THE IMPACT OF ARTIFICIAL INTELLIGENCE ON GROWTH IN THE AGRI-FOOD INDUSTRY: LITHUANIAN CASE

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Abstract. The paper examines the concept of artificial intelligence and its impact on economic growth in the agri-food industry. Artificial intelligence is divided into seven main areas, but machine learning, expert systems, vision and robotics are most widely used in the agri-food industry. The authors discuss artificial intelligence technologies being developed in Lithuania for the agri-food industry. Directions of application of each area of artificial intelligence used in the agri-food industry are being analyzed. The authors argue that the impact of artificial intelligence on economic growth in the agri-food industry responds through increased productivity. Growing gross value added to Lithuanian agriculture, forestry and fisheries, as well as in the Lithuanian food processing industry shows improving labor productivity. It is appropriate to continue research and innovation in the agri-food industry, as farms tend to increase investment, which creates preconditions for the agri-food industry to increase productivity.
Keywords: *artificial intelligence, agriculture, agri-food industry, economic growth.*

Introduction

Artificial intelligence (AI) currently is the main technological paradigm; therefore, it is important to explore the concept of AI, which was invented in 1955 and introduced to the scientific literature by the computer scientist John McCarthy, however, there is no uniform definition of AI to date. In common dictionaries, artificial intelligence is defined as a branch of science about machines that have the properties of the human mind, such as the ability to speak, recognize image, problems and training, or as a branch of science that studies computer systems that can mimic human behavior. AI is to be treated as an activity intended to produce intelligent machines and intelligence is the property of publishing entities envisaged in the environment. AI technologies are the wayto enable “smart” behavior in the machinery. In order to achieve this, it is possible to use different methods

and combine them into many programs that solve specific tasks. Due to the possibility to combine different task programs according to several methods, AI technologies are distinguished by the peculiarity of general application.

The agri-food industry is complex, challenging a wide range of processes and operations, but in general this industry is inefficient. The agri-food industry needs innovative solutions. There are many stakeholders in the agri-food industry - growers, producers, trade representatives, the national policy-making corporations, so it is important to set goals and challenges in implementing sustainable solutions. Technology is one of the tools to achieve the goals and a key tool in the digitalisation of agriculture, with technological tools already in place 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.

Theoretical Background. As more and more countries have announced initiatives and plans to promote the use of AI, some of them have introduced the concepts of AI itself. The Lithuanian Artificial Intelligence Strategy defines AI as systems that demonstrate intelligence and intelligent behavior by analyzing their environment and making fairly independent decisions to achieve goals. The European Union definedAI as systems that behave intelligently, analyzing their environment and making fairly independent decisions to achieve a goal. AI systems can be software-based and operate in a virtual world (voice synthesizers, image analysis software, search engines, speech and facial recognition systems) or can be integrated in hardware (advanced robots, self-propelled vehicles, drones or IoT). In France, the concept of AI is officially defined as 'a theoretical and practical interdisciplinary field that aims to understand the mechanisms of cognition and thinking, and to simulate them using hardware and software to help or modifyhuman activity'.

Whatever term is used, AI encompasses many different areas that are interrelated (Figure 1).

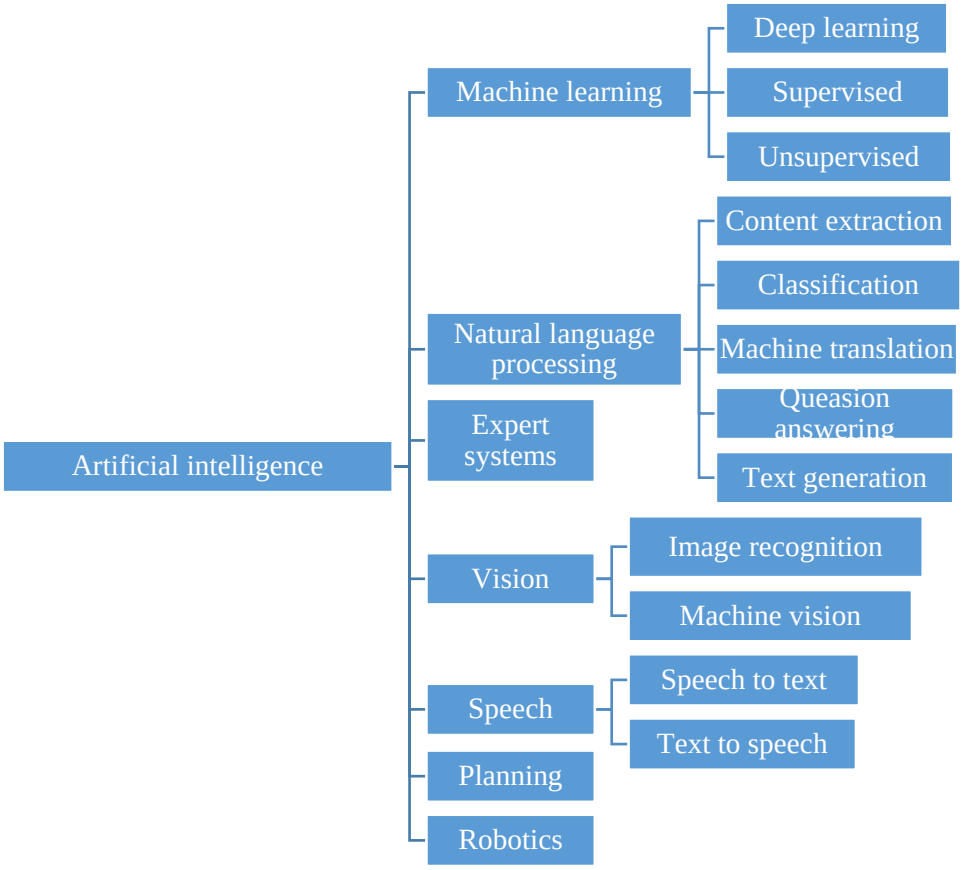

Figure 1. The branches artificial intelligence (AI)

In the agri-food industry not all areas related to AI are relevant. Machine learning, expert systems, vision and robotics are more widely used.

Machine learning is a type of AI where computers use massive databases to figure out how to perform tasks. In the case of classical programming, the person himself enters the rules (program) into the computer and the data for their processing in order to obtain answers. Therefore, it can be argued that a machine learning system is taughtrather than programmed. In the case of machine learning, many important examples are provided for the task, the system statistically structures the examples, and finally develops rules for task automation (Chollet, 2018).

Agricultural technologies and precision farming, also known as digital agriculture, have emerged as a new branch of science that uses data arrays to increase agricultural productivity while reducing environmental impact. Machine learning in agriculture has emerged alongside big data technologies and productivity calculations to create new opportunities to reveal, quantify and understand data-intensive processes in agricultural activities (Liakos, Busato, Moshou, Pearson, Bochtis, 2018).

Machine learning in the agri-food industry can be applied at various stages (Figure 2).

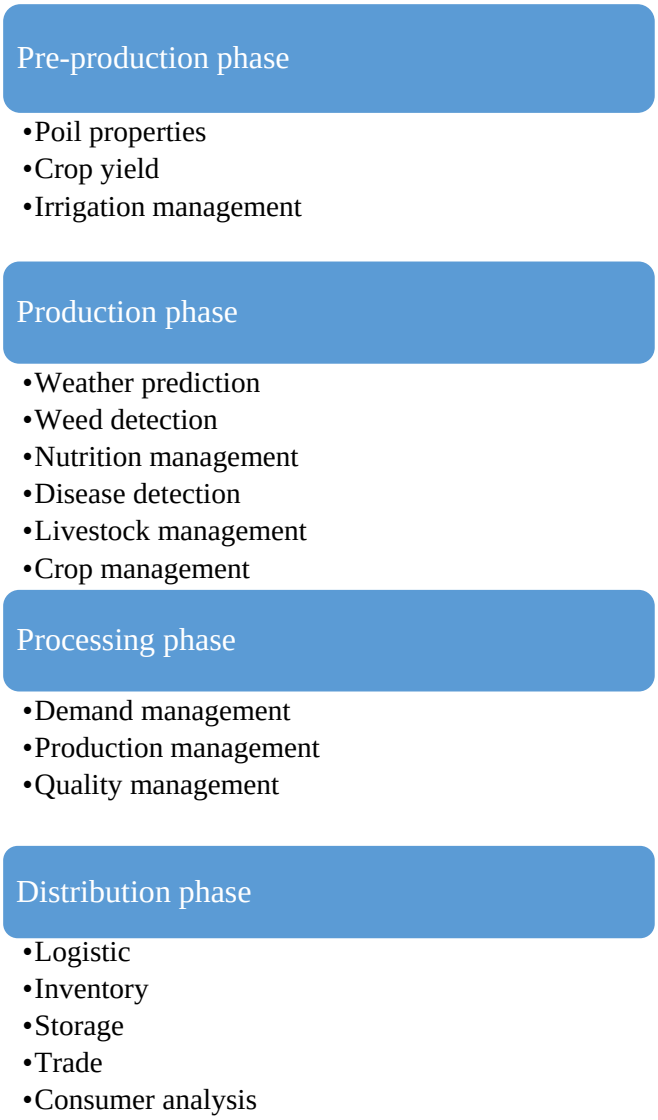

Figure 2. Machine learning in agri-food industry

In a study carried out by the European Parliament's Committee on Agriculture and Rural Development (2019) divided the application ofAI technologies into three categories:

1. Reducing the risk of agricultural production (eg early detection of crop diseases, use of drones to develop comprehensive soil maps for damage control);
2. Risk reduction (eg some technologies focus on risk detection related to emissions and climate change);
3. To increase production efficiency (eg control of water and energy consumption).

The use of AI in the agri-food industry can be divided into two categories: 1) digitalization of farm holdings and activities, and 2) application of new management methods.

AI-based technologies increase the efficiency and productivity of various industries, with no exceptions, and areas of the agricultural sector such as crop yield, irrigation, soil sensing, crop monitoring, weeding, crop sowing / planting. Technological solutions based on AI allow farmers to produce more products at lower costs, but by improving product quality and ensuring faster harvest delivery to the market (Talaviya, Shah, Patel, Yagnik, Shah, 2020).

Artificial intelligence can make a significant contribution to the development of a system of food industry experts to automate and monitor food quality control. Machine learning methodologies can help researchers and technicians to understand human behavior in order to decide on subjective food quality and to determine what are the objective features of food classification according to market and consumer needs. Machine learning algorithms can help: a) extract operational human knowledge from readily available sources (i.e., sample sets); (b) to establish clear rules for the classification of samples, notwithstanding the nonlinearity of the human behavior we study; and (c) determine the degree of influence (relevance) on the final expert's decision for each objectively assessed food characteristic. (Goyache, Bahamonde, Alonso, López, Coz, Quevedo, Ranilla, Luaces, Alvarez, Royo, Díez, 2001). Computer vision technology uses a camera and a computer to identify, track, and measure targets for further image processing. With the development of computer vision technology, it is increasingly applied in the field of agricultural automation (Tian, Wang, Liu, Qia, Li, 2019).

Computer vision can help accurately monitor crop developments to predict crop and environmental conditions affecting agricultural growth and productivity. By placing sensors in fields and farms, it is possible to collect information and analyze it. It becomes possible to predict soil conditions (drought, moisture, etc.), diagnose plant diseases using images of the leaves of healthy and unhealthyplants, and collect a variety of information on temperature, sunlight, seeds, fertilizers, pesticides, and agricultural equipment. Image analysis automatically detects anomalies or non-compliance with hygiene standards to strengthen quality control of agricultural products. For example, AI can be used to automatically sort grains to remove those that may contain cancer-causing aflatoxin, reducing milk E. coli bacterial contamination. Human work withdigital cameras, monitoring health compliance procedures, checking that workers wash their hands, wearing the necessary equipment (shoes, bathrobes and hats), etc., can be fully automated with the help of computer vision. Computer vision allows animals to be automatically counted to ensure their traceability and determine their weight to to guarantee healthy growth.

Various simulations show that by 2030 about 70 percent of companies will apply one of the categories of AI, so it is clear that it has the potential to contribute to global economical activity.

In summary, there is still no uniform concept of AI, but the basis of all definitions is that machines or computers become intelligent, whether it is goal-oriented or imitation of human intelligence or adaptation to the environment. The use of AI in the agri-food industry automates some tasks which increases productivity. With the help of AI, the ability to collect, store and analyze data arrays enables increase of the product quality, making them user-friendly.

Results and analysis. The gross value added indicator is used to assess the process of mechanization of production, when human labor is replaced by various mechanisms. In agriculture, this would be the replacement of workers with agricultural machinery and equipment, and so on (Figure 3).

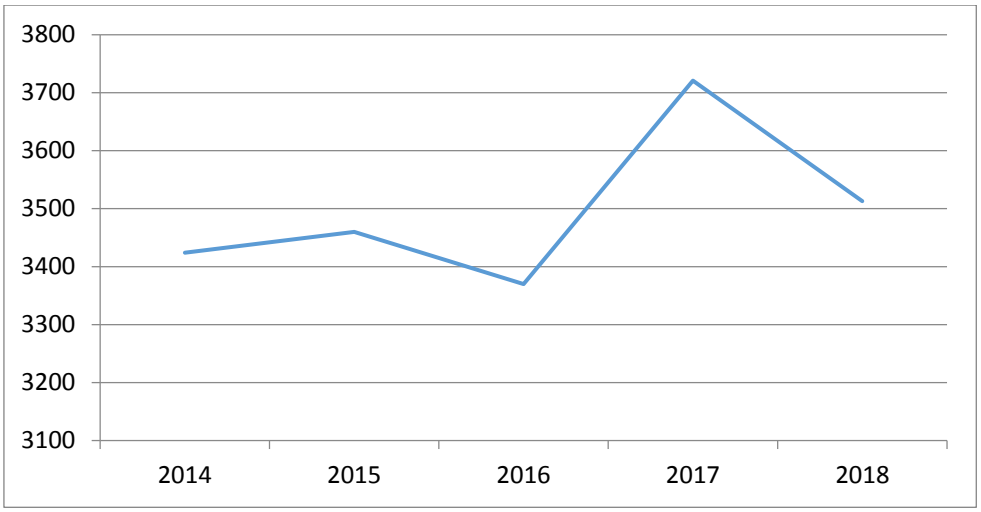

Figure 3. Gross value of Lithuanian production in agriculture, forestry and fishing, mln. Eur, (sources - data of Statistics Lithuania and Eurostat)

The growth of the value of gross production in agriculture, forestry and fishing was observed in 2014-2018. The same trend persists in the food processing industry (Figure 4). The analysis of the indicators shows that in agriculture, forestry and fisheries, as well as in the food processing industry, gross value added grew in 2014-2018, with a particularly marked increase observed in 2017. Positive change means improved productivity. During the period of 2014-2018, investments per 1 ha of agricultural land in farmers' farms averaged 1 314 Eur. The largest investments in the area of 1 ha of agricultural land went to farmers' farms smaller than 10.0 ha (2 424 Eur). Relatively much was invested in farmers' farms with 10.1–20 ha, 20.1–30.0 ha and more than 150.1 ha.

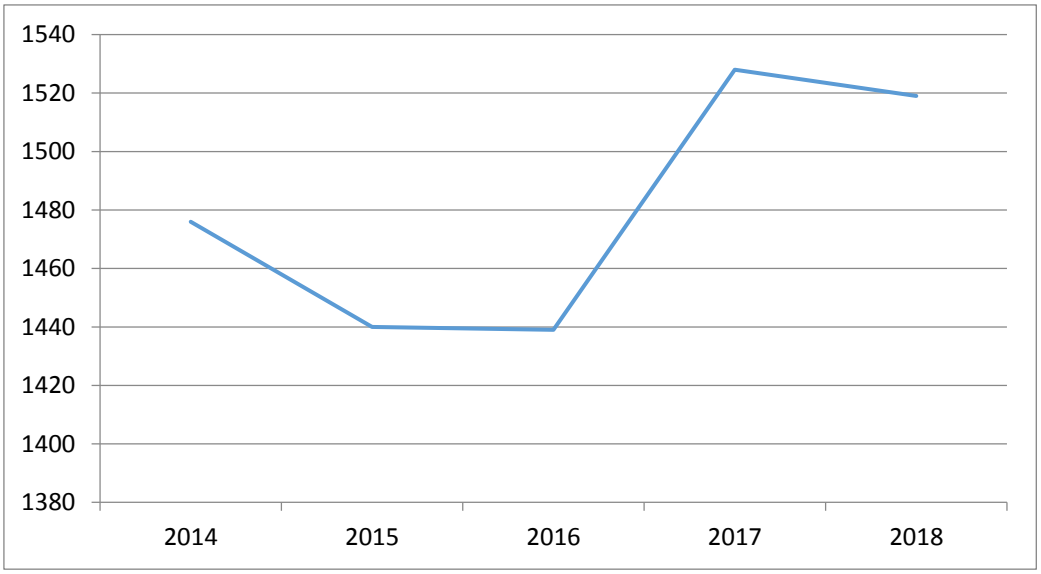

Figure 4. Gross value added created in the food processing industry in Lithuania, mln. Eur, (sources - data of Statistics Lithuania and Eurostat)

Currently innovative research is being carried out in the agri-food industry in Lithuania:

1. Hyperspectral imaging for precision agriculture. The benefit of the research is the application of analytical methods for hyperspectral image analysis of crop plants. Ability to remotely assess plant nutritional status and identify early stages of disease using field scanners. Data integration with a smart machine for sustainable and efficient use of agrochemistry;

2. Distributed algorithm processing infrastructure. The benefits of the study

include the application of innovative cryptographic solutions for agri-food technologies, the implementation of distributed and decentralized data processing infrastructure, ensuring the availability and use of advanced data processing algorithms, while maintaining their privacy and property rights.

3. Farm and grain management software. The benefits of the study are specialized information and process management solutions for agriculture, ranging from GIS-based farm management and planning platforms for farmers to integrated systems for grain elevators and fertilizer vendors.

4. Food integrity using AI and Raman spectroscopy. The benefit of the study is the possibility to widely use Raman spectroscopy in the food industry using machine learning and artificial intelligence analysis methods for spectral data analysis. The ability toquickly, non-invasively and on-site assess the quality, safety and authenticity of food and beverages.

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5. Electronic-nose devices to check the freshness of food. The benefits of the research and development, commercialization and innovation of gas sensor technology for the food industry. Introduction of the world's first handheld user-level device for non-invasive freshness of raw meat, poultry and fish.

6. 3D LiDAR programs in forestry. The benefits of the study are methodological studies for remote wood age, forest wood content and evaluation of potential production using 3D LiDAR technologies and real-time scanning. Modeling solutions in agriculture and fruit growing.

In summary, the growing gross value added in agriculture, forestry and fisheries, as well as in the food processing industry, indicates improvement in labor productivity. It is appropriate to continue research and innovation in the agri-food industry, as farms tend to increase investment, which creates preconditions for the agri-food industry to increase productivity

Conclusions

Examining the concept of AI and the directions of its use, it can be said that there is still no uniform concept of AI, but the basis of all definitions is that machines or computers become intelligent, whether it is goal-oriented or simulated human intelligence or adaptation to the environment. The use of artificial intelligence in the agri-food industry automates some tasks and tasks, which increases productivity. With the help of artificial intelligence, the ability to collect, store and analyze data arrays allows the increase product quality, making them user-friendly..

A theoretical assessment of the use of AI for economic growth shows that the use of AI will have a direct and indirect effects on GDP growth, depending on the industry (developing or applying the technology). AI companies will choose the "Human-in-the-loop" strategy as creating benefits throughout the value chain. Modern productivity theory questions the impact of AI as intangible capital on the impossibility of estimating it in national statistics.

After the analysis of the gross value added of the Lithuanian agri-food industry and investments in agriculture, it can be stated that the growing gross value added in agriculture, forestry and fisheries, as well as in the food processing industry shows improving labor productivity. It is appropriate to continue research and innovation in the agri-food industry, as farms tend to increase investment, which creates preconditions for the agri-food industry to increase productivity.

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