

ECONOMIC, ETHICAL AND LEGAL ASPECTS OF DIGITALIZATION IN THE AGRI-FOOD SECTOR

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Abstract

The article aims to contribute to the discussion and research on economic, ethical and legal aspects of digital transformation in the agri-food sector. The previous technological revolution (the so-called Green Revolution) significantly raised the efficiency indices and productivity in agriculture. At the same time, however, it led to many negative environmental consequences. It also deepened income inequalities in the sector. According to some researchers, the current digital revolution, in fact based on intensive use of knowledge, may reverse the adverse consequences of the previous revolution. On the other hand, there is growing evidence that digital technologies lead to new social divides and to greater inequalities in the world. Many digital products and services are developed with the use of data to which ownership rights remain unclear. At the same time, the ongoing digitalization processes seem to significantly increase the risk of privacy violations. The article discusses the benefits, problems and possible risks associated with the digitalization processes in the agri-food sector. Particular attention is devoted to the ethical aspects of collecting, processing, sharing and using digital data from smart farming systems. It is argued that the potential of the digital revolution in the agri-food sector is not fully realized. The influencing factors are i.a. the lack of laws and regulatory frameworks for the governance of digital data gathered in the agriculture and food sector; the structure of the market of digital products and services favoring large and very large farms, low level of trust between actors in the data value chain and insufficient cooperation between the private and the public sector with regard to using and sharing digital data. Therefore, a broad discussion engaging various

stakeholders on the vision of digital transformation in the agri-food sector is necessary. The foundations for the development of the agri-food sector based on data exchange and digital innovation should take into account common values and ethical principles, as well as the need to build mutual trust between the actors in the data value chain.

Keywords: digitalization, digital technologies, digital innovation, data-driven agri-food sector, the ethics of digital revolution.

JEL codes: L16, O31, O32, O33, Q16.

Introduction

The global economy is now on the threshold of another industrial revolution. It is based on information and communication technologies, advanced data analyses and artificial intelligence. The growing application of these technologies leads to digitalization of economic and social life all over the world. Therefore, digitalization is the essence of the current industrial revolution and the basis for the development of an economy called Economy 4.0. In fact, it comes down to measuring, describing and explaining processes, phenomena and events using numbers, signals and images that are collected and saved in extensive IT ecosystems. These systems include functions to automatically process and analyse growing digital data resources, are scalable and do not require direct human involvement. The knowledge and information acquired in this way have a great transformational potential – they open up new development and growth opportunities to companies and economies, change approaches to resource management, business models, as well as ways to create and capture values in the economy.

The digital revolution is also increasingly visible in the agri-food sector (Trendov, Varas and Zeng, 2019). The growing amount of digital data on the environment, land and agricultural production significantly expands the possibilities of precision farming technology. Although precision technologies have been known in agriculture for more than 20 years, the practice of aggregating data from multiple fields and farms, combining them with off-farm data and controlling production processes with mobile and digital applications has been developing recently. As a result, in recent times the concept of smart farming has become popular, which, thanks to the use of new technologies and digital solutions, is to enable the more efficient and also more eco-friendly agricultural production. It is worth explaining that the term “smart farming” is mainly used in Europe. In Australia, in fact, the same concept is referred to as “digital agriculture”. In the USA, the term “precision farming” is still the one which is the most commonly used. We can also encounter other terms, such as data-driven agriculture or agriculture 4.0. Digitalization also changes the functioning of other links in the agri-food chain – suppliers of production means, distributors, processors, sellers and consumers. New technologies affect the conditions of competition in food markets

and the structure of the agri-food chain. We can observe that the presence and activity of entities not yet associated with the production and sale of food, in particular, companies involved in the production of IT equipment, software, provision of IT and analytical services, are clearly growing in the chain. Food is more and more often sold through e-commerce platforms (Figiel, 2019). What is also developed, are automatic systems for food identification and tracking in the chain and applications to make it easier for consumers to make purchasing decisions.

Given the rapid pace of digitalization processes, there are a number of questions about their impact on the production, environment and social welfare. The objective of this article is to contribute to discussions and studies on the economic, ethical and legal aspects of digital transformation in the agri-food sector. In particular, the article will discuss potential benefits, problems and risks related to digitalization. The previous technological revolution (the so-called Green Revolution) raised significantly the efficiency indices and productivity in the sector. At the same time, however, it led to many negative environmental consequences. It also deepened income inequalities in the sector. According to some researchers, the current digital revolution, in fact based on intensive use of knowledge, may reverse the adverse consequences of the previous revolution (Walter, Finger, Huber and Buchmann, 2017). At the same time, there are also no opinions and evidence showing that digital technologies lead to new social divides and the greater scale of global inequalities (Allen, 2017; Guellec and Paunov, 2017).

The literature of the subject and discussions taking place in the forum of international organisations argue that, in addition to economic issues, ethical issues related to the use of new digital technologies in the food chain are also of key importance (cf. Carbonell, 2016; Eastwood, Klerkx, Ayre and Dela Rue, 2017; Kritikos, 2017; Ryan, 2019; FAO, 2019). Digital data management (personal and non-personal), including issues related to its security, reprocessing, sharing and monetisation, becomes a particularly important issue. Many digital products and services, including those for digital agriculture, are developed with the use of data to which ownership rights remain unclear. At the same time, the ongoing digitalization processes seem to significantly increase the risk of privacy violations. Concerns in this area are growing along with the increasing number of new technologies and business models requiring intense data exchange.

The article discusses the benefits, problems and possible risks associated with the digitalization processes in the agri-food sector. Since the use of digital solutions in one link of the food chain often determines and stimulates digitalization processes in other links, it will be appropriate to highlight the directions and dynamics of digital transformation throughout the food chain. The ethical problems of digitalization will be further presented on an example of processes of collecting, processing and using digital data in smart farming systems. This is one of many digitalization-related subjects requiring discussion and reflection. Other ethical dilemmas are related to, *inter alia*, the impact of new technologies on the labor

market and employment in the sector, assurance of data integrity and reliability in the individual links of the food chain or identification of entities responsible for potential errors in decisions made by artificial intelligence and machine learning algorithms (see, *inter alia*, Marinoudi, Sørensen, Pearson and Bochtis 2019; Miles, 2019). Given the very extensive and complex nature of these problems, it will not be possible to discuss them more profoundly in this article.

Digitalization, digital transformation, digital economy

The main driver of the current industrial revolution is digital data, saved and stored on data carriers in a form of binary code (sequence of zeros and ones). The possibilities to record and save events, phenomena and processes using numbers are now greater than ever before. The development of quantum technologies is expected to lead to further digital breakthroughs – quantum computers are based on qubits that allow to process data much faster. However, digitalization is not a new phenomenon – efforts to transform information and analog data into digital data have been undertaken since the first computers appeared. But only tangible benefits resulting from using advanced computer analyses and calculations based on growing volumes of digital data made this phenomenon acquire new and greater importance in recent times. As a result, digitalization has turned from activities being, to some extent, a side effect of the development of information technologies to the objective of many organizations. New growth opportunities related to the use of digital data and technologies make companies, sectors and economies as a whole to enter the path of digital transformation. The OECD points to two types of activities in this area – digitization and digitalization (OECD 2017, 2019a). Digitization means a conversion of processes and analogue data into machine-readable formats. In turn, digitalization means new types of activities or changes in existing activities resulting from the use of digital data and technologies as well as mutual connectivity. Digital transformation, according to the OECD, relates to economic and social effects of both these processes (OECD, 2019a).

In the literature of the subject, we can find various definitions of digital economy. The UNCTAD points to a broader and narrower understanding of this concept (UNCTAD, 2019). In a narrow sense, this is the “part of production which, completely or to a large extent, results from the use of digital technologies and business models based on digital products and services” (Bukht and Heeks, 2017). In a broad sense, it is the “part of total production being a result of the use of many different digital production factors. Digital production factors include digital skills, digital equipment (computers, software, communication devices) as well as digital intermediate products and services” (Knickrehm, Berthon and Daugherty, 2016).

It is more and more often pointed out that digitalization will be one of the most important factors affecting the competitiveness of companies, sectors and coun-

tries. According to forecasts, by 2030 as much as 14% of the global GDP growth (about USD 15 trillion) will have resulted from the use of digital solutions and automation (Trendov et al., 2019). However, it is not clear how new profits and benefits will translate into incomes of individual social groups and the level of social welfare. In fact, digitalization entails many new economic developments, which, on the one hand, promote innovation, efficiency and competitiveness, yet on the other hand, lead to market concentration and restriction of competition. Today, the digital technology market is clearly dominated by two countries: the USA and China. Only these two countries have the share of more than 75% in the cloud computing market and hold 75% of patents related to distributed database (blockchain) technology. The vast majority of the highest-priced digital platforms on the stock exchange (90%) belongs to companies from the USA and China. Only slightly more than 3.5% of platforms in this category come from Europe (UNCTAD 2019). There may be concerns whether such high control of digital technologies and related data by American and Chinese companies may have a negative impact on the competitiveness of less digitally advanced economies.

Digital technologies for agriculture and food economy

According to market forecasts, the digital revolution will change agriculture and food economy over the next decade (Trendov et al., 2019). The literature of the subject and the specialist press list various technologies and solutions that can revolutionize the functioning of the sector (Table 1).

Digital transformation in the food sector is made possible by both general-purpose technologies (such as, inter alia, the Internet, communication networks, artificial intelligence), technologies supporting and/or improving the efficiency of action in various areas (cyber-physical systems, monitoring systems, blockchain, cloud computing), as well as solutions and equipment dedicated exclusively to agriculture (VRT – variable rate technology, irrigation systems, agrorobots, agricultural drones, farm management systems). The technologies and solutions indicated in the literature are a kind of technology stack – combined and used together, they have the greatest transformational potential.

Table 1

*List of digital technologies and solutions used and possible to be used
in the agri-food chain*

Digital technologies and solutions	Source of the list
<ul style="list-style-type: none"> • Mobile devices and social media • Precise farming and remote sensing technologies (Internet of Things, GNSS, RTK, VRT, PLF, UAV and satellite imagery) • Big data, cloud computing, analytics and cybersecurity • Integration and coordination (blockchain, ERP, financing and insurance systems) • Smart systems (deep learning, machine learning, artificial intelligence, robotics and autonomic systems) 	Trendov, Varas and Zeng, 2019
<ul style="list-style-type: none"> • Big Data analytics • Industrial Internet of Things • Cyber-physical production systems (CPPS) • Cloud computing technology • Additive manufacturing technologies – 3D printing • Holograms (VR – Virtual Reality, AR – Augmented Reality) 	Demartini et al., 2018
<ul style="list-style-type: none"> • Internet-connected tractors and agricultural machinery • Automation (irrigation systems, fertilisation systems, systems to control climatic conditions, yields, etc.) • Agrorobotics (fruit-picking robots, drones, autonomic tractors, spraying machinery) • Data measurement and collection devices (sensors, satellite imagery) • Internet of Things • Communication networks, monitoring systems • Smart data processing (cognitive computing), machine learning, data collection, data processing, analytical techniques • IT systems to manage farms, artificial intelligence interfaces and man-machine interfaces (augmented reality, 3D scanners, touchscreens, mobile apps, etc.) • Machine communication protocols. 	Miranda, Ponce, Molina and Wright, 2019

Source: own study.

Impact of digitalization on the agri-food chain

When compared to other sectors, digital transformation in the agri-food sector is relatively slow (CEPS, 2019). At the same time, in some links of the agri-food chain, changes take place faster and are more visible. More digitally advanced links include suppliers of production means, distributors and sellers. In agriculture and agri-food processing, digital changes take place but are still quite limited (ABB, 2018). Digital technologies and advanced data analyses are used mainly by large and very large farms, transnational corporations and larger food industry plants. Many small farms and smaller production plants lag behind digitalization processes. Most of them use only simple tools for communication and information acquisition (Internet access, website, mobile devices).

The sector of suppliers of production means for agriculture is the link in the food chain, where the transformational nature of digitalization processes is particularly visible. The sector saw new entities which so far have not been linked to the production of food or widely understood agribusiness sector. They include large high-tech companies, online platforms, software producers, companies producing chips and sensors, as well as smaller agtech companies and startups involved in data analysis, provision of advisory services and development of digital applications for agriculture. The second visible change is the significant concentration of market power of suppliers of production means for agriculture (Pham and Stack, 2018). The process of concentration of companies in this sector has been taking place for a long time, but recently it has been significantly intensified. New business opportunities related to the use of digital technologies are one of the more important motives underlying decisions to merge companies. Consequently, a number of acquisitions and mergers have resulted in unprecedented consolidation of companies in seed, agrochemical, fertilizer, animal genetics and agricultural machinery markets in recent years (IPESFood, 2017). It is also more and more common for suppliers of production means for agriculture to use extensive strategies to acquire and monetize agricultural data. These strategies are implemented both through acquisitions and mergers, as well as through partnership and cooperation agreements. Cooperation around agricultural data among producers of agricultural machinery, plant protection products and other production factors allows to obtain higher margins – companies improve existing products with new digital solutions and functionalities or develop new products and services based on shared agricultural data resources.

The implementation of sales through online platforms is another change in the agri-food chain, which takes place under the influence of digitalization. Various e-commerce platforms are more and more often used in trade in agri-food products, both in the wholesale and retail link of the marketing chain (Figiel, 2019). E-commerce platforms significantly improve access to market and commercial information, thereby connecting the demand and supply side of the market in the more efficient and faster manner. They reduce the number of intermediaries in the supply chain, shorten the distance between producers and consumers, empower small farmers by eliminating barriers to access to markets and, at the same time, promote

price transparency in food markets. Thanks to online platforms, producers gain potentially global coverage and have easier access to global value chains (OECD, 2019b). The Internet reduces the importance of the producers' place of operation, it also makes them independent of their links to traditional sales networks. As a result, there are changes in the configuration and system of relations among food supply chain entities (Figiel, 2019). However, the effects of platforming agri-food trade have not been fully understood yet. On the one hand, relatively cheap and quick access to trade information and potential customers can reduce the inefficiency of food markets, support the development of agri-food trade and promote the competitiveness of the agri-food sector. On the other hand, economies of scale and scope, characteristic of the digital economy, can lead to the predominance of individual e-commerce platforms and high access prices.

In the agricultural production link, digitalization strengthens the role and importance of large and very large farms (Carbonell, 2016). On such farms, more advanced agricultural equipment is typically used, which can be integrated into new digital technologies. Owners of larger farms are also more likely to make decisions on purchasing new technologies. The concentration of digital technologies on large farms is additionally supported by the structure of market of digital products and services for agriculture. Many digital solution providers make the provision of analytical services dependent on the farm size – the cultivation area or the number of animals bred. In the subscription system, fees for the most valuable analytical services are usually charged per hectare or animal. However, the development of digital products and services for the largest farms is not only promoted by business, but also methodological and technical considerations. Analyses using artificial intelligence and machine learning algorithms to generate guidance for producers in real time require access to a large amount of data which can be relatively easily submitted to providers by larger farms. Data from smaller farms is usually dispersed and does not allow to achieve a comparable return on investment. As a result, more digitally advanced are currently those food economies, where large and very large farms dominate the structure of agricultural land use.¹

Properly selected and implemented digital technologies are becoming a key factor strengthening the competitiveness of farms and other entities in the agri-food chain. The growing requirements of processors, sellers and consumers with regard to the quality of agricultural products and methods of their production are a reason for which farms using IT production management systems and other technologies to monitor and reconstruct the production process gain a significant advantage in the food supply chain. However, benefits of digitalization are not limited to the sphere of production only. Digitally advanced producers and processors can also participate in new and more developed collaboration networks opening up new business opportunities.

¹ For example, in Denmark, harvesters with precision farming systems in 2017 were used by 16% of farms. The area occupied by those farms accounted for as much as 45% of the country's agricultural land (Paderson, 2017).

Ethical and legal aspects of collecting and using digital data in smart farming systems

The collection, storage, sharing, use and monetization of farm data raise the most questions and controversy in the context of digitalization in the agri-food sector (Carbonell, 2016; Dyer, 2016; Wiseman, Sanderson, Zhang and Jakku, 2019). The concentration of data discussions results from the key role it plays in the digital revolution. Digital data is gradually becoming a kind of new production factor. However, due to its characteristics and properties, it differs significantly from other production factors used in agriculture. Complex data collection, processing and economic value extraction processes require the involvement of many entities. These entities often pursue different objectives and have different visions and expectations regarding the usefulness of data collected. Access to digital data may be unlimited (open public data) or limited to selected groups (private data). In the case of this latter category, digital data is therefore an excludable good, however, within a group of entities that have access to it, it remains non-competitive in consumption. It can be used repeatedly for various purposes without losing its value. The participation of many entities in the data value chain means that it is difficult to clearly define ownership rights to digital agricultural data (in particular aggregated data on the agricultural production, which is recorded by agricultural machinery and equipment). This is the primary source of many ethical problems and dilemmas that currently arise in smart farming systems.

The absence of clear definitions in this area means that it is difficult to determine to what extent individual entities in the data value chain have the right to participate in benefits of digitalization. In addition to unclear data ownership rights and dilemmas that arise during attempts to define them, the problem is also the absence of transparency of agreements between digital solution providers and farmers. Consequently, there are a number of additional dilemmas and problems likely to have a negative impact on the prospects for the development of digital agriculture. They can include, *inter alia*, uncertainty regarding the data flow in the chain, possible violations of privacy rights of farm owners, restriction of the possibility to transfer data to other digital solution providers, growing inequalities both at the agri-food chain level and among farms. A separate issue remains the social importance of data collected in private databases of entities involved in the development of smart farming. Data on agricultural land, the state of crops and farm animals is of key importance to public policies in areas related to providing food security, environmental protection, fight against climate change and minimizing risks to human health and life. Digital solutions have a great potential in these areas. However, the absence of transparent and ethical principles for the operation of the data value chain in the agri-food sector increases the risk that this potential will not be fully tapped. Assessments by some researchers are even more pessimistic; in their opinion, digital (precision) farming is, in fact, a new version of traditional agriculture, which is geared towards intensifying

production and maximizing profits (cf. Miles, 2019). The most important ethical and legal issues that appear in the context of the development of digital agriculture will be discussed below. These are:

- a) the issue of ownership rights to digital agriculture data and resulting benefits,
- b) the absence of transparency in provisions of data licensing agreements and dependence on selected digital solution providers (lock-in effects),
- c) the security and privacy protection in digital agriculture systems,
- d) the importance of digital agriculture data for the supply of public goods.

Issue of ownership rights to digital agriculture data and resulting benefits

The digital (smart) farming ecosystem comprises a relatively wide group of cooperating companies and organizations that create value for customers (farms) based on their own, joint and/or shared tangible and intangible resources. Agricultural technology providers play a key role in the smart farming ecosystem. In recent years, many producers of agricultural equipment and machinery have modified their strategies and business models, placing a greater emphasis on finding new business opportunities related to the use and integration of digital technologies and data. In legal systems, there are currently no clear definitions of ownership rights to digital agriculture data. The issues related to data management and data flow in the data value chain are determined at the level of private agreements between farmers and agricultural technology providers (Wiseman et al., 2019). In agreements determining the conditions to use software for agricultural machinery and equipment, most providers include a provision indicating that collected raw farm data remains the property of farmers. At the same time, however, the rights to aggregated data, i.e. its storage, analyzing and processing, are kept by producers of machinery. Therefore, farmers, although they formally remain owners of their data, are deprived of the rights to residual control of their data, i.e. the rights to decide how their data, as part of larger databases, will be used (Ellixson and Griffin, 2016). Producers of agricultural machinery collect data on various aspects and areas of operation of farms. This is data on agricultural equipment and its functioning, as well as data on land, yields, agronomic means applied or farm management methods (Fig. 1).

Data on production	Data on machinery	Administrative data
<ul style="list-style-type: none"> • data on field work • areas of performing field work • machinery routes • data on yields and productivity • agronomic means applied 	<ul style="list-style-type: none"> • data on condition of machinery, settings and readings • working hours or life cycle of machinery • location of machinery • diagnostic codes • computer software and firmware versions 	<ul style="list-style-type: none"> • consents for data sharing • users using the account • machinery, equipment and account-related licences • area • size of files • methods to use the account

Fig. 1. Types of data collected by suppliers of agricultural machinery connected to the Internet of Things – example of the John Deere company.

Source: study based on John Deere Data Services & Subscriptions Statement 2019, www.johndeere.com.

However, raw data does not have any greater economic value; this value lies in information and knowledge that can be extracted from data using appropriate analytical technologies and tools. Analytics is one of the most important and, at the same time, one of the most expensive activities in the data value chain (Duch-Brown, Martens and Mueller-Langer, 2017). The costs of collecting, processing and storing data are included by companies in the price of offered equipment, machinery and accompanying services or are recovered through various data monetization options (Kerber, 2019). Studies conducted in Australia show that farmers have many concerns and doubts as to the use of their data by suppliers of production means (Wiseman et al., 2019). On the one hand, data analysis serves to develop tools that can enhance the on-farm productivity. On the other hand, the same data also serves to achieve business objectives of suppliers of production means. It can show how to increase the sales value of specific agronomic means or what products and services can be combined in precisely targeted sales offers. According to surveys, farmers have a sense of being the weakest link in the data value chain; they incur the costs of purchasing agricultural equipment and then, without charging any fees, provide producers with data on their land and farms (Wiseman et al., 2019).

The lack of clear definitions of data ownership rights and rights to residual control of data makes farmers believe that they do not have a proper share in benefits of the development of digital agriculture. Farmers do not know all purposes of aggregating and processing their data. Moreover, they have no impact on the directions of flow of aggregated data in the chain, including the selection of data recipients. In many cases, farmers are afraid that data on their farms will be used to their detriment (Carbonell, 2016). As a result, a serious current problem in the data value chain is the limited confidence of some agricultural communities in digital solution providers. However, there are no ready-made and clear solutions

to the problem of ownership of digital agriculture data (cf. Duch-Brown et al., 2017). Full ownership rights for one group can restrict or hinder the data flow in the chain that remains essential for the development of digital products and services. On the other hand, the distribution of data ownership rights, which reduces the possibility to decide on applications of data processed at the subsequent stages of the data value chain, may discourage entities from collecting data and engaging in innovation activities (cf. Kerber, 2019).

Absence of transparency in provisions of data licensing agreements and dependence on selected digital solution providers (lock-in effects)

Another problem in smart farming systems are complex and insufficiently clear provisions of licensing agreements concerning the collection, processing and use of digital data from farms. The number of digital products and services and related agreements varies at the level of individual sectors of agricultural production. However, farmers who pursue their activities in smart farming systems usually sign more than one agreement, which concerns data from their farms. For farmers, becoming familiar with the detailed provisions of agreements signed is a great challenge. It requires not only time, but also legal expertise, which farmers usually do not have (Kritikos, 2017). Many agreements are signed concurrently and frequently – just like in the case of software licensing agreements and sales agreements for online services in other sectors – based on clicking the Agree button (so-called clickwrap agreements) (Wiseman et al., 2019). When entering the platform with services, farmers are prompted to click, which includes consents regarding data processing (including consents to link farm data to other farm data and to create anonymized databases), privacy policies and providing data to third parties. Access to the full version of the platform and services offered is possible only after all the consents required have been granted. We can read them in detail after extending the accompanying description. In addition, providers use one model for agreements, which makes agreements concluded with farmers, in fact, non-negotiable. If farmers wish to use digital services, they must accept all the terms of the agreement on processing their data. The lack of acceptance means that the use of the service is impossible. Agreements for selling services for digital agriculture are therefore agreements which cannot be refused. However, Australian farmers admitted in interviews that they often did not read detailed provisions of licensing agreements they signed (Wiseman et al., 2019). As a result, their knowledge on processing data from their farms was limited. Usually, farmers also do not have access to advisory services in this area.

Farmers who decide to sign the agreement with the given digital equipment and solution provider generally become dependent on this provider not only in terms of services covered by the agreement, but also in terms of other services requiring the use of digital data. The problem is the limited interoperability of databases collected by digital technology providers for agriculture. Producers of hardware and software often use their own interfaces and IT solutions for databases being cre-

ated, which impedes the later transfer of data among digital service providers. Even if a farmer decides to provide their raw data to another provider, it can be difficult to send, read and use it. As a result, there is a lock-in effect of farms in IT systems of individual providers (Kritikos, 2017).

Security and privacy protection in digital agriculture systems

The unclear legal status of digital data, the absence of transparency in provisions of agreements with digital solution providers and numerous data monetization options are the reasons for which some farmers are afraid of abuse on the part of data aggregators or recipients of aggregated data (Ellixson and Griffin, 2016). These concerns are strengthened by repeated scandals related to the leak of personal data from various digital platforms.²

Some difficulties related to ensuring an effective protection and security system for data collected by private sector companies result from the specific business architecture of digital economy. The development and sale of digital products and services take place within highly extensive ecosystems involving different companies and entities. Uncertainty in this area is additionally escalated by recent concentration processes in the sector of suppliers of production means for agriculture. Acquisitions and mergers result in combining corporate tangible and intangible resources (including data) on which farmers do not have much influence. Therefore, the actual data flow in smart farming systems is defined by the logic of corporate interests and, to a lesser extent, by original decisions of farm owners on processing their data. As a result, farm data may be located in databases of companies and entities which not only have not cooperated with farmers before, but were also not mentioned among entities cooperating with data collection companies.

Concerns are growing as to whether it is possible to ensure data security, including keeping trade secrets of the farm and protection of farmers' privacy right, in the conditions of intense data exchange and flow (Ferris, 2017). Current technologies allow to identify specific entities, even if data on them is placed in anonymized and aggregated databases. In the EU, personal data is protected by the 2018 Data Protection Regulation. However, most data from smart farming systems is non-personal data (in the EU, it is covered by the 2019 Regulation setting out a framework for the free flow of non-personal data) that is not protected as strongly as personal data. Nevertheless, the above-mentioned possibilities of data compilation and combination make also non-personal data very sensitive. Therefore, adequate data security safeguards and the effective privacy policy for different data categories remain crucial to increasing farmers' confidence in smart farming systems.

² Data leaks (as a result of cyberattacks or unauthorized transfer or sales of data) affect various sectors and industries. For example, in Poland at the end of 2018, there was a leak of customer data of the Morele.net sales platform (Business Insider Polska, 2018). At the end of 2019, the data leak also affected thousands of Polish customers of the Chinese AliExpress platform. The leak took place through the external parcel tracking system Postal Ninja (Długosz, 2020).

Concerns about possible violations of the privacy right and abuse in data analyses, as well as the previously discussed issues of unclear data rights and unclear provisions of agreements, made representatives of agricultural organizations, digital technology providers and other agri-food stakeholders develop, at the sector level, common guidelines and codes of good practices with regard to the flow and sharing of data from digital agriculture systems³. Their primary objective is to ensure greater transparency in provisions of agreements between digital agricultural technology providers and farmers, including an indication of a set of rules that would facilitate the efficient data flow and sharing in the data value chain. However, these codes are informal and are not legally binding.

Importance of digital agriculture data for the supply of public goods

Smart farming systems are evolving based on access to public data (inter alia, meteorological data, geospatial data and satellite remote sensing data) and thanks to data collected by farmers and private sector entities directly on the farm. The latter category of data is necessary in the process of implementing precise production techniques on the farm. It has the greatest value, both for the viewpoint of private interests of farm owners who are looking for ways and methods to optimally use their resources and from the viewpoint of wider social interests and objectives related to promoting sustainable development and providing environmental and other public goods by the agricultural sector. Thus, the question arises whether aggregated digital data from farms regarding land, agricultural production and food should remain locked in private databases of farmers and agricultural technology providers. Knowledge and information resulting from advanced analyses of digital agriculture data may support the provision of public goods, but private sector companies – by definition guided by the profit maximization principle – may not be interested in data analyses for this purpose. As a result, the potential related to the development of smart farming systems may not be fully tapped.

The private sector is becoming an increasingly important entity in the system of collecting agricultural data. Until now, the leading role in this field has been played by the state and its institutions. It is therefore necessary to develop new rules for cooperation between the public sector and the private sector in the area of agricultural data management. Today, private sector companies can develop their products and services using access to open public data. Regulations opening up public data resources and encouraging economic entities to reuse public sector information promote the increased competitiveness and innovation of the economy.

³ In the US, efforts to develop agricultural data management standards were initiated in 2014 by the American Farm Bureau Federation, an organization representing both farms and large corporations of the agricultural industry. In 2016, it adopted an initiative for transparent agricultural data management (Ag Data Transparent Initiative). In the EU, the EU Code of Conduct on Agricultural Data Sharing by Contractual Agreement was developed jointly in 2018 by the European agricultural associations COPA and COGECA and the European Agricultural Machinery Association CEMA.

A similar potential can be found in rapidly developing private databases. Therefore, the appropriate integration of public sector and private sector data seems to be essential, including the possibility of reusing private databases collected by means of new equipment and digital machinery on farms (Kosior, 2019). So far, cooperation between the public sector and the private sector has been insufficient with regard to the development of digital agriculture. Consequently, the potential associated with digitalization in the sector is not fully tapped. This is a huge social loss, as the possibly full use of digital agriculture data can support objectives such as food security, environmental protection and fight against climate change. However, sharing private production data on the farm production may raise resistance and doubts both on the part of the agricultural community and technology providers for agriculture. Some data may contain information protected by trade secret or other information perceived by data owners as sensitive. Therefore, solutions and proposals for common systems smart farming data management systems should take into account a need to keep a balance between the right of economic entities to protect their resources and related economic benefits and a need to pursue wider social interests.

The literature of the subject and the studies and reports of international institutions (*inter alia*, FAO, EU) present various options and proposals to organize relations between the business sector and the public sector in the area of digital data management. Their common objective is to make the full use of the digital agriculture potential as much as possible. For many years, international non-governmental organizations have been calling for creating open repositories of data from agriculture and the agri-food sector that could serve to provide global public goods related to food security, environmental and climate protection⁴. What is also indicated, is the possibility for the state to purchase certain databases collected by the private sector, the option of making data available to the state on preferential terms, the implementation of joint projects under public-private partnerships, the exchange of anonymized and aggregated data within closed platforms, funding awards from public funds for individuals and companies ready to solve certain social challenges based on their data resources, or bottom-up initiatives of citizens to provide the state with personal data which was previously processed by private sector companies – civic data sharing (cf. European Commission, 2018).

The latest EU data strategy assumes to take a number of measures to create a common European data space (European Commission, 2020). It is to be based on the free data flow, both among the EU Member States and among various sectors. The common data space is to be created based on respect for European values and rights, such as the personal data protection, consumer and competition rules pro-

⁴ Such an organization is, *inter alia*, GODAN (Global Open Data for Agriculture and Nutrition), which calls for opening access to agricultural and food production data and for guaranteeing the possibility of unlimited use of this data.

tection, care for the development of a fair and competitive economy, promotion of the open, democratic and sustainable society and counteracting social and digital exclusion. The European Commission proposes to adopt, in the near future, regulations that would define data management methods, data access and reuse issues. It is also proposed to collect data from key sectors in European-wide, common data spaces which guarantee interoperability (e.g. in the field of environmental protection and the European Commission's new program for the "Green Deal"). The proposed measures are important for the prospects of developing the digital economy in the EU. They are also essential to strengthening the competitiveness and innovation of the data-driven food economy.

Conclusions and summary

Agriculture and the global food system are entering the period of development, where traditional business models based on maximizing profits at the expense of wider social interests entail growing risks. The imperative of changes is starting to be recognized by the wider public as a result of overlapping concerns related to the long-term consequences of rapid climate change, the unresolved problem of feeding the growing global population and the epidemic of lifestyle diseases. The pressure on the agri-food sector to produce more food with the smaller environmental burden is more and more noticeable. A growing group of consumers is looking for food produced in a sustainable and ethical manner. Also, the possibility of tracking and gaining insight into food production and distribution processes becomes more and more important for consumers. Digitalization and new opportunities related to the development of digital technologies are becoming in this context a huge opportunity for the agri-food sector.

Digitalization in the agri-food sector also encounters specific problems. Some of them, especially unresolved ethical problems, may limit the positive potential of digital transformation in the sector. Farmers have many concerns related to the collection, processing and use of data coming from their farms. The main source of concerns is the non-transparency of the farm digital data management system, including the possible additional purposes of using data collected and the directions of sharing data with third parties which are unknown to farmers. Farmers have doubts about the possibility of enforcing effectively ownership rights to data related to their farms. They are apprehensive for their privacy and have a sense of unequal share in benefits of the development of smart farming. Uncertainty in this area is promoted by the absence of legal regulations that would determine the framework and principles of cooperation among various entities in the data value chain. The practice of smart farming is primarily shaped by provisions of private agreements between farmers and digital solution providers. These provisions may, although not necessarily, include informal guidelines and codes of good practice with regard to farming data management, developed at the sector level. What is currently needed, is a wide-ranging discussion involv-

ing various communities and regarding the vision of digital transformation in the agri-food sector. Recent initiatives in the EU show that more comprehensive regulations on digital data management in various sectors, including the agri-food sector, may appear soon. It is important for these regulations to form stable foundations for the development of the agri-food sector based on data exchange and digital innovations.

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EKONOMICZNE I ETYCZNO-PRAWNE ASPEKTY CYFRYZACJI W SEKTORZE ROLNO-SPOŻYWCZYM

Abstrakt

Celem artykułu jest wkład do dyskusji i badań poświęconych ekonomicznym i etyczno-prawnym aspektom cyfrowej transformacji w sektorze rolno-spożywczym. Poprzednia rewolucja technologiczna (tzw. Zielona Rewolucja) istotnie podniosła wskaźniki wydajności i produktywność w rolnictwie. Równocześnie jednak doprowadziła do wielu negatywnych konsekwencji środowiskowych. Pogłębiła również nierówności dochodowe w sektorze. Zdaniem niektórych badaczy obecna rewolucja cyfrowa, w istocie oparta na intensywnym wykorzystaniu wiedzy, może odwrócić niekorzystne zjawiska wywołane poprzednią rewolucją. Jednakże nie brak też dowodów wskazujących, że technologie cyfrowe prowadzą do nowych podziałów społecznych i większej skali nierówności na świecie. Wiele produktów i usług cyfrowych powstaje w oparciu o wykorzystanie danych, do których prawa własności pozostają niejasne. Równocześnie postępujące procesy cyfryzacji wydają się istotnie zwiększać ryzyko naruszeń prawa do prywatności. W artykule omówione są korzyści, problemy i możliwe ryzyka związane z procesami cyfryzacji w sektorze rolno-spożywczym. Szczególna uwaga poświęcona jest aspektom etycznym gromadzenia, przetwarzania, udostępniania i wykorzystywania danych cyfrowych z systemów rolnictwa inteligentnego (smart farming). Stawiana jest teza, że potencjał rewolucji cyfrowej w sektorze rolno-spożywczym nie jest w pełni wykorzystywany. Wpływa na to wiele czynników – m.in. brak regulacji prawnych dotyczących zarządzania danymi cyfrowymi gromadzonymi w sektorze rolno-spożywczym, struktura rynku produktów i usług cyfrowych faworyzująca duże i bardzo duże gospodarstwa rolne, niski poziom zaufania między uczestnikami łańcucha wartości danych oraz niedostateczna współpraca sektora prywatnego i sektora publicznego w zakresie wykorzystania i udostępniania danych cyfrowych. Konieczna jest zatem szeroka i angażująca różne środowiska dyskusja na temat wizji cyfrowej transformacji w sektorze rolno-spożywczym. Fundamenty dla rozwoju sektora rolno-spożywczego opartego na wymianie danych i innowacjach cyfrowych powinny uwzględniać wspólne wartości i zasady etyczne oraz potrzebę budowania wzajemnego zaufania między uczestnikami łańcucha wartości danych.

Słowa kluczowe: cyfryzacja, technologie cyfrowe, innowacje cyfrowe, sektor rolno-spożywczy oparty na danych, etyka rewolucji cyfrowej.

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