DIGITALIZATION, ROBOTICS AND GENOMIC RESEARCH OF LIVESTOCK DEVELOPMENT

I. Lozynska, S. Lukash, N. Maslak, A. Brychko

Inna Lozynska, DSci in Economics, Professor of Management Department (Sumy National Agrarian University)

Svitlana Lukash, PhD in Economics, Senior Lecture of Public Management and Administration Department (Sumy National Agrarian University)

Nataliia Maslak, PhD in Economics, Associate Professor of Finance, Banking and Insurance Department (Sumy National Agrarian University)

Alina Brychko, PhD in Economics, Associate Professor of Public Management and Administration Department (Sumy National Agrarian University)

ABSTRACT

The article explores the scientific, innovative and technological trends of livestock development, such as: digitization, robotics and genomic research. Were highlighted the restraining factors of the widespread introduction of digitalization and peculiarities impact of genomic research on the development of livestock products. Also was analyzed the evolution of technological stages of introduction the innovative technologies for maximum automation and robotics of all technological processes. This approach provides the farms with the necessary tools and leverage to make the decisions to improve milk quality, manage the herd, increase cow productivity and profitability of production, outlining the overall synergistic effect.

Keywords: digitalization, farm management, modern technologies, agrarian production, robotics, genomic research, livestock development

INTRODUCTION

The scientific and technological progress that underpins the evolutionary changes of technics, technology, organization and management of production processes is an integral part of modern economic development of any society. Technological updates as the process of production and management, acting basis effective functioning of the economic system and guarantee increasing the competitiveness of the latter in a changing market environment. The level of technology has integrated impact on economic, technical, technological, social and environmental aspects of agricultural enterprises activity. To improve the sustainability and competitiveness of livestock production in Ukraine it is necessary to distinguish the following current world trends: digitalization, robotics and genomics. These processes are spreading to an

increasing number of processes and phenomena occurring in agribusinesses, which require relevant research and make them relevant.

Digitalization of agriculture is needed to improve the efficiency and sustainability of its operations by changing the quality management of technological and decision-making processes at all levels of the hierarchy, based on modern production methods with the using of information on the current state and forecasting of possible changes of control elements and subsystems, as well as economic conditions in agriculture. The best practices and experience of successful domestic farmers show that the use of modern digital technologies allows us to form optimal conditions that ensure a significant increase in animal and labor productivity, reducing material costs for fuel, electricity, veterinary drugs, other types of costs, conservation of soil fertility and environmental protection.

RESULTS AND DISCUSSION

The first stage of the introduction of computer and electronic equipment for the management of agricultural complex was called automation. It was quite a long period of creation of various automated control systems and automated process control systems.

The second phase involved the emergence of personal computers and fairly efficient electronic sensors in the early 1980s. At the suggestion of GDR leader E. Honnecker, the process of introducing these devices was officially called electronics.

From the mid-1990s began the third stage of development called informatization. Technically, it is related to the proliferation of personal computers and the Internet. Together with computers came a variety of software, including not only accounting systems but also ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), SCM (Supply Chain Management), EAM (Enterprise Asset Management), etc.

Unfortunately, nowadays there are some factors in Ukraine that are holding back the digitalization of the agricultural economy in general and livestock production in particular:

- lack of a unified approach to the standardization of processes, forms and formats for collecting, storing and transmitting complete and up-to-date information on land, natural factors, available resource base, labor market, capital involved in agricultural production;
- high deficit on the labor market specialists able to work effectively with innovative digital technologies;
- lack of documents governing long-term forecasting and planning for agricultural development;
- lack of legal framework and practice of interagency cooperation at the regional level;

● lack of national information systems and digital platforms providing agricultural producers and regional executive authorities with a set of spatial data containing the following information:

- reliable information about the origin of products breeding livestock, feeds, fertilizers and veterinary drugs, leading to growth the counterfeiting and can be a result of low productivity and premature death of animals;

- prompt recommendations on the need to start or stop animal care processes according to gender groups;

- the total cost of implementing the innovative technologies, taking into account all operations, follow-up services, personnel costs, etc;

- information on the economic potential realized as a result of introduction the complex of end-to-end digital products and technologies.

● lack of training programs for professionals in the use of modern innovative technologies for gathering and processing information on the status of land use in agriculture [1].

Decision problems hindering the digitization of agriculture, is part of a nationwide complex task of rural development, which includes the need to develop the layout and specialization of agricultural production. These problems include:

● lack of financial resources to implement information technology in most agricultural producers. In the agrarian sector was created the so-called bipolar economy, where one pole are highly profitable farms with wide access to efficient technologies, but on the another pole are farms that are on the verge of payback with using outdated technology;

● shortage of skilled personnel. According to the Ministry of Economic Development, Trade and Agriculture of Ukraine, there are just half as many IT professionals working in agriculture than in countries with traditionally developed agribusiness.

● underdevelopment of digital infrastructure in rural areas, especially in the rural hinterland. Radical changes are taking place in this area, but still persists the digital inequality between the city and the countryside;

● imperfection of legal regulation in development the information technology in agriculture. The issues of development the state information support system in agriculture are regulated only by declarative statements of the Cabinet of Ministers of Ukraine and by the creation in November 2019 the Ministry of Digital Transformation of the Economy [2].

EXPERIMENTAL

The most widely used in livestock breeding are the elements of digital agriculture such as smart light management systems, microclimate, feeding, manure removal, veterinary

administration, automated control systems and accounting for daily gains, etc. But it is necessary to develop farms with automated control systems, the parameters of which vary depending on the microclimate and the state of animals on farms.

Table 1. Comparative characteristics of milking systems efficiency

	Livestock dairy cows			
	Up to 200	200-500	500-100	More than 1000
Type of milking machine	tree	parallel	Carousel, dairy robot	Carousel, dairy robot
The average% automation of retention and milking processes	12%	45%	73	76%
The level of commodity production,%	74.5	79.5	91.2	95
Investment cost per head, US $	913.6	1289.9	2111.3	1981.1
Average return on investment, years	8.9	6.1	5.6	4.6
Profitability of activity,%	39.9	46.6	55.3	64.5
Total bacterial contamination, thousand pieces / cm3 (National standard DSTU 2661: 200X is 100)	120-140	85-103	50-85	20-50

Source: own research

Robotic milking has been associated with the development over the last 20 years of the concept of "intelligent farm", which aims to create the foundation for future dairy farming. In essence, it is the desire to accelerate the process of transition from habitual milking management to managing the overall profitability of the dairy farm by using new decision-making tools and automation technologies to improve milk quality and profitability, as well as product competitiveness [3].

The term "intelligent farm" was proposed by the Swedish company DeLaval for innovative technologies of cost-effective milk production based on the system of automated and robotic milking of cows. A little later, other companies that came to the market with similar technological innovations began to use it as a common concept of the idea of integrated production management to ensure its efficiency.

The concept is based on innovative technologies of maximum automation and robotization of all technological processes that provide the farm with the necessary tools, as well as leverage to make the necessary decisions to improve milk quality, herd management and increase the productivity of cows and profitability of production [4].

The voluntary milking system using robotic boxes and milking parlors is one of the basic concepts in the smart farm concept, which encompasses the principles of building a balanced farm as defined by DeLaval:

• create solutions that meet the environmental requirements of safe production;

• not to harm animals;

• benefit consumers and society at large.

The latest smart farm concept is an integrated production management suite that includes 8 components of the interconnected technology cycle (Figure 1).

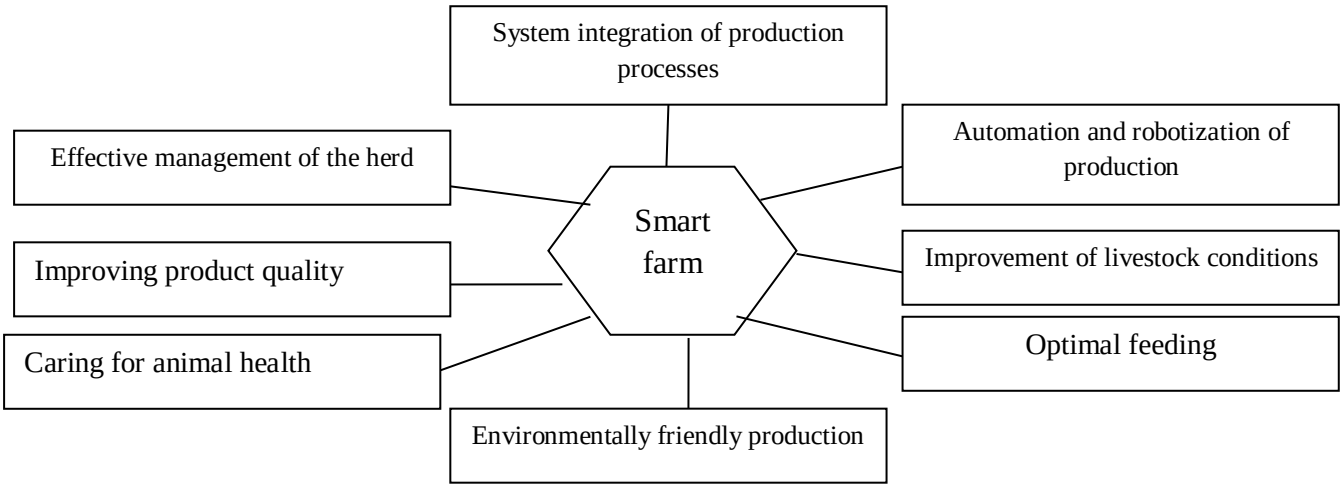

Fig. 1. An innovative concept for the development of robotic livestock

According to various experts, there are already more than 60,000 farms with automatic milking systems in the world today. The most common robotic milking in cows in Europe. In particular, a significant number of milking robots are concentrated in Denmark, the Netherlands, Germany, Sweden, the United Kingdom and France. The forecast for the development of the livestock market in 2020-2026 showed that the volume of the dairy farm robotization market in Ukraine in 2023 will reach $ 2.5 million. The global market for milking robots is currently estimated at around $ 120 billion [5].

The main advantage of milking robots compared to traditional systems is the ability to work around the clock for 24 hours, of which 21 hours are spent on the voluntary milking process and 3 hours are required for two cycles of washing and cleaning of the laser sensor. Let us dwell in more detail on the general characteristics of the herd of a robotic dairy farm (Table 2).

Table 2. Milking performance of cows during milking with or without milking

Indicator	Indicator value	
	using a robot	without using a robot
Total milking time, min	4.82	7.13

Total one-time milk hope, kg	11.27	8.9
Average intensity of milk production as a whole for milking, kg / min	2.57	2.11
The maximum intensity of milk production, kg / min	3.88	3.43
Average milking intensity for the first three minutes of milking, kg / min	3.01	2.66
The degree of milking cows,%	89.6	82.2
The length of time from the beginning of the preparation of the udder to the connection of the milking machine, p	116.2	88.9

Source: own research

In addition to using the robot to improve all milking performance (from the total milking time to the average milk production rate), it is worth noting that increasing cow milking by up to 90% helps reduce cow disease with mastitis on modern dairy farms. Many years of experience and research findings in the field of mastitis diagnostics and prophylaxis indicate that the total incidence of cow disease for mastitis in herds should not exceed 15% [3]. According to the computerized zootechnical accounting of a robotic dairy farm, the incidence of mastitis cows on a robotic dairy farm does not exceed 15% and is only 5.5%.

Population growth and a changing climate are straining the limits of modern agricultural practice. Genomics provides powerful tools to address the need to develop strains of crops and livestock breeds that can support increased food production by resisting pests and diseases and reducing the ecological footprint of traditional farming. Application of genomics is one of the most perspective directions in agriculture on the way of future transformation. The ability to read genome sequences coupled with technologies that introduce new genes or gene changes now allow people to speed up the ability to select for desirable traits in plants and animals [6]. Agrigenomics has and will continue to drive sustainable productivity and offer solutions to the mounting challenges of feeding the global population. Every farmer needs to find a little extra advantage to make their herd profitable and to increase competitiveness. Using modern technology, farmers, breeders, and researchers can easily identify the genetic markers linked to desirable traits, informing cultivation and breeding decisions. One of the greatest opportunities that we can have with genomic selection is separating the traditional relationships that exist between positive and negative traits. For example, high-production animals traditionally have more difficulty on the fertility side. If we can identify those animals that carry genes for high production and the right genes for good fertility, we can introduce more of those animals into our populations [7].

Genotyping technologies are revolutionizing animal husbandry. Genotyping allows the farmer to increase the quantity and quality of his produce. Genomics can be used to accelerate

the genetic improvement of livestock characteristics such as milk yield, meat quality, reproductive life, resistance to diseases. The process of genomics consists in using DNA markers that are associated with the desired traits to identify the animals with the highest potential and to select those for production and breeding. This type of genomic breeding has quickly become a key strategy for breeders and growers to reduce costs and increase the productivity of their herds across a range of species [8].

The bovine genome, completed in 2009, has provided the beef and dairy industries with powerful tools to undertake genome selection to improve desirable traits, including complex traits like health and fertility that could not be assessed using traditional methods. Within two years of completing the bovine genome, a new class of genomics evaluation tests became required information for all bulls presented as sires for artificial insemination (AI). This drastically reduced the time and cost of bringing AI bulls to market, and improved the accuracy of genetic predictions of traits over classic progeny-based evaluations, which are based on performance data on hundreds to thousands of AI daughters. The use of these tools has already provided annual benefits of over $180M to Canada. And there is still much more potential for innovative uses of this genomic resource. In Nova Scotia, Performance Genomics Inc. is working with a global animal health leader to validate and commercialize a genomic marker test that allows farmers to select dairy cows with longer reproductive lifetime potential. Cows that have more pregnancies produce more milk per cow, and need to be replaced less often, so dairy farmers can derive more economic value from fewer cows while reducing financial costs and lowering environmental impacts [9].

Good breeding is crucial to animal husbandry, and genomic selection will ensure that the semen used for such insemination continues to produce better offspring.

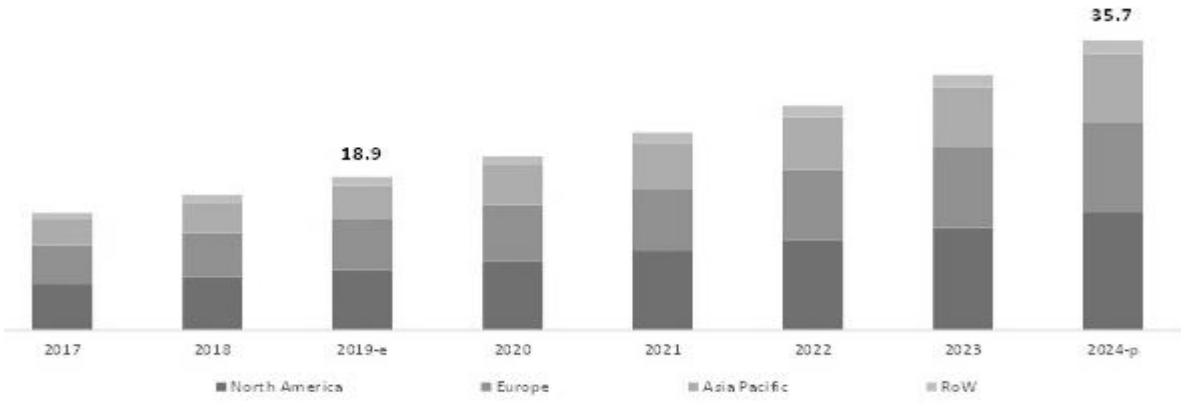

Fig.2. Genomics market by regions, USD billion [10]

On the basis of end user, the market is segmented into research centers and academic & government institutes, hospitals and clinics, pharmaceutical and biotechnology companies, and

other end users. The research centers and academic & government institutes segment accounted for the largest share of the market in 2018. The large share of this segment can be attributed to the increase in research intensity in this end-user segment and the rising funding for research.

North America accounted for the largest share of the genomics market in 2018. Much of North America is associated with increased funding for genomics research and government initiatives. On the other hand, the Asia-Pacific market is expected to witness the highest CAGR over the forecast period. So we can find the main targets of genomics using:

- Provide better detection and treatment of diseases using a data-based approach through the development and use of sensor technologies and prognostic algorithms.

- Accelerate genetic enhancement of resistance traits (such as fertility, increased feed efficiency, well-being, and disease resistance) in livestock, poultry, and aquaculture populations, using large sets of genotypic and sequential data related to field phenotypes, and combined reproductive technologies and methods of accurate breeding.

- Identify objective indicators of the sustainability and well-being of animals, how they can be incorporated into precision livestock systems, and how the social sciences can inform and translate these scientific findings to facilitate consumer understanding of trade-offs and enable them to make informed purchasing decisions [11].

CONCLUSION

The conducted research suggests that digital technological changes have a significant impact on the functioning and economic development of agricultural enterprises. The introduction into practice of livestock breeding producers of modern digital technologies is the main driving force of progress. The new model of economic growth of livestock breeding enterprises, based on the information-digital type of development, involves changing the overall paradigm of production process management. The priorities of the digital component of development are intellectualization of production and management activities, environmental friendliness, use of modern technologies, digital assistants, updating of technical and technological base and so on.

One of the main obstacles hindering the implementation of robotic milking projects in Ukrainian farms in Ukraine is its high cost. According to the criterion of comparing the cost ratio of one conventional place in livestock premises based on cows, robotic voluntary milking stations are much inferior to the function of a modern automated milking parlor, even in the equipment line of the same company.

Today, only agro holdings or large agricultural enterprises can afford to purchase a robotic voluntary milking system. The cost of equipment due to the devaluation of the hryvnia

has increased significantly over the last year, but it is not absolutely unbearable for an investor who wants to produce high quality milk.

However, without the introduction of such technologies, it will be difficult for the domestic dairy industry to compete not only for the possibility of exporting dairy products to the markets of other countries with sufficiently rigorous criteria for its quality and food security, but also to maintain a position in the domestic market.

The list of economic benefits of using robotic milking technologies include, but are not limited to:

• a significant increase in the quality of the milk obtained, which meets all the environmental requirements of safe production of products and, accordingly, its price is always higher;

• Improvement of livestock conditions, reduction of diseases and prolongation of their economic use;

• improving the milk productivity of the actual herd, which generally provides more income per cow;

• savings on the need to build a milking parlor, as this technology can be implemented through the reconstruction of existing livestock facilities;

• efficient and flexible use of working time and reduction of labor input in the cost of production;

• benefit consumers and society as a whole.

Genome-based analysis, which expands the knowledge of the genetic basis of production traits, will lead to the development of new technologies that optimize animal breeding strategies and will make management decisions to maximize the production potential of animals in different conditions. Increased productivity and selection of heifers drive farm efficiency and competitiveness.

Thus, modern digitalization processes cause competition of national economies for a worthy place in the global ranking and mobilization of all the state's possibilities for adaptation of domestic enterprises to modern technological trajectories of development.

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