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Artificial Intelligence and Innovation Management as a Factor of Competitive and Innovative Improvement of Agricultural Companies

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Abstract

The article discusses the characteristics of innovation management in agricultural companies and the role of artificial intelligence in this process. Modern agricultural companies should pay more attention to introducing innovations based on artificial intelligence (AI) into their management processes. However, to date, the management of such companies demonstrates a lack of understanding of the changes required and the impact of AI-based innovation management, alongside an overabundance of interpretations of AI's potential based on perception rather than fact in the field of innovation. Thus, as part of expanding the concept of introducing management innovations and AI in agricultural companies, it is necessary to study the cause-and-effect relationships between the necessary preconditions and their impact on the management of AI-based innovations in these companies.

Keywords: artificial intelligence, innovation, agricultural companies, innovation clusters, consultancy.

Introduction

One of the global processes of our time can be called the rapid informatisation of all economic systems, the transition from a post-industrial to a digital economy, an economy of knowledge and innovation. In some industries, this process occurs faster; in others, agriculture is the most accurate example: much slower. Agricultural production relies on the use of natural resources and biological transformations of plants and animals, which cannot be significantly altered without harming people and the environment. Natural, biological processes in agricultural production do not allow agricultural producers to keep pace with innovations in other industries, which has led to the so-called "long-term problem of agriculture" and the withdrawal of qualified personnel from agriculture. Not only the system of higher and secondary agricultural vocational education, but also information consulting for agricultural companies and workers is called upon to preserve the personnel and labour potential of agriculture.

The prospects for artificial intelligence (AI) in business and the global economy are pretty broad. The idea that artificial intelligence – and machine learning in particular – will increasingly match or surpass human capabilities, take over service roles, fundamentally transform the operational core of business, and change the way people manage themselves has significant potential (Torikov, 2022). In general, AI is expected to enhance human capabilities, complete tasks or solve problems faster, produce better results, and increase efficiency.

AI is not just a new technology that can create revolutionary products and services and transform existing processes to make them faster, cheaper, and better; it is considered the most important universal technology of our time. Artificial intelligence is expected to transform every industry, including agriculture, just as the internet did 30 years ago and electricity 100 years ago, leading to an estimated $13 trillion increase in GDP by 2030. (Keding, 2021)

According to EV Ivanova, agricultural consultancy is the activity of consultants to provide necessary services to agricultural producers and the countryside population to master new knowledge, such as artificial intelligence, new technologies, selection and genetic, marketing, organisational, economic and socio-ecological innovations in order to achieve an economic, social and environmental effect (Ivanova, 2017).

The crucial role of consultancy in modernising agriculture in the information age

The specifics of information and consultative activities in agriculture arise from the objective characteristics of the industry. The most significant differences in the agricultural industry are based, first of all, on the natural and biological characteristics of agricultural production (the use of land as the main means of production, the use of biological objects (plants and animals) as objects of labour, dependence on zonal and natural biological conditions, etc.). Natural and biological characteristics also determine the technological and technical specifics of the industry (seasonality of production, the duration of technological cycles, the mobility of most means of labour, the diversity and irreplaceability of factors influencing the result of production, etc.).

From the point of view of modernisation and consultancy activities, the following distinctive features of agriculture can be identified:

– As land resources are depleted, extensive factors in agriculture should give way to intensive factors, which makes it possible to obtain more products per unit area.

– The level of specialisation of agricultural companies in general is much lower than in other production sectors, which is associated with the need for rational land use and the seasonality of agricultural production.

– Small and medium agricultural companies, as well as private farms, are not able to independently implement a package of measures for the development of production, which require significant capital investments.

– The significant duration of the technological cycle and the dependence on natural and climatic factors make it impossible to predict production results, and the long period of time between material costs and their results leads to the need for widespread use of the credit mechanism.

– Due to the relatively small size of most agricultural companies, many production and economic functions in the industry are performed by specialised services (machine and tractor stations, agrochemical services, construction organisations, etc.).

– The characteristics of crop production and the development of scientific and technological advancement increase the need for farms for highly qualified personnel or professional consultations.

– in crop production, to a greater extent than in other industries, reproductive funds are formed from own products, as a result, in order to ensure uninterrupted production, it is needed to create insurance funds of significant size.

– under the conditions of different forms of ownership in the farming sector, special forms of influence from the state are necessary (implementation of technical and scientific policy, provision of an information base, tax and credit measures, etc.) (Bondarchuk, 2021).

The analysis of the category of information and advisory activities in the domain of crop production makes it possible to differentiate it according to the areas of advisory and the corresponding functional purpose. Information and advisory services, depending on the scope of consulting, may have the following functional content:

– in the domain of training and education – transfer of experience;

– in the domain of clarification and information – dissemination of knowledge, generalization of experience, clarity, analytical skills;

– in the domain of consultancy – regulation, individualization;

– in the domain of assistance, dispute resolution and representation of interests – assistance in the implementation of decisions and their implementation (Kalachevska, 2017).

Information and advisory services should be structured depending on the type of advisory service itself (public, private, mixed - with state participation), since the precise determination of the range of activities of various types of advisory institutions makes it possible to optimize the organization of information and advisory services both for individual regions and for the agricultural industry of the entire country.

In this case, it is essential to observe the principle of priority provision of general services by state institutions and institutions with state participation, as well as special services by private organizations.

Government institutions must perform the following tasks: development and implementation of national and regional programs; training, consulting and advanced training of both managers and specialists of agricultural companies, as well as specialists of regional consulting offices; assistance in requesting and obtaining preferential credit resources; consulting on current industry issues; collection of statistical information and formation of a regional data bank; control over compliance with environmental standards and production quotas, etc.

Mixed-form institutions (with state participation), which include services organized on the basis of large regional industrial universities, research institutes, farmers and other professional associations, should be engaged in applied consulting on issues of agriculture, rural economy, development of family farming, programs for rural youth, natural resource management.

The competence of private organizations in the domain of information and consultative activities must encompass a wide range of purely practical services: consulting, diagnostics, analytics, design.

Information and advisory activities in any form represent an important factor in the sustainable and efficient development of the agricultural industry of the economy, combining science and practice and presenting scientific developments in the form of information accessible to certain consumers.

Agricultural innovation through artificial intelligence and the role of regional innovation and consultancy centers

Artificial intelligence will fundamentally change the way companies operate and compete. AI will also challenge the basic axioms and assumptions that underlie the innovation process and its management. The underlying hypothesis is that AI can transform innovation management practices by making the innovation process much more efficient and effective, thus opening up a new era of innovation. However, knowledge about how to apply AI to manage innovation in agriculture is still scarce, and managers struggle to find the most appropriate approach to apply AI to their innovation efforts.

Meanwhile, the more prepared and informed agricultural producers and countryside residents are, the faster the process of innovative progression of the agricultural industry of the economy goes, both at the point of the entire country and its individual regions. One of most effective directions in the sphere of improving information and consultative activities in regional agro-industrial complexes is the organization of regional innovation centers. The main purpose of the activities of such centers is to create favorable conditions for rising the innovation of all subjects of the industrial and regional economy, if the agro-industrial complex belongs to one of the budgetary industries of the region. At the initial stages, the regional management body performs the functions of a coordination center, and later occupies an advisory function, subordinate to the formed innovative infrastructure unit. The regional system of information and consultancy services should be considered primarily as an open system that receives resources from the external environment and, generating them, creates the final product (Figure 1).

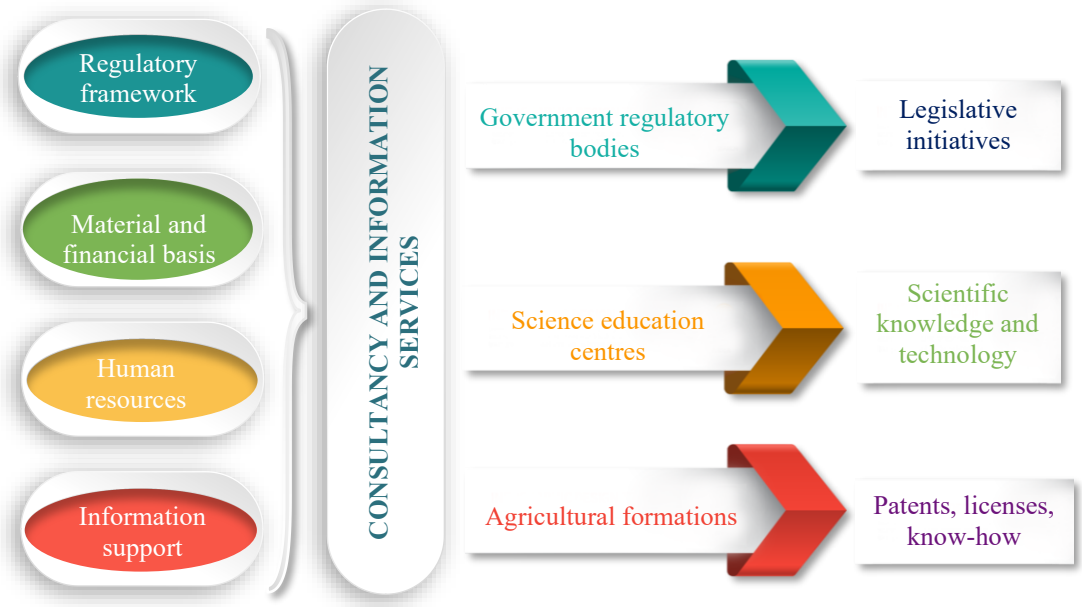

Figure 1. Structural model of information services and system consultancy agro-industrial at the regional level

Source: drafted by the authors based on materials (Donets, 2018)

Understanding how to manage innovation is fundamental, especially when innovation is essential for corporate growth and competitive advantage of an agricultural

company. The innovation process typically describes the sequence of different activities carried out to realize an opportunity and bring an idea to market (Skvortsov, 2020).

The creation of regional innovation centers will make it possible to bring innovations to agriculturally oriented regions at the level of introduced technologies and products, will ensure the search for strategic partners, will stimulate companies and the population to innovative activities, will help attract investments in the innovation sphere, and will produce an additional effect as a result of increasing innovative activity and the interest of companies in using artificial intelligence services. The scheme for promoting information and advising services on the regional agricultural market, implemented by regional information and advising services, is presented in Figure 2.

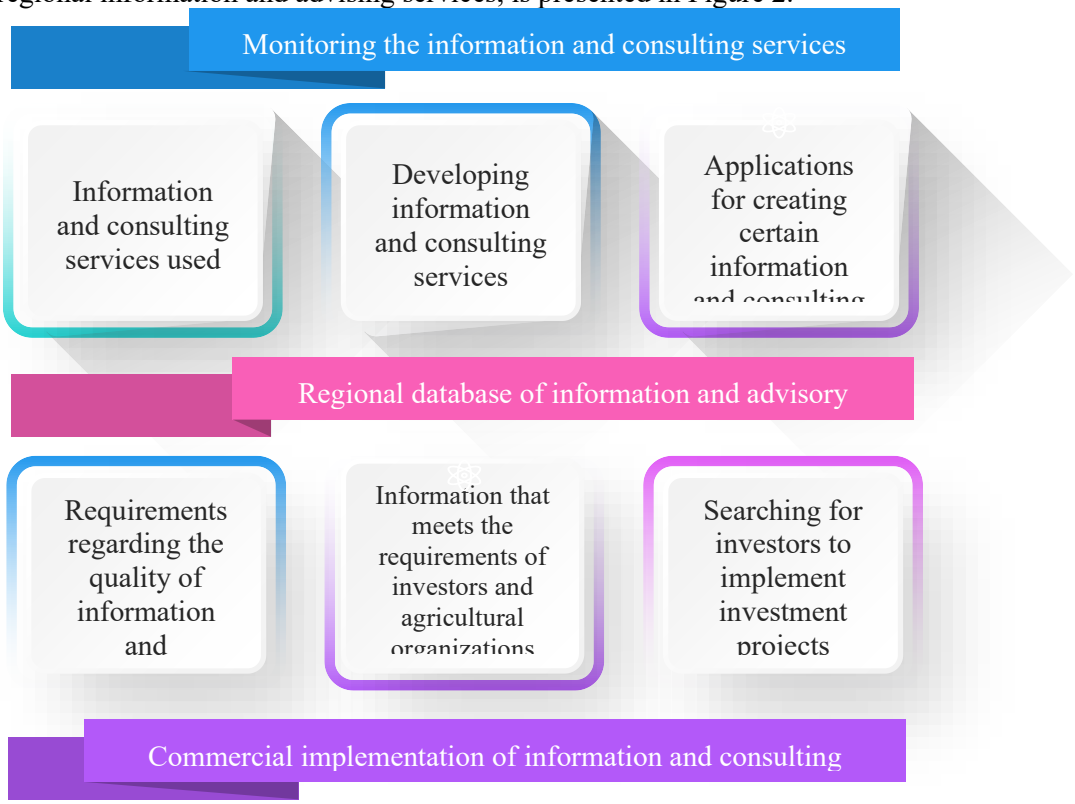

Figure 2. Scheme for promoting information and consultative services on the regional market in the information and consultative system of the agro-industrial system
Source: drafted by the authors based on materials (Donets, 2018)

The designed regional innovation centres can include both information and consultative services only for the agro-industrial system, or for other sectors of the economy, depending on the region's production specialisation. In regions where agricultural information and consultative services already operate, the proposed schemes can be used to develop comprehensive, systematic approaches to information and consultative activities.

Dynamics of the innovation process: stages and approaches in innovation management

Literature on innovation management has attempted to adopt different approaches to managing innovation or the broader research and development processes, with different stages

from idea generation to product implementation and launch. Experts say that innovation consists of two parts: the generation of an idea or invention and the transformation of that invention into a business or other useful application. Innovation includes all stages from technical invention to final commercialization (Brynjolfsson, 2017).

To better represent the complexity as well as the variety of activities within the innovation process, scholars have taken a more granular approach and divided the innovation process into different phases, ranging from three to seven. For example, one group of authors illustrates the innovation process as involving four stages:

– *search* – analysis of the internal and external environment and management of relevant signals about threats and opportunities for innovation;

– *choice* – a decision based on an innovation strategy, how the organisation can respond to signals;

– *implementation* – introduction of relevant ideas for the development of new products and services;

– *training* – creating a knowledge base and continuously improving the innovation process within this cycle (Chesbrough, 2017).

Another group of researchers proposes a seven-stage technological innovation process: opportunity recognition, idea formulation, basic applied research, solution prototype development, standardisation, production, and commercialisation. In addition, the literature suggests five stages: initial design, commercial evaluation, development, production launch, and initial commercialisation (Panteleeva 2021 & Kolmykova 2021).

The evolution of innovation management in agricultural companies

As innovative agricultural companies adapt their innovation processes and determine the sequence and granularity of their activities, different approaches to innovation management have evolved over the years, from simple linear models (first- and second-generation) to increasingly complex interactive models (fourth- and fifth-generation) (Haefner, 2021).

In the first generation (1950s), known as the technological breakthrough, new technological capabilities increased productivity across various sectors and industries. Companies focused on research and development to further improve products.

As competitive pressure increased over time, it became clear that technological advancement was failing the new market conditions, and the second-generation innovation model, also called the market pull model (1960s), was developed. While the technology push model emphasized research and development, the market pull model incorporated a market focus into the innovation process to overcome the technological push's blindness to customer needs. In this generation, most companies adapted existing products to meet changing customer requirements. In doing so, companies began to suffer from the continued weakening of research and development and risked being left behind by radical innovators.

To counter these shortcomings, the third generation (early 1970s) - the two-stroke innovation - developed a combination of technology and market appeal.

Over time, as markets became more international, competition intensified, and product life cycles shortened, it became clear that the pace of development was necessary to remain competitive. The fourth generation emerged (mid-1980s), focusing on integration and parallel development, and was therefore also called interactive parallel processing innovation. While traditional innovation approaches, such as the popular gateway model, were designed to develop new products under stable and predictable conditions, companies must adapt to unpredictable

events in the face of change. Faster product life cycles, ever-changing customer needs, new technologies, and high uncertainty force companies to capitalize on current competitive advantages while exploring new potential advantages.

Advances in information technology (IT) have contributed to the further development of the innovation model and have stimulated integrated and parallel product development (Sharapova, 2021). Thus, the fifth generation (2000s–present) – integrated electronic innovation – focuses on integrating IT tools to accelerate the innovation process and increase flexibility.

Digital transformation in agricultural innovation management: from skills and structures to advanced AI strategies

The innovation management literature also explores open innovation approaches to develop collaboration with internal and external partners, such as universities, research institutes, companies from various industries, and start- ups as sources of inspiration and innovation. Various agile and flexible innovation formats, such as innovation labs, improvisation sessions, start- up boot camps, corporate incubators, and accelerators, have evolved to encourage agility in innovation management and capitalize on the start- up mindset (Keding, 2021).

Over the years, companies in the farming sector have experimented with different approaches to innovation process management, ranging from quite rudimentary approaches to more complex and sophisticated innovation management systems. However, artificial intelligence can take the innovation process from idea to launch to the next and more advanced stage, the sixth.

Machines powered by artificial intelligence are already capable of solving many problems that not long ago were considered "human" tasks requiring human knowledge. For example, in agriculture, machines can identify complex patterns, synthesize information, draw conclusions, make predictions, or perform problem-solving tasks (Skvortsov, 2020).

Intentional innovation management is a complex task. It requires a solid innovation strategy, an effective organizational structure, and dedicated people with the right mindset, skills, and innovation tools. Experts identify three critical aspects of successful innovation management in the agricultural industry: skills, structure, and strategy (Keding, 2021).

1) *Competencies.* Attracting the right people with the right skills and mindset is essential for every innovative company. Innovative AI projects need dedicated people with the right skills and knowledge. Formalized expertise and subject matter experts from diverse backgrounds, such as data scientists, developers or IT infrastructure engineers, are the means to realize the opportunities created by AI technology. Agricultural companies also rely on existing staff who must skillfully apply the technology to innovative tasks and processes.

Training to drive interest should target potential AI developers with more technical experience, decision-makers, and employees on a broader scale. Strong integration of people and technology, as well as appropriate management actions to maximize productivity, are important success factors in managing AI-based innovation.

2) *Structure.* Organizational structures are essential for organizational performance because they influence the ability of companies to act and respond effectively. They reflect the formal pattern of relationships, communications, decision-making processes, procedures, and systems, and therefore contribute to the ability of companies to adapt to change, learn, or innovate. The internal structures of companies have evolved, and the most common structures are functional companies—with a hierarchical division of labor between workers and their

managers—and matrix companies, which maintain functional specialization while improving cross-functional integration.

The adoption of a particular organizational structure depends largely on the context of the organization - the nature of the business the company is engaged in. While functional structures focus on high performance in stable environments, matrix structures are better able to cope with uncertainty and change in dynamic markets.

Organizational structures also show how information and knowledge are distributed within a company, which further influences its effectiveness. Decentralized organizational structures are chosen when the decision-making process is divided into several divisions or departments, each of which makes its own decisions. In contrast, in centralized organizational structures, decisions are made at headquarters and throughout the company.

3) *Strategy.* An innovation strategy is required to cope with a complex, constantly changing external environment characterized by significant uncertainty regarding current and future technological developments, competitive threats and market demands. To overcome the aforementioned challenges and to stimulate innovation, agricultural companies can increasingly use AI in their innovation strategy.

Agricultural companies need to understand how AI contributes to value creation and how AI contributes to the overall strategy as a driver of digital transformation. Furthermore, a company's strategy determines its position as a leader, follower, or imitator. Therefore, companies need to determine what resources they need and how much they are willing to dedicate to managing AI innovation to achieve their goals.

Many agricultural companies struggle with allocating adequate resources to manage innovation. The research identifies three levels of innovation objectives:

1) improving the companies' core offerings;

2) searching for related opportunities;

3) enterprises in a transformational, often destructive territory (Brynjolfsson, 2017).

Farmers show a strong preference for innovative core offerings (70%), complemented by a few discoveries for adjacent capabilities (20%), and only a small share (10%) for transformational innovations. Consequently, as the researchers note, such companies in practice usually understand how to manage incremental innovation (and spend 80-90% of their technology budgets on upgrades, modifications, and extensions) but often struggle with more exploratory innovations and fail to manage them. (Haefner, 2021) These studies suggest that most agricultural companies focus on incremental innovation and allocate relatively small budgets to the transformational level, indicating a rather low level of innovation ambition.

Conclusions

In modern agricultural production, information and innovation are factors no less important than land, labor and capital, and the difficulties in their quantitative measurement and provision of a personalized form and type require the establishment of a certain system, which is ensured by information and advising activities and the introduction of AI solutions. The main purpose of the activities of information and consultive services in the agricultural industry of the economy is the dissemination of special knowledge, the introduction of modern achievements of science, technology into production, the provision of information and advising services to agricultural producers and monitoring the market of information and consultive services. The agricultural advisory system in agrarian-oriented regions should become the most important tool for the dissemination of specialized knowledge and market information among agricultural

producers and the countryside population. Information and innovation activities of agricultural advisory services through artificial intelligence are a hopeful direction for the growth of modern agricultural consulting and one of the most important directions in the formation of an information and innovative support system for agricultural production.

The problems associated with AI will require additional efforts from agricultural companies to become more open to the external environment.

Consequently, we can conclude that the impact of AI on the innovation process is different from the impact of traditional digital technologies. In addition to accelerating and streamlining what people already do, AI can enable data-driven innovation and even automate problem solving without the need for humans. Thus, the focus of innovation teams can shift from carrying out certain types of innovation activities and designing the innovation process to developing AI-based innovation tools that can assist or even automate innovation activities for them.

From an organizational perspective, a key challenge for innovation is developing the most appropriate process and structures that will fit the specific task and context. Current innovation practices suggest that agricultural companies should not automatically follow a best practice but rather adopt widely applied models and manage their innovation processes based on company-specific contexts, such as industry, company size, company development stage, or competitive position. It is also consistent with contingency theory, which is attributed to the fundamental assumption that there is no one best way to organize due to various internal and external factors and constraints.

Thus, modern agricultural companies should pay more attention to the introduction of innovations based on artificial intelligence into the management process. However, to date, leaders and managers of agricultural companies demonstrate a lack of understanding of the necessary changes and the impact of AI-based innovation management, along with an overabundance of interpretations of the potential of AI based on perception rather than facts in the area of innovation. Accordingly, as part of the development of the concept of introducing management innovations and AI in agricultural companies, it is mandatory to study and learn from the best and worst practices, as good as to study the cause-effect relationships between the necessary prerequisites and their impact on the management of AI-based innovations.

Also important in this context is the study of critical success factors or the real impact of AI-based innovation management on innovation outcomes. Since AI innovation management depends on technical and organizational aspects, these aspects may deserve special attention, as they can determine the extent and timing of the transition to AI innovation management.

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