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AI in Manufacturing - Business Models for Platform Ecosystem Stakeholders

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Abstract: This paper presents the preliminary findings from a H2020 funded knowlEdge project that is focusing on developing AI solutions and their marketplace for the manufacturing sector together with the related business models. The key findings regarding the business models are presented using the developed marketplace platform canvas as a framework. Compared to the traditional software business, AI solutions business seem to require much more human support. Also, data sharing between the customer and the AI service provider is often required. These are some of the AI application specific issues that need to be considered when developing the business models of different stakeholders in the AI marketplace ecosystem.

Keywords: Business models, Artificial intelligence, AI marketplace, Business networks, Business ecosystems

1 Introduction

The paper focuses on business model perspective of AI application in manufacturing context from different stakeholder perspectives. Recent studies suggest that AI implementation in manufacturing is still in the early phases of development. Companies are exploring the opportunities of AI in their core processes, as well as its impact on business models. Value from AI is typically created through increasing the intelligence of the processes, focusing mostly on quality control and predictive maintenance. Major challenges of implementing AI solutions are identification and development of AI related capabilities and employee competences, as well as data availability. Value capturing is challenging, as the AI implementation typically requires several service providers, creating costs that must be balanced with perceived benefits.

2 Theoretical background

AI is fairly new technology that is still in the early phases of implementation in manufacturing context. Thus, research-based knowledge is limited as well, especially regarding the connection of AI and business-model innovation in industrial ecosystems (Burstom et al, 2021; Bretones Cassoli et al, 2021).

AI and business models in manufacturing

According to Burstrom et al (2021), firms in the manufacturing industry are in the exploration phase of AI opportunities, and there is only preliminary evidence about theory development on combining AI, business models, and ecosystems. Burstrom et al (2021) studied the AI related business model innovation from three perspectives: 1) value creation designs, 2) value delivery, and 3) value capture mechanisms. From value creation perspective the main new source of value creation is quality control by using digital AI technologies. Bretones Cassoli et al (2021) consider different predictive maintenance concepts as one promising area to create value from AI solutions. From value delivery perspective a major challenge concerns the development of new technology-based capabilities and employee competences, as well as ensuring data availability (Bretones Cassoli et al, 2021). From value capture perspective Nguyen et al (2021) emphasise the creation of incentive mechanisms to engage different stakeholders to collaborative development and training of AI models. According to Björkdahl (2020), manufacturing incumbents have mainly pursued cost reduction through efficiency improvements, and far less used AI to drive revenue growth.

Manufacturing incumbents are currently developing several AI functionalities such as forecasting, monitoring/controlling, optimizing, and autonomy, but there is a significant difference in the utilization of these business applications (Burstrom et al, 2021). Although AI has been deployed in different business functions, manufacturing companies have focused more on the core production processes. Forecasting and monitoring/control applications such as predictive maintenance applications (Bretones Cassoli et al,2021)) have reached a more mature stage of development, while optimization and autonomy functionalities are still in the exploration stage.

According to Burstrom et al (2021) incumbents are also increasingly trying to develop multiple AI functionalities in parallel, unlike single functionality aims reported in earlier studies. However, AI applications have not yet disrupted major parts of the manufacturing industry (Burstrom et al, 2021). Small-scale AI innovations in collaboration activities are performed with various ecosystem stakeholders - such as developer communities, research institutes, academia, and customers - in order to identify a competitive edge through AI (Bretones Cassoli et al, 2021; Metelskaia et al,2018). According to Burstrom et al (2021), AI has not yet brought a decisive competitive advantage to incumbents in the manufacturing industry, but it is seen as a competitive requirement.

Business models for AI developers

Faggella (2021) has conceptualised 5 different business models for AI solutions providers. Four of them are shortly presented below, the fifth one i.e., the platform business model is presented in more detail in the next chapter. Faggella (2021) makes the distinction of product models and services models, the former being based on providing AI technology solutions and software, the latter being based on providing AI consulting services. *AI SaaS Product Vendor* focuses on offering solutions that operate on top of existing systems with minimum tailoring and integration. This model does not require AI competencies and maturity from customers. SaaS concept entails that subscription fee revenue models are often used (Faggella, 2021). *AI Product Vendor* offers solutions that integrate with client systems and use client data. Integration is more challenging than in

SaaS model, requiring longer pilots, more hands-on integration, and maintenance. AI maturity on customer side is necessary (Faggella, 2021). *AI technical and management consulting* model offers the combination of the widest range of surface-level AI tools and SaaS integrations, or consulting and strategy work, or longer-term AI maturity at a technical level, i.e., data/IT infrastructure. With broad offering AI technical services firms with management consulting capabilities aim to become a long-term “AI partner” for the customer (Faggella, 2021). *Management consulting* business model aims to advise customers on strategy, education, and process development, but not hands-on technical AI work. Strategy or management consulting firms, like their technical consulting counterparts, aim to become a trusted “AI advisor” to their clients, but lacking the ability to deliver short-term AI pilots/products (Faggella, 2021).

Casado & Bornstein (2020) emphasize that most AI systems currently available are not quite like software in the traditional sense. AI solutions involve ongoing human support and material variable costs and often do not scale as easily as traditional software business. This implies that Casado & Bornstein (2020) seem to consider that typical AI business model is close to the AI product vendor category of Faggella (2021). This is in contrast to Metelskaia et al (2018), who a couple of years earlier foresee that, comparing to traditional software ventures, AI as SaaS models and their variations would become more popular. These contradicting perceptions perhaps give minor additional confirmation about the immaturity of AI services provisioning.

Trying to bridge technological solutions and their application Metelskaia et al (2018) presented a business model canvas for AI solution developers emphasizing the start-up perspective. According to Metelskaia et al (2018) the customer segments for AI are very diverse and difficult to identify, especially for small start-ups. Considering the start-up context, they add one unique potential business model that focuses on technology development and aims for selling the whole company to other larger enterprise.

Business models for AI marketplace

Marketplaces are considered as an essential tool to support the diffusion and scalable deployment of AI models (Kumar et al, 2021; Nguyen et al, 2021, Xu et al, 2019). Though existing software and application marketplaces can be used as a reference for AI marketplaces, there are differences. AI solutions typically require data sharing from customer, which could require mechanisms to secure confidentiality. Additionally, AI marketplace should have a mechanism to determine the quality and trustworthiness of the AI models (Kumar et al, 2021). As AI models often require maintenance during their life cycle and the original AI model developers may not be available anymore, AI marketplace needs to provide guidelines to developers to support AI model maintenance by other AI developers (Kumar et al, 2021). Nguyen et al (2021) recommend paying attention to valuation methods of the AI models and collaboration incentives for different stakeholders in model training. Concepts such as decentralized marketplace structures with Distributed Ledger Technologies and Federated Learning concepts have been developed to overcome the challenges of AI marketplace development (Kumar et al, 2021; Nguyen et al, 2021).

According to Kumar et al (2021) most of the currently available marketplaces are still under development and their underlying technical details and functionalities are not public. Most of the marketplaces are proprietary and are based on a centralized architecture. Fixed price per model is the predominant pricing model.

Regarding future developments, Kumar et al (2021) found that many of the marketplaces aim to solve the current bottlenecks in model availability. These efforts include e.g., developing interoperability standards for AI development, reputation systems to rate AI developers and companies, signalling malicious AI models and informing developer quality. In addition, several marketplaces are developing data sharing frameworks to integrate data from separate databases and to create unified virtual data stores for use in model training.

3 Methods

The research was based on participatory observation where the researchers took active role in facilitating the development of the business models. A task force was formed consisting of three industry partners and three AI technology developers. After the researchers' preparation work and methodology development the process continued with monthly or biweekly discussions with the task group. Altogether there was 9 task group meetings. Business model canvas (Osterwalder et al, 2010; Ovans, 2015) and platform canvas (Allweins et al, 2021) were used as frameworks to facilitate the work. Based on the discussions three generic stakeholder perspectives on the business models were created: 1) marketplace perspective, 2) AI technology provider perspective, and 3) manufacturer perspective.

A survey was carried out among the relevant project partners to collect their initial views on the different aspects of the business models. Limiting to 10 partners only, the survey may not give statistically relevant results for broader discussion but provided ground to elaborate the business models further during the rest of the project.

In this paper we present selected findings from the task group development work and the survey using the marketplace canvas as a framework. More detailed results can be found from the project deliverable D9.3 publicly available at knowlEdge project website (2022).

4 Findings

Following business models were drafted in the first half of the project. *The marketplace business model* gives an overall view on the business relations between the different stakeholders. *Marketplace operator* and *AI technology provider* related business models focus on these actors specifically. Two separate business models were also created for *manufacturers*, the other taking a bit visionary perspective of manufacturer as AI prosumer, i.e. providing trained AI models to other manufacturers.

Marketplace business model canvas

Marketplace is the central activity connecting the inputs and outputs of different stakeholders together. Its business model canvas is presented in Figure 1. Selected findings relating to the different elements of the canvas are presented in the following sub-chapters.

Stimuli				
Opportunities to trade your AI models and Solutions		Promoting AI models exchange		Explore and purchase AI Models for your business needs
Producer segments		Interaction		Consumer segments
<ul style="list-style-type: none"> Software Developers Data Scientists Researchers Manufacturing companies as prosumers 		<ul style="list-style-type: none"> consumers provide their business needs and requirements, and domain expertise producers develop and provide AI solutions for the above needs 		<ul style="list-style-type: none"> Large Enterprises and SMEs from Industrial Sector Researchers and Data Analysts
Producer substitutes	Producer value propositions	Facilitation		Consumer value propositions
<ul style="list-style-type: none"> Other developers, scientists and companies producing AI models for industries IT consultancy firms (e.g. Accenture). in-house expertise. 	<ul style="list-style-type: none"> Access to an established Marketplace for AI models Reliable Transaction procedure based on Blockchain Easy to use interface for uploading your models 	<ul style="list-style-type: none"> Web Interface Decentralized Marketplace based on Blockchain Advanced Search and Recommendation functionalities Download/upload AI Models Protection of personal information 		<ul style="list-style-type: none"> Large variety of AI models Easy to use interfaces Secure purchasing mechanisms
Metrics				
<ul style="list-style-type: none"> Number of contributors Number of AI models and solutions 		<ul style="list-style-type: none"> Number of total users Number of interactions/exchanges/purchases 		<ul style="list-style-type: none"> Number of consumers/customers
Cost model			Monetization	
<ul style="list-style-type: none"> producer and consumer acquisition costs (stimuli), salaries for marketplace maintenance and customer and producer support, technology costs (e.g. cloud services) 			<ul style="list-style-type: none"> Premium Membership - Free of charge for knowlEdge consortium members Advertisement Services Low Platform Commission 	

Figure 1. Marketplace business model canvas (Knowledge project deliverable D9.3, 2022).

Interaction

Regarding interaction, the consumers (i.e. manufacturing companies) bring to the marketplace their business needs and requirements, which they can solve by collaborating with the producers (AI technology developers), who have the capabilities to develop and provide AI solutions. Another value co-creation opportunity is for consumers to provide their use-case trained AI models to other AI developers as well as other consumers (manufacturers).

To compose an overview on how the partners see the interaction between producers and consumers most likely happening, 5 different interaction scenarios were formulated in the task group, which were requested to be put in the order of preference (3 most preferred) in the survey. The scenarios were:

- Scenario 1: A company has a description of a target problem and a data model and wants to rent computing time in knowlEdge for using a model (automatically recommended by the platform) without having to share their data.
- Scenario 2: A company has a description of a target problem and a data model and wants to run, in their edge platform, a model provided by knowlEdge (automatically recommended by the platform) without having to share their data.

- Scenario 3: A company has a description of a target problem, a data model and actual data and wants to rent computing time in knowlEdge for using a model trained using this data.
- Scenario 4: A company wants to rent (in a secure way) the usage of their own data, so that knowlEdge can use it to train and improve models.
- Scenario 5: A software development company wants to develop a new method to become available in the knowlEdge marketplace.

The results of the survey on the most preferred interaction scenarios are presented in the Figure 2. Scenarios 2 and 1 were the top selections, suggesting that partners prefer models, which don't require sharing of data.

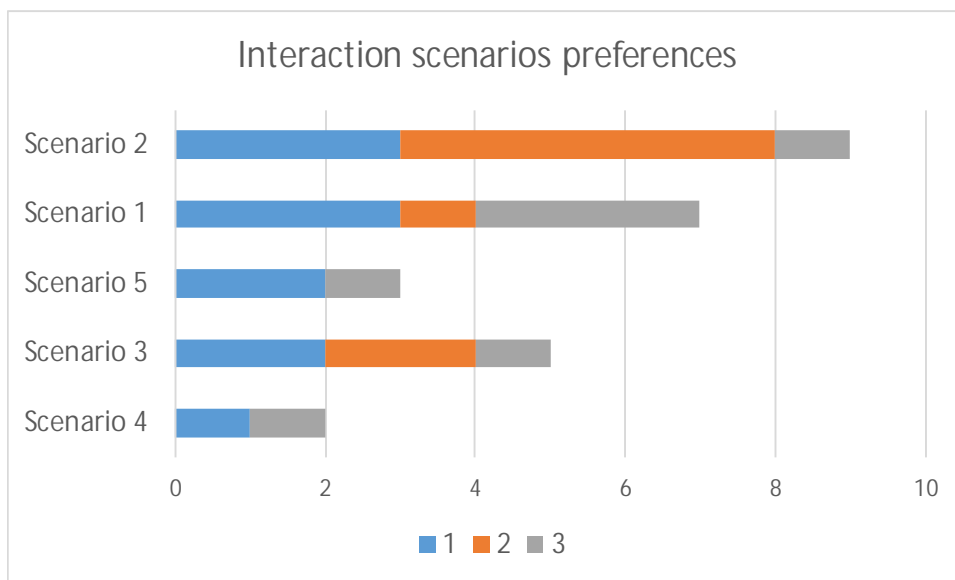


Figure 2. Most likely interaction scenarios for the marketplace producers and consumers according to knowlEdge business model survey (Legend: 1 = selected as no 1, 2 = selected as no 2, 3 = selected as no 3).

Consumers and producers

The consumer element includes end-user companies for AI solutions, typically manufacturing companies in various industrial sectors. The producer element includes different kind of AI solutions providers, e.g., software developers, IT service providers, and academic technology developers. Particularly interesting idea identified was a producer group (manufacturers) that could provide the AI models or data sets they have trained in their business context for others to use, a kind of prosumer model (producer-consumer).

Figure 3 shows the results of the survey on the potential target consumer groups for knowlEdge marketplace. As expected, manufacturing companies are the main target. Some manufacturers pointed out that they often buy IT services from dedicated IT service providers and that the AI solutions could be purchased similarly. Interestingly,

this option did not get support in the survey. Nevertheless, this may be important to consider.

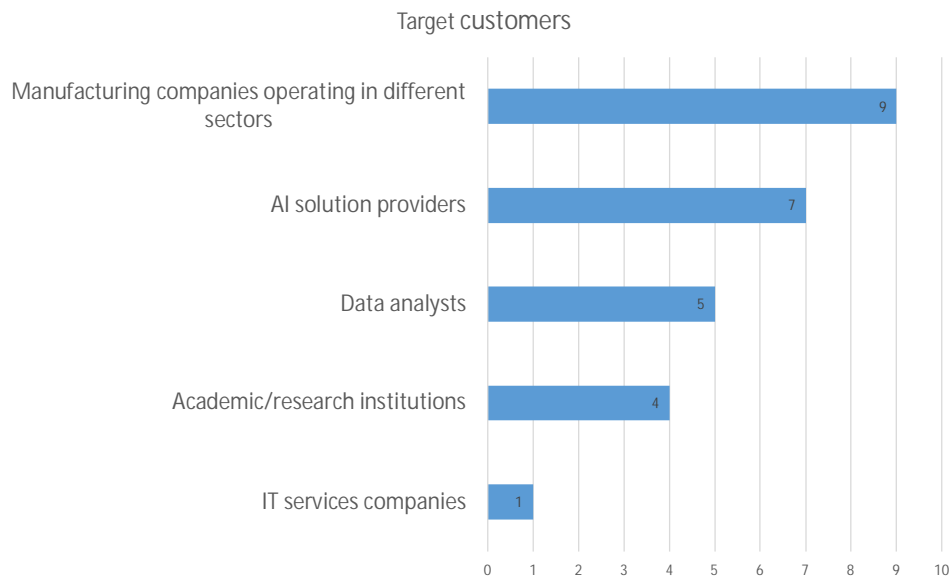


Figure 3. Survey results on the potential target customers for knowlEdge marketplace.

Consumer and producer value propositions

For the consumers (i.e. manufacturers) participating to the marketplace provides an opportunity to improve and optimize the efficiency of their production processes, as well as enhancing their quality control and management. Applying the AI models and algorithms render their operations more reliable and economically profitable.

The producers (i.e. AI technology providers) are able to sell their easy-to-use, trustworthy and tailorable algorithms and models in order to help customers' business to improve and grow. Basically, their value proposition is to help solve the process improvement needs of the manufacturers. One interesting finding was that many partners aim to provide AI related consultation services alongside AI technology solutions, which was perhaps not anticipated when business model discussions started.

The project partners were asked to indicate their business model preferences in the survey (Figure 4). The business model options in the survey were based on the 5 categories of Faggella (2021). AI software provisioning either with SaaS model or software product model are naturally most preferred, but many partners aim to deliver AI related technical consulting as well.

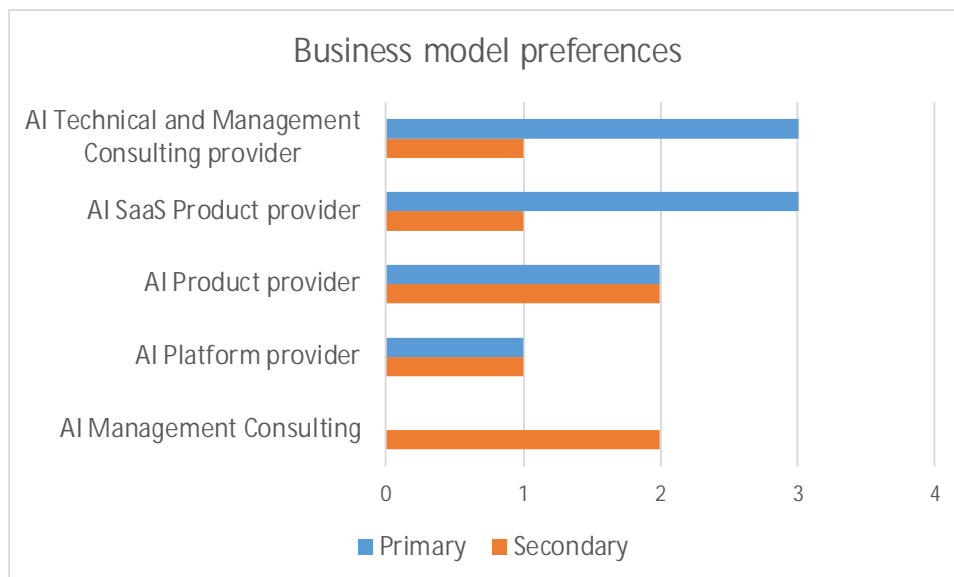


Figure 4. Business model preferences indicated by the partners in the survey.

Facilitation

The marketplace provides the following services that facilitate the exchange between the participants: easy-to-use interface with upload and download functions for AI models and datasets, search algorithms and filters for consumers to browse the marketplace offering, recommendation system for consumers to rate the products and services, and payment mechanism to purchase products and services. The marketplace governance is yet to be decided, potential ideas are to form a joint venture or that one of the partners takes the role of marketplace operator.

Consumer and producer substitutes

For producers, substitutes can be other AI marketplaces where they can offer their products and services. Also, substitutes can be any IT firms offering their services to manufacturing companies that are searching AI solutions. Additionally, if the customer has adequate competences, the producer can provide the services directly to the customer. Consumer substitutes are all those products and services that may cater to consumers' needs outside the knowlEdge marketplace.

Metrics

Preliminary performance and financial metrics for different marketplace actors were identified and are presented in the Table 1.

Table 1. Preliminary performance and financial metrics developed for the marketplace actors.

<i>Actor</i>	<i>Performance metric</i>	<i>Financial metric</i>
Marketplace	No. of total users (producers and customers)	Amount of sales and the amount of transaction fees incurred (€)
	No. of interactions/ ratings/ exchanges/ purchases	Costs of maintaining the marketplace (€)
Producers	No. of contributors	Amount of sales (€)
	No. of AI models and solutions	Costs of sales
	Recommendation rating from consumers	Profit (€), profitability
Consumers	No. of consumers	Amount of purchases (€)

Monetization

The project partners prioritized different pricing models in the survey from their perspective (

Figure 5). Software licensing and subscription fee models were the most preferred. Additionally, many partners aim to get revenue from AI implementation related services. No one was considering advertising-based revenue model.

Cost models were not considered at early stage of the project. Some general fixed cost categories were identified, e.g. producer and consumer acquisition costs, marketplace maintenance salaries, customer and producer support, and technology costs.

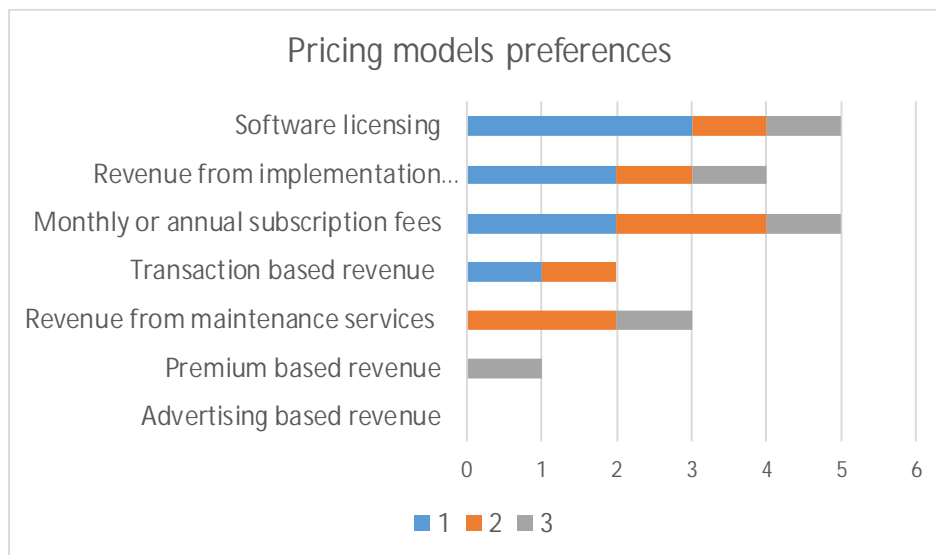


Figure 5. Partners' preferences regarding the pricing models (Legend: 1 = selected as no 1, 2 = selected as no 2, 3 = selected as no 3).

5 Discussion

AI utilization in manufacturing is still in its early stages. Companies see AI providing big opportunities for process improvement and business development and are currently making the first AI experimentations and implementations to find out how to best take advantage of it. From business development perspective there is currently more expressions of expectations rather than actual results.

Introduction of AI technologies changes the business environment. Each stakeholder in various business networks, value chains and ecosystems need to reconsider and revise their strategies to include the potential impact of AI (Reim et al, 2020). In manufacturing context, we have identified following key stakeholders or actors: Manufacturers as AI users, AI technology developers as AI solution providers, and AI marketplace as a connector of the previous actors. For each actor type we have identified a couple of alternative roles depending on their potential interests and business ideas regarding AI use or offering. For each of the different actor types and their roles we have developed preliminary business models using the Business model canvas and Platform canvas as base frameworks. These preliminary business models will be refined in the latter part of the project.

One interesting finding has been that many technology developers aim to provide AI related consultation services alongside AI technology solutions, which was perhaps not anticipated when business model discussions started. This seems to confirm the earlier research findings that AI deployment requires more human effort than traditional software business. This is further confirmed by many partners aiming to get revenue from implementation services. This is also in line with the findings from earlier studies. Regarding pricing, the partners find software licensing and subscription fee models most preferred, which contradicts e.g., Kumar et al (2021) finding that fixed pricing per model is dominant.

The different actor types and their various alternative AI offerings and AI uses may form a network where most likely each actor must consider several different business models for different business situations. One major consideration is the relationship of the marketplace both with the AI users and providers, e.g., on the division of responsibilities. The technological concept aims at the decentralized structure, but from business perspective there may be a need to have one actor in central role (e.g. as a marketplace operator) in the network. This issue is still open and will be considered in the latter part of the project.

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