ARTIFICIAL INTELLIGENCE IN THE AGRI-FOOD INDUSTRY

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Abstract

The agri-food industry faces productivity challenges due to low levels of automation and a lack of innovative solutions. Artificial intelligence can become a tool to meet these challenges. Existing artificial intelligence solutions are already inevitably changing the agri-food industry. This technology is evolving rapidly and its range of applicability is expanding. The article presents an analysis the model of Benefits, Organizational Readiness and External Pressure (BOE) application to artificial intelligence in the agri-food industry. The model constructs – farm readiness, perceived benefits, external pressure– are analyzed in the agri-food industry. Growing investment in technological innovation in the agri-food industry shows that farms are organized to adopt artificial intelligence technology, realize the benefits, and external pressures accelerate the adoption of this technology. Financial resources are often identified as a major barrier to the use of artificial intelligence on farms, but the lack of financial resources can be overcome as an alternative to new business models in the agri-food industry.

Key words:
Agri-food industry, artificial intelligence, new business models

JEL Classification Q01, Q16, Q18 https://doi.org/10.52665/ser20220201

Introduction

The agri-food industry is complex, challenging a wide range of processes and operations, but is largely inefficient. The agri-food industry faces challenges to increase productivity, and this industry needs innovative solutions. The intensity of agriculture is low, due to the insufficient level of automation and the lack of innovative solutions. There are many stakeholders in the agri-food industry - growers, producers, trade representatives, and national policy-making corps - so it is important to set goals and challenges for sustainable solutions, and technology is one of the tools to achieve these goals. Technology is a key tool in the digitalization of agriculture, and technological tools have already been developed to monitor processes in real time, streamline interventions in agriculture and calculate reasonable costs. Technology can drive the agri-food industry to become more productive, improve the sustainability and management of agriculture. Artificial intelligence technologies can be rapidly integrated into agriculture due to their wide functional range. The cost of artificial intelligence technologies and solutions in agriculture is projected to increase from $ 1 billion USD 2020 up to 4 billion USD in 2026, reaching 25.5 percent overall annual growth rate (Markets and markets, 2021). In 2016, the European Commission launched the Digital Initiative for European Industry to strengthen the competitiveness of the European Union. Artificial intelligence is considered to be the most important moment in the digital transformation, which is why the application of artificial intelligence in the European Union has been identified as a priority for a decade. Artificial intelligence can help farmers work more accurately, efficiently and sustainably. Big data-based decisions can make decision-making easier and make farming more attractive to the younger generation.

Literature overview

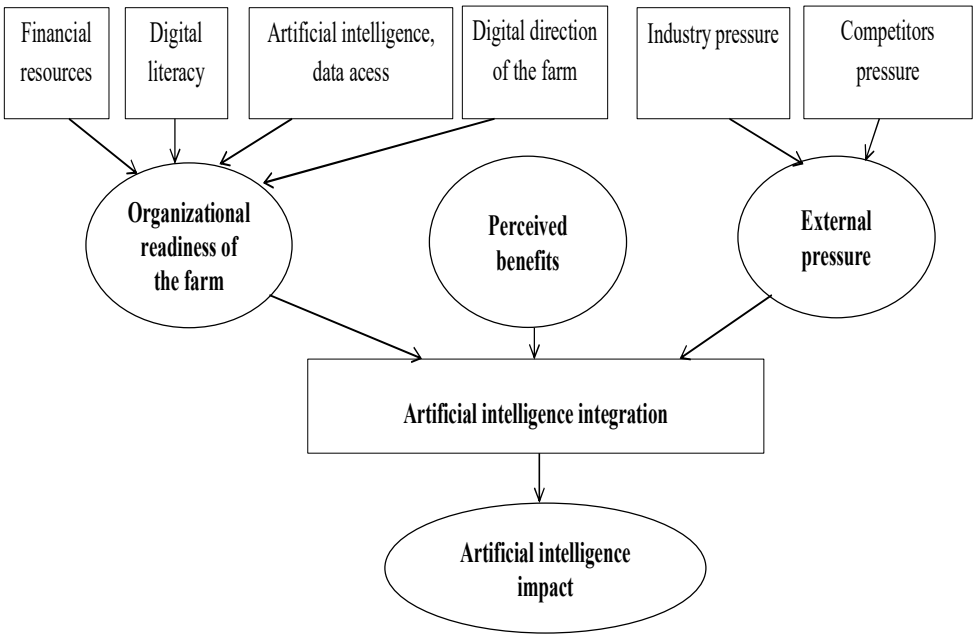
For the development of artificial intelligence, countries are developing initiatives, strategies, and guidelines for setting out how to create an artificial intelligence system that defines what constitutes artificial intelligence, but there is no consensus on how to define artificial intelligence (Brachman 2006; Nilsson, 2010; Monett and Lewis, 2018).). In the definitions

provided in the Country Strategy Papers, it is possible to single out repetitive keywords which describe artificial intelligence as *systems, autonomous (self-contained), intelligent or demonstrating intelligent suitability, ability to analyze, perform tasks, ability to learn*. Consistent with these keywords, some researchers also define artificial intelligence as information processing systems capable of correctly interpreting external data (Haenlein and Kaplan, 2019; Scotti, 2020), learning from such data (Haenlein and Kaplan, 2019), making decisions (Scotti, 2020), the flexibility to achieve specific goals or perform tasks (Haenlein and Kaplan, 2019; Wang, 2019).

Artificial intelligence in the agri-food industry offers new opportunities to gain and maintain a competitive advantage. The development of artificial intelligence technologies in the agri-food industry is leading to new business models that can compensate for the limited financial resources of farms. **The subscription business model**, with the help of artificial intelligence algorithms, gives the farmer the opportunity to test both software and hardware or mechanisms. The farmer does not acquire ownership of this software or hardware, but pays a periodic fee for its use. This business model removes barriers to testing the latest artificial intelligence solutions on the farm when the farmer lacks financial resources, leaving the option to unsubscribe if services, equipment, devices, machinery or software do not meet the farmer's expectations and needs. Feedback from farmers is also important in this model. Manufacturers of hardware or software receive feedback on their product or service through the data they collect, so they can continually improve functions; adjust processes to suit the needs of the economy (Berlin et al., 2020). **Pay-per-use business model** provides access to specific services, such as crop or soil maps. The recognition tool with an artificial intelligence algorithm records how many times the service has been used and automatically generates a bill for usage per month. The recognition tool itself is available as an online service, so the farmer does not need any additional software to use the service (Berlin et al., 2020). **Pay-per-performance business model** offers farmers to pay for the actual production, for example: a farmer no longer buys a combine but pays for a harvest over a period of time. The owner may offer the hardware or machinery on a performance basis, assuming the risk of maintaining the hardware to ensure its operation. In this type of business model, agricultural services can be offered that ensure proper soil properties or animal nutrition. Small robots or drones can also be offered according to this model (Berlin et al., 2020). When farmers purchase expensive hardware or software, they often do not use the maximum capacity of the equipment, so **the asset-sharing business model** provides the opportunity to share such equipment. Excessive capacity of equipment, machinery or software is shared to enable the acquisition of state-of-the-art solutions in the absence of equipment on the market that meets the needs of the farmer. The asset-sharing business model involves the sale of additional capacity back to the market. The sharing business model is implemented on the principle of an online platform, where artificial intelligence algorithms can determine when equipment is free and offer it to the nearest farmer (e.g., Hello Tractor app) (Berlin et al., 2020).

Although artificial intelligence enables agri-food industry players to be more productive, new business models make up for the limited financial resources, but the integration of artificial intelligence in the agri-food industry faces challenges. The Benefit, Organizational Readiness and External Pressure model is used to understand the application of artificial intelligence in the agri-food industry (Fig. 1).

Figure 1. The Benefit, Organizational Readiness and External Pressure (BOE) model in agri-food industry



1995 to understand the application of electronic data interchange) technology in small and medium-sized businesses. Later, the model was used to understand the application of various technologies, and in 2019 the BOE model has been adapted to artificial intelligence (Iacovou et al., 1995; Mehrtens, 2001; Dasgupta and Wendler, 2019). The BOE model consists of three main factors: perceived benefits, organizational readiness, and external pressures. In the agri-food industry, the constructs of the BOE model - farm organizational readiness, external pressure - are supplemented with substructures that detail the main factors.

Results and analysis

In the agri-food industry, the central axis of the application of artificial intelligence is the farm, so the organizational readiness of the farm is important. The behavior of artificial intelligence technology application on the farm is determined by financial resources, digital literacy, artificial intelligence solutions, data access and the digital direction of the farm.

Financial resources enable the farm to integrate artificial intelligence, but budget constraints may prevent investment and retraining of farm workers (Dasgupta et al. 2019).

The limited financial resources on the farm can be offset by new business models that are also based on artificial intelligence systems. In the agri-food industry the production is affected by the seasonality that determines natural conditions, so sharing business models can compensate for expensive investments in artificial intelligence systems. New business models based on artificial intelligence provide farmers with access to expensive hardware or software without acquiring ownership. Owners of agricultural equipment and machinery are connected with the help of an artificial intelligence app to farmers who do not have such machinery, and it is possible to manage e. trade, consumer analysis.

Digital literacy is important for new business models. Digital literacy not only captures the level of technological expertise, but it is important to assess the level of technology management and support for the use of

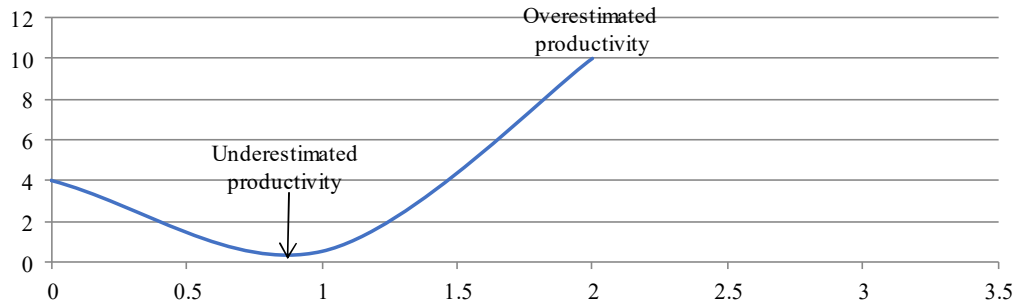
technology to achieve organizational goals (Chwelos et al., 2001). Farmers, although acquiring digital literacy, are not always inclined to adopt digital technologies, with low levels of support for the use of technology. This situation is determined by several factors - conservative approach to farming as a business, application of innovations in agriculture, lack of incentives from state institutions, uncertainty about legal regulation. A limited understanding of the possibilities of artificial intelligence does not provide a clear digital direction for the economy. In the absence of clear leadership in agri-food organizations, organizational structures are limited to the silos of the organization, i. y. the sharing of information, acting independently is avoided, so new changes are not accepted, artificial intelligence technologies is refused, thus limiting the possibility to increase efficiency on the farm. Despite these limitations, digitization is taking place and more digitized farms have enough digital data that is fragmented, unstructured. It is mistakenly believed that only accurate, organized data is one of the prerequisites for implementing artificial intelligence solutions. With the development of artificial intelligence technologies, they are enabled to systematize incomplete, fragmented data. In addition, more and more opportunities are provided by open data sets, which are mostly opened by public institutions, non-governmental organizations, and researchers (Dasgupta and Wendler, 2019).

Access to artificial intelligence solutions is important factor in assessing the application of artificial technology on a farm. One access option is to use artificial intelligence solutions that are based on open source. The availability of open source technologies facilitates their diffusion, and these technologies are free, freely available, and easy to modify. Open source projects promote the development of an artificial intelligence ecosystem. Another access option is access to complete artificial intelligence solutions. In this case, there is no need for a long period of time to realize the advantage of artificial intelligence technology. The farmer does not need to make additional investments in the development of costly systems (Dasgupta and Wendler, 2019).

External pressure comes from two levels: industry and competitors. Early application of artificial intelligence technology in agricultural processes creates a competitive advantage, which increases efficiency, production volume, creates technological improvements in processes. Competitive pressure determines whether the economy's decision to apply artificial intelligence technologies will be proactive or reactive response. At the industry level, the pressure is related to the efforts of industry associations to embed artificial intelligence technologies. At this level, the pressure is transformed into forms of cooperation, uniting public authorities, businesses - farms, artificial intelligence developers, investors, associations, e. g., connecting various Lithuanian public and private organizations, non-profit network (Lithuania Agro Space Digital Innovation Hub, digital innovation centers AgriFOOD Lithuania, EDIH4IAE.lt.). The goals of these organizations are to unite stakeholders due to the emergence of digital technology innovations, to make the agri-food industry more efficient, and to accelerate the implementation of artificial intelligence (Bačiulienė et al., 2020).

Perceived benefits determine the choice to use technology, but perceived costs reduce the likelihood of applying and integrating technology (Chwelos et al., 2001). In assessing benefits, the productivity J curve studied by researchers Brynjolfsson et al. (2018). Researchers have found that companies initially invest in artificial intelligence technologies, but economic indicators show a decline in productivity that reflects initial costs, followed by a sharp increase in productivity as it also reflects the intangible benefits accumulated in previous years. This phenomenon has been described by researchers as the productivity J curve (Fig. 2).

Figure 2. The productivity J curve

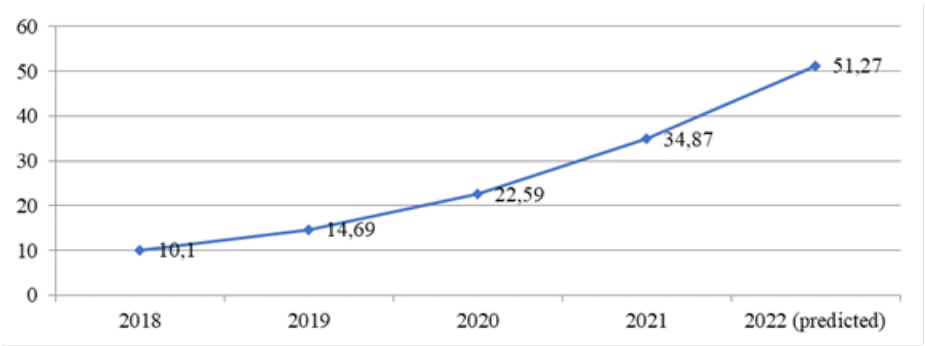


Source: own on basis of Brynjolfsson et al., 2018

Farms need time to figure out how to use artificial intelligence, which requires investment in intangible change, including rethinking the organization of production itself. After installing physical equipment, farms must create new business and farm processes, train employees, improve software if necessary, and create other intangible assets. Therefore, intangible investments related to highlighting the potential of artificial intelligence are not immediately reflected in economic indicators (Brynjolfsson et al., 2018).

Despite perceived costs of applying and integrating artificial intelligence technology, the global market value of artificial intelligence since 2018 until 2021 increased by 24.77 billion USD. The market value of artificial intelligence is forecast to increase 5 times in 2022 compared to 2018 and reach 51.27 billion USD. Since 2018, a steady increase in the market value of this technology has been observed (Fig. 3).

Figure 3. Market value of artificial intelligence, billion dollars

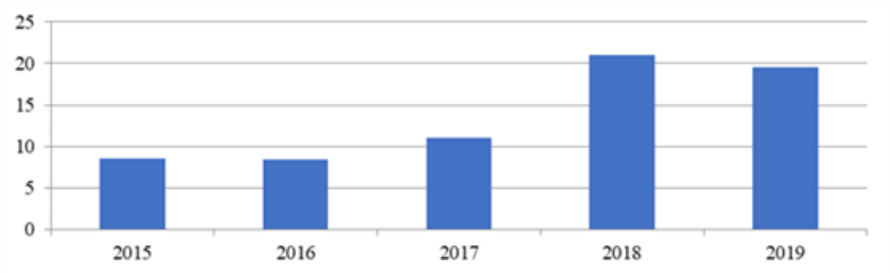


Source: Statista, 2022

Artificial intelligence technologies are also spreading in the agri-food industry. The use of this technology in the agri-food industry is increasing, start-ups are focusing on the development of artificial intelligence in this industry, and standardized solutions are increasingly being used on farms.

In the agri-food industry, investments in technological innovations in the agri-food industry also grew in the period 2015-2019 (see Fig. 4). Although in 2019 fixed decline in investment, but the industry remains strategically important and investment in technological innovation is likely to increase in the future.

Figure 4. Investment in technological innovation in the agri-food industry, billion dollars



Source: Financial Times, 2020

Conclusion

Artificial intelligence is changing the agri-food industry. The organizational readiness of the economy, perceived benefits and external pressures are important for the adoption of artificial intelligence in this industry. One of the most important factors determining the use of artificial intelligence is financial resources, but with the help of artificial intelligence technologies, the lack of financial resources can be overcome by using an alternative - new business models. The growing market value of artificial intelligence and investment in technological innovation in the agri-food industry show that farms are increasingly aware of the benefits, are organized to adopt artificial intelligence technologies, and external pressures are accelerating the use of this technology in the agri-food industry.

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