive maintenance . . ., better planning of resources, better organization and planning of production, forecasting").

The eight DIHs interviewed (three local, two national and three European) showed a good distribution of staff capacity and scope of operations, which allowed them to include different visions and perspectives. However, all the respondents focused their activity on similar areas: IoT, cloud computing, simulation, big data and AI. While blockchain and smart contracts, human-machine interfaces, virtual reality and high-performance computing were somewhat niche. All the respondents declared good awareness of the increasing number of AI opportunities. DIHs are highly motivated to act in this area. All but two of the analyzed DIHs were involved in the development of AI experiments for their associates, with generally successful results. However, several respondents declared that they had to rethink their design of AI operations due to questionable alignment of the solution with corporate objectives. Since all the interviewees expected the demand for AI-related services to grow, they admitted to the existence of certain personnel shortages, particularly with respect to skills such as machine learning, robotics and modeling. Surely, DIHs will need such skills if they are to interface with companies directly and be able to propose suitable alternatives for the future implementation of AI solutions in robotics and autonomous systems, quality systems, production forecasting, monitoring of the human factor and customer behavior modeling. However, most of the interviewees stated that they needed support, especially with activities related to training the employees in addressing the lack of skills of the workers who will use the AI solution, integrating the solution with the legacy IT systems used and finding the proper technology provider. An AI platform can fully support the DIH in overcoming these problems by providing AI solutions, helping with better positioning and network expansion on the European market. The main concerns of collaboration pertain to sensitive data security and sharing. Almost all the respondents stressed this aspect as something that requires efficient handling. All the DIHs emphasized the importance of holistic considerations for ecosystems given the multisided nature of the AI platforms ("all partners . . . should contribute to platform design and operation").

The survey of AI developers provided a better understanding of their AI services, e.g. the development of software models and interfaces and the installation of hardware and sensors for I4.0. Only half of the companies stated that they provide at least one such service at a high maturity level. Thus, not all of them were ready to independently assist SMEs in all the steps of AI implementation. Instead, they had to rely on external assistance from, e.g. AI platforms. Only one respondent declared having an ethics committee in the company focused on AI

usage. Because ethics gains importance (Schiff, Biddle, Borenstein, & Laas, 2019) to ensure the correct use of the worker data, this is a significant shortcoming that requires immediate action in accordance with the applicable European regulations. The respondents focused primarily on ML algorithms, machine vision solutions, human-machine interaction interfaces and neural networks for process modeling. Most of the companies considered after-sales support important and focused in particular on personalized training. However, when the interviewees deploy a solution, it can still undergo modifications as almost all the respondents confirmed they had to rethink, redesign or override the AI applications due to unsatisfactory results or benefits. Half of the companies already use a platform assisting with the integration of their AI-based solutions, emphasizing the necessity of complementing AI developers' service packages, sometimes relying on third-party modules already available on the platforms and creating "kits" in collaboration with other developers. To recapitulate, 11 of the 13 AI developers were in favor of collaborating with platforms as they offer the possibility of reasonably expanding the market share, provide valid market testing for new AI modules and have experience in solving manufacturing SMEs' problems, which can help to steer AI development in more viable directions. Furthermore, AI developers expect new market opportunities but also smoother deployments of their modules ("simplification of the deployment of AI algorithms in the industry, generalization of middleware and AI solutions, integration with several modules, simplification of implementation, e.g. dashboard, persistence").

5. Discussion: good practices and guidelines

The following section presents a discussion on specific guidelines for AI platform managers. First, we divided the relevant challenges into seven main categories (economic, social, ethical, political, legal, managerial, data and technological), as identified in the literature (Sun & Medaglia, 2019):

(1) Social: issues related to existing social norms and attitudes toward adopting AI in the manufacturing sector.

(2) Economic: obstacles to profitability and economic sustainability of AI in manufacturing.

(3) Ethical: challenges related to the moral principles and moral considerations of applying AI to the industry.

(4) Political and legal: issues of political principles, legal regulations and public order influencing the adoption of AI in the manufacturing sector.

(5) Managerial: challenges of an organization's strategy, human resources and management practices for deploying AI.

(6) Data: issues related to data quality and quantity, data security and privacy, data standards and database development that impact the adoption of AI in manufacturing companies.

(7) Technological: the nature and characteristics of AI technology in manufacturing from the point of view of each stakeholder.

We propose sets of guidelines to overcome the identified gaps and various types of challenges based on the performed interviews, in which we directly asked the respondents about these challenges. We assigned the challenges to the categories listed above. It will allow decision-makers to recognize the challenges faster and deal with them more easily. Thanks to it, they will be able to better determine the specific course of action in response to the specific

challenge category. For example, if the challenge pertains to data, the ICT staff should be involved, while if the issue is of an economic nature, it is crucial to include financial services staff.

Table 2 presents several guidelines that can be applied when approaching new SMEs to integrate them into the platform's ecosystem, new AI developers to integrate them into the platform's ecosystem and DIHs to integrate them into the platform's ecosystem.

The guidelines are not exhaustive since the sample was relatively small and the developed framework remains limited to our own perspective. However, they can serve as a starting point for further analysis. We plan to conduct further interviews with stakeholders in the future. The list of identified challenges requires verification to determine whether all stakeholders of the same group share common problems, identify in which areas they struggle the most and indicate what the platform should focus on. Moreover, future research will have to ensure that we did not omit important challenges. Concerning SMEs, many challenges are related to human resources (low awareness of AI possibilities, lack of understanding of AI decisions, lack of skills and skepticism toward new technologies). Therefore, an AI platform will play a very important role in convincing SMEs to consider the possible support offered by the platform's functionalities. An AI platform dedicated to manufacturing SMEs should be user-friendly and do its best not to encourage reluctance/resistance from the staff. Moreover, its operation should not require specialized skills, and the obtained results should be understandable to users. Another issue for SMEs is data (data leaks, lack of access to high-quality private and public data, lack of internal data and data protection laws). Adequate data security and access to datasets by platform users is necessary. The last issue is of a technological nature. The platform should be easily adaptable to the SMEs' existing IT infrastructure. Moreover, SMEs have to be able to understand the technical aspects of how the platform operates. As there are very few platforms on the market offering dedicated AI services for SMEs in the manufacturing sector, we should consider the results presented in this article as a new contribution to the current state-of-the-art. In the literature, we found one paper presenting a conceptual AI adoption model for SMEs (Bettoni *et al.*, 2021). Moreover, we also identified articles discussing the problems faced by manufacturing SMEs in the context of adopting digital technologies (Ghobakhloo & Ching, 2019) or general problems and challenges faced by SMEs in the context of I4.0 (Matt, Modrák, & Zsifkovits, 2020). However, we found no articles that would present guidelines and good practices specifically for manufacturing SMEs wishing to implement AI solutions. The results of our study may be an important step toward implementing the directives and recommendations of the EU, which encourage SMEs to incorporate AI into their activities (Watney & Auer, 2021).

Furthermore, AI developers indicated social, data-related and technological issues. They also mentioned the economic aspect and determined other challenges. Concerning the social category, AI developers found that the key problem was their clients' very low awareness of how they can apply AI in their processes. They also considered finding staff who can work with AI to be a big challenge. Both AI developers and their clients reported problems in this regard. As for the data-related issues, the respondents underlined the importance of data security and privacy. Furthermore, respondents identified issues related to data ownership as important. In the technological category, AI developers indicated that integrating AI with other modules and middleware control is a very important challenge. AI developers considered it important to have sufficient IT infrastructure compatible with AI technologies. Moreover, they raised the issues of intellectual property and costs (the cost of development/adoption of an AI solution and the cost of adapting operational processes). Although scholars list the category of AI developers as one of the main stakeholders in the context of AI (Meske *et al.*, 2022), we distinguished only the quality criteria that this group should meet. While, the importance of AI developers is not debatable in the context of AI creation and propagation

	Challenge	Category	Guidelines for AI platforms
SMEs	Low awareness about AI opportunities provided for the manufacturing sector	Social	Provide an effective dissemination of the services, the products and all the aftersales to attract new companies
	The misuse of data with the huge amount of information that AI algorithms need	Data	Secure SMEs' trust by the provision of a very clear and easy-to-understand data management
	Difficulties within companies to support the implementation of AI with proper training which can be effective for the company workers	Managerial/ Social	Understand the skills of each worker and propose a personalized training path is of primary importance to differentiate the offer from the other platforms and attract SMEs
	The mechanism to eliminate threats to data security and privacy and cyber-attacks derived from the sensible data that the AI algorithms are processing	Data	Emphasize data protection; constantly update conformance with new European laws in the field
	Lack of concrete use cases of companies that perform in the same sector with successful results	Managerial	Provide a section with videos and experiences of users that already joined the platform and implemented some solutions
	Difficulties in finding which technology is the best in accordance with the problem of the company	Social/ Technological	Start the proposed solution from the analysis of the critical issues leading to the identification of the best AI technology to deploy, and not from the technology
	The lack of skill is often a barrier to approach AI adoption	Managerial/ Social	Provide solutions easy to use and also support the SME in all the steps from selection and implementation till continuous improvement; offer-dedicated trainings tailored to the needs of the specific organization
	The necessity to understand the logic behind the AI algorithms	Managerial/ Social	Offer a package of offerings that provide some explanations (tutorials, how to interpret results)
AI developers	Quite low market size of their existing solutions is quite low	Economic	Create an ecosystem with DIHs, companies, and potential customers that are interested in implementing new AI technologies
	Low integrability of the AI solution with the specific platform infrastructure	Technological	Provide minimum requirements that the solution needs to meet to be uploaded in the platform infrastructure
	Low integrability of the AI solution with the modules of other developers	Technological	Provide a common framework for the development of the AI solutions
	The low awareness of the needs of the manufacturing companies	Managerial	Understand the needs of companies and communicate to the developers the most recurrent needs on which they can focus; provide a section with videos and experiences of users in the manufacturing world
	Difficulties in hiring staff with the right skill	Social	Create services supporting AI developers in this context, including training about the platform itself

(*continued*)

Table 2. Guidelines

	Challenge	Category	Guidelines for AI platforms
	The lack of skill/knowledge regarding AI and programming among the staff of potential customers	Social	Assign to each company a person (one from each organization involved in implementation) in charge of assisting and helping with the implementation of the solution
	The high cost of the development of a single AI solution related to the number of customers that use it	Economic	Allow to start from a general version of the solution, and personalize it at a later stage
	The intellectual property of the AI solutions	Political and Legal	Include clear IPR management rules and communicate them directly online
DIHs	The lack of skills/competences to deal with technologies such as AI	Managerial	Include services to enrich the pure platform features with the support in this context, including offer of trainings, mentoring, and tutoring along AI implementation (especially in early phases) to limit the risks of insufficient competences
	Relatively small network/ecosystem of partners (AI developers and SMEs)	Social	Involve more AI supporters than just DIHs, including the academia and consulting companies
	Not recognized reputational risk if the platform is reliable and trustworthy	Ethical	Provide documents that certify the commitment of the platform and the results obtained to be of high quality
	The difficulty in understanding what each AI solution does and understanding if the platform can be a solution to the company's needs	Managerial	Provide a package of offerings that include some explanations as tutorials for each AI solution
	Reputational risks in using AI	Ethical	Provide materials and online training sessions in this matter, involve professional ethicists/ philosophers of science and technology on this issue

Table 2. **Source(s):** Own elaboration

(Lima & Cha, 2020; Preece *et al.*, 2018), we found it difficult to find guidelines and best practices for this category of stakeholders in the literature. We may conclude that the challenges faced by AI platforms oriented toward applications dedicated to manufacturing SMEs are similar from both AI developers' and SMEs' perspectives.

We found DIHs to be by far the most demanding (the holistic character of the challenges of a broad and strategic nature), because they often serve as an intermediary between AI solution providers (e.g. AI developers) and their end users (e.g. SMEs). DIHs want solutions satisfactory from both the supply and demand perspectives to be developed in all significant areas. However, the most important challenges seem to stem from the cooperation between entities related to AI and the transition from the testing phase to the exploitation phase of AI solutions. The role of DIHs in supporting SMEs in the implementation of AI is critical as the basis of the "value delivery system" (Jurčić & Strahonja, 2021). Given that a program has been launched with a view to establish DIHs in Europe, they will become the most important bridge between AI developers and SMEs (Hervas-Oliver *et al.*, 2020). Undoubtedly, the EU policy aims to make DIHs play a leading role in the companies' digitalization (EU, 2019, 2022). However, precise guidelines and best practices for supporting SMEs in implementing AI are

still lacking. Policymakers could consider the above challenges so that they provide better support for the improvement of the relatively new DIH's ecosystem effectiveness. The social and ethical challenges are particularly important areas that require the support from policymakers, who could use these conclusions when considering specific goals, e.g. funding measures.

AI developers do not see barriers but challenges. This trust in their capabilities to overcome most issues is contrary to other stakeholders and requires further exploration. All stakeholders highlighted costs as an important factor. Meanwhile, SMEs do not expect explainable AI. They are willing to adopt AI with no deep understanding of its algorithms but only if it is demonstrably effective. It seems that simulation modeling could provide support in such a case.

6. Conclusions

The diffusion of multisided platforms makes it reasonable to direct scientific attention toward approaches that their managers can employ to attract and engage stakeholders. In this article, we focused on platforms aimed at facilitating the adoption of AI solutions by manufacturing SMEs. We conducted an in-depth investigation to identify the main stakeholders that needs to be taken into consideration as well as the challenges they face when interacting with each other within the same ecosystem. We performed a two-level analysis with this goal in mind. First, we provided a literature review for a better insight into the level of maturity of the topics. This allowed us to identify different perspectives from which we analyzed stakeholders. Second, we collected empirical data to further confirm the list of AI platforms' primary stakeholders and explore the challenges they face in actual operation. When we identified the main issues preventing successful AI adoption, we could develop guidelines that should support platform managers in preparing dedicated service bundles for the respective types of stakeholders. The implications for different national and regional economies would presumably differ depending on the economy's structure. This constitutes further potential for studies that would be interesting for policymakers and practitioners.

One limitation relates to scarce topic representation in scientific literature, which forced us to rely on secondary sources in the first stage of the study. In this context, we recognized the importance of grey literature and partially addressed it by using the Google Scholar search engine. However, to fully eliminate this limitation, we would have to further explore white papers including governmental and non-governmental reports, consulting reports, professional websites, etc. Thus, this is one of the further research directions. As we were aware of the discussed limitation, the study also entailed an analysis of primary data collected from stakeholders during dedicated workshops. This corroborated our findings from the review of literature that was not always directly linked to the manufacturing domain. However, we need to acknowledge the potential subjectivity of the participants involved as well as the fact that our scope regarded only the European perspective. To further reduce said limitations, we conducted in-depth interviews using the computer-assisted telephonic interviewing approach to obtain qualitative insights into the subject matter. This facilitated a more detailed discussion but could not change the strictly European scope of our considerations, which means that the respondent population did not include many world economies. The sample size partially resulted from the need to finish the activity within the given period, but future research should consider a better coverage of all European economies (and possibly even going beyond Europe in later future).

We adopted the scientific approach to explore a research topic that remains largely immature. This analysis contributes to the spread of scientific interest in the AI multisided platform and other dissemination activities (traditional media, social media, fairs, exhibitions, etc.) support this goal. The final set of guidelines needs validation against additional

empirical data. A mapping of the services offered by different platforms considering the identified guidelines constitutes a promising analysis direction. The results presented can be useful not only for the specified stakeholder groups but also for others included in the AI platform ecosystem (e.g. owners, partners, peer producers, peer consumers). It is very important to understand how to create and offer services with added value for platform users. The defined guidelines will also help the developers of AI platforms identify key relationships, transactions and channels through which key services can be rendered. Impacts of AI on the operations of SMEs are growing (EY, 2018; McKinsey, 2020; BeyondMinds, 2021). Therefore, developing guidelines for potential users is becoming increasingly important so they go through the AI adoption process as smoothly as possible. Importantly, the EU and national policymakers can also benefit from the results as they are responsible for AI development programs and industry transformation (EU, 2022). We may base it on the experience of similar programs launched in the USA (Beckmann *et al.*, 2016). A properly constructed AI development strategy requires recommendations directly from companies (bottom-up approach) (Hansen & Bøgh, 2021). Only then, there is a chance that politicians will correctly understand companies' expectations of AI (Dignum, 2019). Our research results presented constitute a good preliminary contribution to this topic.

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