# ОСОБЛИВОСТІ РОЗВИТКУ СВІТОВОГО ГОСПОДАРСТВА

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## LOGICAL DIMENSIONS OF ECONOMIC RISKS

***The article examines the economic nature of risks due to the interaction of local (internal and external) and global factors that influence the course of economic events. Logical dimensions of economic risks are considered mainly in the context of probabilistic approaches formulated by K. Popper and J.M. Keynes. Applied aspects are analysed on the basis of the Bayes conditional probability theorem and decision theory, which considers the maximisation of the expected value, the maximisation of the expected monetary value and the maximisation of the expected utility.***

***Keywords: risk, uncertainty, probability, logical probability, logical proximity, risk analysis.***

**Formulation of the problem.** Studies of the problem of risk were initiated in economic works (F. Knight) and in scientific works on probability and statistics (T. Bayes, D. Bernoulli, P. S. Laplace, K. Pearson, etc.). They consider a set of factors of any system, including economic, analyse the relationship between them, study trends, patterns of their behaviour in the context of the probability of economic, social, technological, environmental risks, and so on. A priori logical-mathematical probabilistic approaches or statistical groupings are used at that. J. M. Keynes explored the question of probability, paying more attention in his economic works to the problem of uncertainty, being the one of the main principles of his scientific doctrine. In modern risk management, Bayesian approaches and tools of fuzzy logic predominate.

**Research methodology.** To clarify probabilistic approaches in the riskology system, it is essential to consider the basic principles and economic nature of economic risks. The essence of economic risk, its forms of manifestation are determined by the content and nature of the system of economic relations of the appropriate hierarchical level – from a household to global supersystems. Thus, the neoclassical scientific school prefers the micro level; considering individual behaviour and risks in conditions of limited resources, Keynesian and post-Keynesian schools of thought use a holistic methodology, analysing holistic economic systems and macro-level risks. Behavioural concept gravitates to normative economics, uses an interdisciplinary approach based on a combination of economics and psychology [9; 7]. The elements of decision theory, where economic risk is considered through the prism of the cognitive and psychological capabilities of the subjects to make decisions, may be noticeable in it.

The article aims to clarify the nature, economic content of risks, justify the need to use logical concepts, methods, techniques for identifying risks and their consequences.

**Key findings.** The existing dialectical relationship between risk and uncertainty is unquestionable, but they have different quantitative characteristics. Uncertainty had not had any quantitative measurements for a long time while manifesting qualitative differences, in particular S. Hawking and L. Mlodinow use the term 'fundamental uncertainty' [8, p. 78–79]. At the same time, last century meteorologists proposed four methods for measuring uncertainty. One of them includes the standard deviation, expressed in the probability density functions based on experience or other information [12, p. 25]. Quantitative risk parameters have mostly probabilistic and statistical dimensions. In addition, the literature uses the relationship between the concepts of risk-ignorance-uncertainty [7, p. 5–6; 11, p. 133–134]. Under risk, the probability of certain consequences is assumed; for ignorance – the probability is either unknown or does not exist; uncertainty is articulated as a synonym for ignorance or in a broad sense includes both risk and ignorance with an unknown probability.

Therefore, the economic nature of risks is conditional upon the uncertainty, stochasticity of internal and external economic processes, on the one hand, and the impact of a number of global factors on the economy, on the other hand, the most striking example of which is the current coronavirus pandemic. Taxonomy and classification of internal risks is based on the qualitative and quantitative composition of the economic system of the country, when the main components of its structure – labour, capital, property, resources, institutions, technologies and more – are considered. In the labour subsystem, the risks are associated with the problem of unemployment, the quality of the workforce, with various social movements, with migration processes. In the area of capital, there are risks of profitability, adequate dividend policy, repatriation of profits, deficits or imbalances in the sectoral and territorial distribution of investments. Property risks may be caused by nationalisation and expropriation of means of production, outdated fixed assets and infrastructure, low efficiency of state property, insufficient level of public-private partnership. The resource subsystem creates risks of depletion of certain types of resources, financial component deficit, reliability of food security of the population, risks of outflow or reduction of the intellectual resources level. The institutional area generates risks of inconsistency between the positive and normative vision of the economy, inadequacy of economic policy to the challenges and tasks of sustainable development, lack of proper trust in society, flourishing of a shadow economy, legislative and legal systems imperfection. The technological aspect includes the risk of technological backwardness in the context of the 4$^{th}$ industrial revolution requirements, pushing to peripheral positions in world technological development, the formation of a technological gap in comparison with the leading industrialised countries. The economic nature of internal risks is also determined by the content and nature of the sectoral and territorial structure of the economy, the development of production and market infrastructure.

External risks are related to the level of openness of the national economy, its participation in the system of international division of labour (trade, investment, technology, finance, labour migration), membership in international integration associations and international economic and financial organisations. The experience of recent decades shows that the country's presence in international institutions, groups or close cooperation with the

latter, makes it possible to mitigate the crisis by obtaining loans, credits, free aid.

The following types of economic risks are distinguished in aggregate form: financial, physical (sectoral), environmental, technological [2, p. 153–154].

A generalized, widespread, somewhat simplified definition of economic risk, which is determined by the abovementioned economic processes and factors, is considered to be "the possibility (probability) of deviating from the objective for which the decision was made". Such deviations may be observed at all levels of the economic system – from the household to the global economic dimensions. In the context of the current article, the interpretation of risk as "a combination of a chance event with negative consequences and the probability for that event" is close in meaning [3, p. 4]. The one-sidedness of this definition is to emphasize the negative results while positive economic risks (additional income, increase in investment income, financial transactions, etc.) exist.

Economic risk is defined by such functions as analytical, innovative, regulatory and protective. The analytical function arises from the behavioural concept, where the subject of the economic process analyses the situation and builds alternative preferences based on the neoclassical theory of rational expectations, which considers the whole array of available information. The innovative function is substantiated in the works of J. Schumpeter. It envisages the renewal of production as a result of so-called "creative destruction growth", when crises affect entire sectors of the economy (British coal industry in the 80s of the twentieth century, heavy industry in Germany in the last quarter of the twentieth century, etc.). Instead, new industries are evolving: electronics, computer technology, instrument engineering, robotics, artificial intelligence, and more. The regulatory function is manifested mostly at the level of a firm, an enterprise, when regulation is based on the risk management concept, which involves analysing the ratio of possible positive and negative consequences of risky economic and financial transactions. The protective function has an institutional dimension. It entitles the business entity to open a window of opportunity for risky transactions, on the one hand, and creates the preconditions for risk insurance, on the other.

While studying the problem of risks, such general principles as argumentation, reliability, universality and objectivity are used. The International Organization for Standardization offers 31 methods of risk analysis, mostly of an applied, practical nature in the context of their sources (causes), probability, ranking, determination of consequences, prevention mechanisms, risk negative impact mitigation, etc. The basic principles of risk management are proposed, such as avoiding unwanted risk, risk analysis at appropriate levels, risk perception in case of revenues exceeding costs, use of risk management at all levels of planning.

The basic logic of identifying, assessing and controlling a risk situation involves performing five successive stages (steps). In the first stage, the real and potential possibilities of the consequences of the risks are clarified. The main purpose of this step is to identify the maximum possible range of risks.

The second step is to assess the risks in the context of the probability of possible losses. Quantitative and qualitative parameters that determine the level of risk given the specific hazard are defined. This step determines the probability and severity of an adverse event that could occur in light of the above results.

In the third stage, risk control measures are analysed. Specific strategies and mechanisms that reduce, mitigate or eliminate risk are explored. With effective control, it is possible to reduce or neutralize the assessed risk under three components: probability, severity and impact.

The fourth step results from the previous one and involves monitoring on the basis of preliminary data and mechanisms to determine the level of final risk in the examined areas.

Finally, the fifth stage focuses on monitoring and verifying the life cycle of a system or an activity. Executors of all levels shall perform their respective functions in ensuring constant and reliable control, under which economic processes are periodically examined, the level of effectiveness of risk control is measured.

At one time, F. Knight identified three main ways to determine risks based on a priori probability, statistical probability and largely intuitive estimation [1, p. 21–22]. In further studies of economic risks, issues of economic behaviour associated with risks, the theory of decision-making began to apply the concept of logical probability, which had a deep economic meaning primarily through the inclusion of provisions for determining value, utility and other preferences. The pioneers in this field were J. M. Keynes (1921), K. Popper (1935), R. Carnap (1950), and others. The approaches of these authors were based on the classical concepts of Laplace-Bernoulli probability, the numerical value of which in a simplified version looked like a fraction of the division of the number of favourable cases by the number of equally possible cases. In this case, Popper distinguished three interpretations of probability: subjective, logical-subjective and objective [4, p. 178–179]. Subjective interpretation has a psychological nature, in which the degree of probability is defined as a measure of feelings of authenticity or unreliability, confidence or doubt caused by certain statements or considerations. In the logical-subjective interpretation used by Keynes, the logical component, the so-called "logical proximity", the logical relationship is dominant. For example, the statement $q$ assigns another statement $p$ the probability I if $p$ results from $q$. If $p$ and $q$ contradict each other, the probability assigned by the statement $q$ to the statement $p$ equals 0. Between these extremes there are other probability relationships, which may have a numeric expression. Thus, the numeric probability $p$ for a given $q$ is the greater, the less its content goes beyond what is already contained in the statement $q$, on which the probability $p$ depends, and which gives the statement p a certain (some) probability. In this approach, Keynes defined probability as "the degree of rational confidence" [4, p. 179].

The logical proximity may be illustrated by the example of the ratio of global and local financial markets and the corresponding probability of risks. If we take for granted the global financial market with its inherent risks $q$ and dependent upon it national (local) financial market with potential risk $p$, the probability of the latter will be greater the less the local financial market goes beyond the global one. A perfect example of logical proximity is the global financial crisis of 2008–2009, when financial risks prevailed in countries more integrated into the global financial environment. The example of Ukraine is also illustrative. During the Asian financial crisis of 1995–1996 being actually global in nature (scale) domestic financial risks were relatively small because at that time the financial system of Ukraine was only establishing ties with international financial markets. Howev-

er, the global crisis processes of 2008–2009 significantly affected our economy, including the financial sector and the risks thereof due to closer interaction with global financial networks.

Third, an objective interpretation of probability considers each numerical probabilistic statement as a statement on the relative frequency with which a certain event occurs within a sequence of phenomena. It is also called the frequency theory, the founder of which is considered to be Richard von Mises (works of 1919–1931). This theory considers probability as some recurring events and phenomena that are random and disordered, an example of those is the throwing of dice. That said, two axiomatic conditions are used: the axiom of convergence (or the axiom of limitations) and the axiom of randomization. The axiom of convergence (or axiom of limitations) indicates that as the sequence of events becomes longer, the sequence of frequencies gravitates to a certain limit. The axiom of randomisation shapes the random nature of the sequence into a mathematical form. Thus, according to Mises, the probability applies only to sequences of events, which involves the determination of unknown probabilities on the basis of known ones (probability data).

Based on Keynes' critique of that theory and his own perception of it, Popper proposed two hypotheses of his own: equal opportunities (the hypothesis of equal probability) and extrapolation of statistical results, and replaced the axiom of randomization with the axiom of unity. In addition, using the work of B. Bolzano, J. von Kries and F. Weissman, Popper came close to the concept of logical probability based on the concept of "logical space of possibilities" [4, p. 145–146; 263–264]. Popper's logical probability serves as a criterion for falsifying the theory. "Comparing the degree of falsification of two statements", K. Popper wrote, 'we can say that a less falsified statement is at the same time more probable on the basis of its logical form. I call this probability a 'logical probability – denoted by $P(x)$ and $P(x,y)$' [4, p. 138, 484]. Keynes called a similar approach as "a priori probability" [5, p. 225]. The conditional probability is also close in meaning, which is mainly associated with Bayes' theorem (the terms such as modal, comparative, empirical logical probability, etc. are also used in the literature). The role and significance of logical probability lies, firstly, in the formalisation of inductive rezoning, secondly, in rational estimates of empirical probability, thirdly, in the explication (interpretation) of classical probability, and fourthly, in the rational justification of decisions. In the context of determining the logical probability of risks, it is important to consider their economic content, other essential properties in order to obtain sufficient explanatory power in the form of so-called "weight of evidence" or "weight of argument".

Among the probabilistic methods of determining risks and possible consequences, Bayesian approaches based on the concept of conditional probability hold a prominent place. The mathematical expression of conditional probability is as follows:

$$p\left(h/e\right) = \frac{p\left(e/h\right)p\left(h\right)}{p\left(e\right)},$$

where *p(h)* is the prior probability of the hypothesis *h*; *p(h/e)* is the probability of hypothesis *h* provided that the event *e* occurred; *p(e/h)* is the probability of the event *e* occurrence provided that the hypothesis *h* is true; *p(e)* is the total probability of the event *e* occurrence.

Bayesian formula allows to rearrange the cause and consequences: based on the known fact of the event to calculate the probability that it was generated by this cause. This principle is used in risk analysis, especially to determine the causes in order to remove or eliminate them in the future. Events that reflect the actions of the causes, in this case are called hypotheses.

There are a priori and a posteriori hypotheses, which, in particular, Keynes used.

Bayes' theorem performs a threefold function in risk analysis. It allows, firstly: to analyse and assess the risk in general; secondly, to differentiate risks according to different qualitative and quantitative characteristics; thirdly, to determine the consequences of risks based on the use of different models [10, p. 458]. Integrated Bayesian Risk Analysis option is illustrated in Fig. 1.

This risk analysis includes updated Bayesian doctrine, risk factors including independent, uncertain factors, quantitative measurements of specific (special) and integrated risks, implementation of models and analysis, choice of management concept, decision making. Let us dwell in more detail on the latter in the context (theory) of the principles of decision-making in conditions of risk. The key position is to determine the probability of the consequences of risks. The maximisation of the expected value, the maximisation of the expected monetary value and the maximisation of the expected utility are considered there. [7, p. 65–66].

Consider an example of maximising of expected utility as a universal concept of neoclassical economic theory. Mathematical formalization shall be as:

$$EU = p_1 \cdot u_1 + p_2 \cdot u_2 + \ldots + p_n \cdot u_n,$$

where EU – is the maximum expected utility; $p$ – is the probability of expected utility; $u$ – is the expected utility of the corresponding consequence.

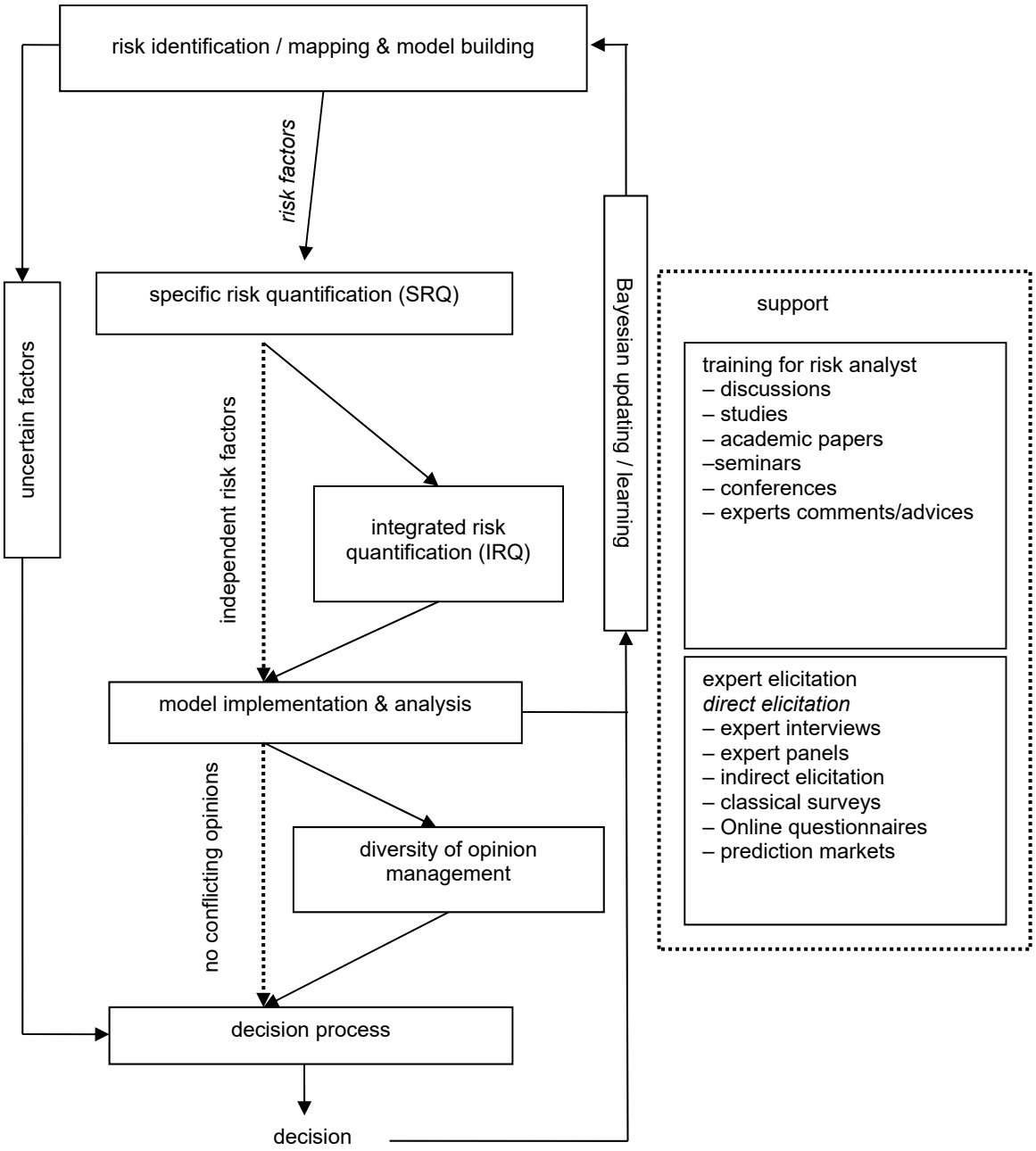


**Fig.1. Integrated Bayesian Risk Analysis [6, p.140]**

It should be noted that the principle of expected utility may be applied when the consequences are not monetary. Consider the following example. Yachts have to be transported from the Spanish port of La Coruna to the British port of Antigua (Caribbean). However, because of the prevailing weather conditions, there are only two feasible routes across the Atlantic: a direct northern route or a slightly longer southern one. The interest of the partners is to deliver the products as soon as possible. The number of days required for the crossing, as noted, depends on weather conditions. The weather is a decisive factor in the context of whether a high-pressure zone develops over the Azores, where cargo is shipped from the coast of Spain. Meteorological data for the last 100 years shows the probability of forming a high-pressure zone, which is 83 %. To study the meteorological data and determine the route, you may use the data in table 1.

***Table* 1. Determining the expected utility of cargo [7, p. 68]**

| | **High pressure zone over the Azores (83%)** | **No high pressure zone over the Azores (17 %)** |
|---|---|---|
| **Northern route** | 27 days | 14 days |
| **Southern route** | 18 days | 21 days |

The utility of the outcomes is negatively (reversely) correlated with the number of days required for crossing the route. Hence, the utility of shipping within 27 days, $u(27)$, is lower than the utility of shipping for 18 days, $u(18)$. If the utility function is linear with respect to the days of shipping, one may calculate the alternatives of the expected utilities and corresponding risks of loss of profitability from the transport operation.

$$\text{EU (Northern route)} =$$
$$= 0{,}83 \cdot u\,(27) + 0{,}17 \cdot u\,(14) = u\,(24{,}79)$$

$$\text{EU (Sothern route)} =$$
$$= 0{,}83 \cdot u\,(18) + 0{,}17 \cdot u\,(21) = u\,(18{,}51)$$

**Conclusion.** Therefore, the Southern route is optimal because the expected utility $u(18.51)$ according to the previous assumption is greater than the expected utility $u(24.79)$.

Bayesian logical network, like logical probability in general, is based on knowledge, so it is called epistemological probability. As a rule, it is acceptable for small-scale economic problems that posess sufficient knowledge of the relationship between the elements of the system. If knowledge about the system and its elements is insufficiant, the elements of fuzzy logic are added to the Bayesian model, which improves the testing of the conclusions of the system of the general Bayesian network. Under such conditions, it is called a Bayesian network of fuzzy logic.

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## ЛОГІЧНІ ВИМІРИ ЕКОНОМІЧНИХ РИЗИКІВ

***Досліджується економічна природа ризиків, зумовлених взаємодією місцевих (внутрішніх і зовнішніх) та глобальних факторів, що впливають на перебіг економічних подій. Логічні виміри економічних ризиків розглядаються переважно в контексті імовірнісних підходів, сформульованих К. Поппером та Дж. М. Кейнсом. Прикладні аспекти аналізуються на основі теореми Баєса про умовну ймовірність і теорії прийняття р ішень, яка розглядає максимізацію очікуваної вартості, максимізацію очікуваної грошової вартості та максимізацію очікуваної корисності.***

***Ключові слова: ризик, невизначеність, ймовірність, логічна ймовірність, логічна близькість, аналіз ризику.***

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## ЛОГИЧЕСКИЕ ИЗМЕРЕНИЯ ЭКОНОМИЧЕСКИХ РИСКОВ

***Исследуется экономическая природа рисков, обусловленных взаимодействием местных (внутренних и внешних) и глобальных факторов, влияющих на ход экономических событий. Логические измерения экономических рисков рассматриваются преимущественно в контексте вероятностных подходов, сформулированных К. Поппером и Дж. М. Кейнсом. Прикладные аспекты анализируются на основе теоремы Байеса об условной вероятности и теории принятия решений, которая рассматривает максимизацию ожидаемой стоимости, максимизацию ожидаемой денежной стоимости и максимизацию ожидаемой полезности.***

***Ключевые слова: риск, неопределенность, вероятность, логическая вероятность, логическая близость, анализ риска.***

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# INNOVATIVE NATURE OF THE WORLD AND DOMESTIC MARKET OF AGRICULTURAL PRODUCTS

***The place and role of agro – innovations are investigated. They are found to be the main driving force both of development of the agricultural products' domestic market and of competitive advantages' formation for the participants in the world market. Accelerated introduction of new generation digital technologies in the agro-industrial complex is determined by the effective use of organizational advantages of the Ukrainian model of agricultural development. Organic production is the latest trend in the world market of agricultural products. However, the advanced technologies actively used by farmers around the world are vertical farms, aquaponics, unmanned aerial vehicles, advances in robotics, and more. Such an active demand for technological innovations and their active use in agriculture contributes to the development of the agri-industry itself, as well as areas that ensure the development and production of innovative products. State assistance and support of farmers' interest in technological innovations, which is implemented in various monetary and budgetary policy measures, remains an urgent issue.***

***Keywords: innovations, technologies, agro-industrial complex, competitive advantages.***

**Introduction.** Ukraine is confidently increasing its position on the world market regarding the export of agro-industrial complex products. But maintaining the achieved results and reaching the leaders in new product segments require the most efficient use of opportunities provided by the market, accelerated technological development.

The population of the Earth is constantly growing. According to UN forecasts, in three decades the population will grow by 15–20 %, and the world's food needs will double by this time.

World agricultural production has entered a period of global change due to a combination of a number of factors,

the key of which are: global climate change; growth and change in the structure of consumption associated with population growth and welfare growth; the technological revolution, which in recent decades has completely changed the structure of industrial production, is coming to agriculture.

The agro-industrial complex is becoming the focus of interests of global investors and an important tool of international policy. Changes are taking place both in the market and in the organization of agricultural production, in the structure of consumption, in the system of agri-innovation.

The **main goal** of the article is to analyze the innovative component in the general model of development of the world market of agricultural products and to determine the place and prospects of Ukraine for its further integration in a strong competitive position in the world market.

**Recent literature review.** Theoretical scientific heritage and achievements in the field of theoretical principles and practical recommendations for solving problems of international trade, including agricultural products, and its regulation are devoted to the works of domestic and foreign scientists: O. Shnyrkova, O. Mykhaylenko, T. Tsygankova; A. Egorov and T. Eroshyna study topical issues of international exchange of agricultural goods in their works; the works of M. Porter, D. Ricardo, P. Samuelson are devoted to theories of competitive advantages; the innovative aspect is investigated in the works of O. Stupnytsky, L. Fedulova, S. Davymuk and others.

However, the analysis of scientific works in this area shows the lack of a comprehensive approach in presenting an innovative model of development of the world market of agricultural products and defining the place and role of Ukraine in it.

**Main research results.** Among the key areas of change in the global agro-industrial complex are: production; consumption; global market; innovations; farm.

The global market for agricultural raw materials and food is awaiting a resumption of rising prices. The wave of mergers and acquisitions in the industry has led to a significant intensification of the land market.

Significant reductions in clean water have already affected not only China and India (water shortages are a traditional problem in these countries), but also the American Midwest, where depletion of aquifers calls into question the possibility of maintaining high yields on irrigated lands. Problems such as soil degradation and the restriction of environmentally harmful farming methods need special attention. For example, in the European Union, agriculture is a source of 10 % of CO2 emissions and more than 50 % of other greenhouse gases, and the agro-industrial complex is a source of 90 %–95 % of ammonia emissions. In the EU, 75 % of used agricultural land is prone to erosion, of which almost 20 % lose more than 10 tons per hectare per year.

Countries and intergovernmental associations are now stepping up work to develop a system of global trade agreements, increasing the promotion of national agricultural products, strengthening the protection of their markets.

Innovations in the agro-industrial complex are experiencing an explosive growth. In the medium term, they will determine the new leaders of the agricultural market. In recent years, the volume of innovations in startups specializing in new agricultural technologies has increased more than 10 times. Robotics, artificial intelligence, and other technologies are becoming commonplace not only on the industrial assembly line, but also in agricultural production. The process of change affects not only startups. Mergers and acquisitions in the "big six" of agri-technological companies are expected to continue [7].

Another important global trend is the active development of centers for the implementation of advanced agricultural technologies as a new tool for state support for the development of agro-industrial complex.

For farms, the trend is the growth of markets with high added value. Key technological innovations are aquaponics, widespread introduction of IT, biological pest control, as well as the development of small mechanization. Interestingly, the best-selling farm car in the UK market in recent years has become a utilitarian ATV.

Widespread introduction of digital technologies is a key trend of the world economy of the last decade. In agriculture, the industry standard is the use of repositioning systems, integrated fleet management, precision farming. But as cross-sectoral analysis shows, the real digital revolution in global agriculture is still ahead.

The world leaders in the introduction of digital technologies are IT companies, media, finance, and insurance. In real production and logistics, the level of digitization is much lower. Agriculture closes the list.

The main deterrent is the peculiarities of agricultural production. But several current trends suggest that this situation will change radically in the coming years. The development and production of robotic agricultural machinery is now at the forefront of innovation.

In general, there are three stages of development and implementation of digital technologies in agriculture:

- pilot technologies: technologies of repositioning, monitoring of the condition of agricultural machinery, etc. are starting to be introduced;
- saturation of the market: currently the number of digital technologies and industry standards in agriculture has reached a critical mass. Virtually all equipment manufacturers, including companies from China and India, offer their own programs and solutions that optimize the use of their machines and equipment. There are several solutions related to precision farming. A variety of options for the use of geodata for crop forecasting, crop optimization, logistics management, etc. are offered. Additional pressure on the user is provided by the arrival of a new generation of agricultural technologies – the Internet of Things and the blockchain;
- integration is a key trend of the future: companies will be a leader in the digitalization of agriculture, which will be able to offer common standards and solutions that combine existing developments in the field of digital agricultural technologies and eliminate the problem of choice and associated risks [11].

It is possible to solve the problem of digital technology development in global agriculture by creating integrated cloud services. Such services will take over the acquisition of data from digital units of agricultural equipment and ensure compatibility of different formats and protocols. In addition, a single service can provide the most efficient use of data that is useful to all agricultural companies in the region – remote sensing, hyperspectral aerial photography, weather forecast data, etc.

An additional advantage of such a cloud service will be marketing and logistical support for farmers. Access to information will reduce the risks of crop overproduction, provide access to real prices for agricultural products and reduce the cost of intermediary services, simplify the construction of transport chains.

The effect of the introduction of unified cloud services for agriculture may be a doubling of profits per hectare [1]. The finding of such services will create the preconditions for a significant acceleration of digitalization of agriculture.

Accelerated introduction of a new generation of digital technologies for the Ukrainian agro-industrial complex is an effective way to use the organizational advantages of the Ukrainian model of agricultural development. In addition, it will significantly increase the efficiency of invest-

ment in the agro-industrial complex, raise the return on each hryvnia invested. The creation of a single state cloud service can be a crucial element of non-financial state support for agriculture.

The use of a systematic, well-thought-out state approach to the introduction of a new generation of digital technologies in agriculture should become an important and promising component of the strategy of development of the Ukrainian agro-industrial complex.

New ambitious tasks of agricultural development require further development of the agricultural financing system, bringing it to a new quality level. The following tasks of development are allocated as priority:

- reduction of terms of decision-making on granting for financing in agro-branch;
- providing more flexible financing conditions that meet the specifics of the agricultural business, which is exposed to significant climate risks;
- further simplification of access to bank and leasing financing for small agribusiness;
- reducing bank interest rates on loans, expanding access to government support [9].

Supporting high rates of development, intensification of investments requires increasing the reliability of investment and expanding the number of investors in agriculture. Modern financial technologies can significantly increase the speed of transactions, provide multifactor analysis of large amounts of data.

It is important that such technologies are implemented not only in the United States, the EU, Canada, and other developed countries. Successful experience in the introduction of modern financial technologies, focused primarily on small agribusiness, farmers, is in a few rapidly growing African countries: South Africa, Kenya, Nigeria, Tanzania. International support and weakness of "traditional" financial institutions have created a good climate in these countries for innovations in the field of financial technology.

It is interesting and important to understand the system of integrated automated scoring which are used for assessment of the creditworthiness of farmers and agricultural entrepreneurs in Kenya. The advantage of this system became wide access to credit and a high rate of return.

A very simple procedure for cooperation is implemented for the user:

- It is enough for farmers and small entrepreneurs to send an application by e-mail and provide a few key financial data: harvest, revenue, expenses. Then the system analyzes the creditworthiness and, in case of a positive decision, opens access to the requested funds. It uses its own payment system, built based on mobile communication.
- Financial institutions are offered a range of services aimed at solving such key problems as reducing transaction costs, improving the reliability of the analysis of borrowers (risk management), portfolio expansion [4].

The scoring system used is based on modern financial technology, which combines highly efficient data search algorithms, processing large arrays of information, decision-making based on neural networks.

Adaptation of Ukrainian legislation for the introduction of new financial technologies will significantly increase the investment attractiveness of the agro-industrial complex of Ukraine, simplify the organization of export supplies of agricultural products to the Middle East and North Africa. It will also allow to take an important step in achieving the goals of the strategy of development of the agro-industrial complex of Ukraine.

Another trend in the global agricultural sector is the technology of protected soil, provide high efficiency of agricultural production and in general allow to solve one of the main problems of investment in agriculture – a significant impact of adverse environmental factors.

Protected soil agriculture requires access to modern technologies: computer control of nutrient solutions, temperature, and humidity of the environment, etc. An example of the active use of natural competitive advantages for the development of agricultural production of protected soil is Israel. Now this country not only exports vegetables grown in greenhouses but is also the largest supplier of agricultural technology in the world.

New technologies such as LED light sources with an optimal spectrum of radiation and aeroponics for photosynthesis have made it possible to take the next step in the development of agricultural production of protected soil.

From a practical point of view, the application of aeroponics technologies has led to the creation of "vertical farms" – a new format of agricultural production [8].

Placing vertical farms directly in the city, near a shop or restaurant significantly reduces the cost of transporting products, maintaining freshness, and so on. Such farms allow to use any free areas or even to make them mobile, based on the truck.

The projected average market growth rate is 25 % per year. The main components of this market are lighting systems, equipment for aero- and hydroponics, load-bearing structures, usually container-type, as well as computer equipment and software.

The largest markets for vertical farm equipment are Southeast Asia and the United States – about 30 % of the world market each.

For Ukraine, the task of developing agriculture of protected soil is particularly acute. The use of vertical farm technologies is an opportunity to become one of the world leaders in the application of modern agricultural technologies and reduce the risks of investing in the industry. The market for vertical farm equipment is growing rapidly. This is a good opportunity for the development of domestic high-tech production.

One of the new directions of technological development is the market of agricultural unmanned aerial vehicles. According to forecasts, it is one of the fastest growing high-tech markets in the world. The average annual growth rate is estimated at 30 % per year [10].

The largest national market for agricultural drones is the United States. Currently, this country sells about a third of all drones. But in the long run, high growth rates will show the markets of Europe and developing countries.

The rapid growth of the world market for agricultural unmanned aerial vehicles confirms the effectiveness of their use. The use of agricultural technologies based on the use of unmanned aerial vehicles is becoming one of the key factors of competitiveness. This is especially important for Ukraine, which agriculture has ambitious goals for entering the world market.

It is important that the export-oriented agro-industrial complex of Ukraine creates an excellent domestic market for agricultural aircraft. Today, they are not very popular in Ukraine, but in the long run its popularity may increase significantly. The opportunities of the domestic market of Ukraine are sufficient to form on its basis one of the world leaders in the market of agri-unmanned aerial vehicles. Given the high growth rate of the market (up to 30 % per year) – it becomes a very promising area.

Thus, now the competitiveness of agricultural products is determined by the efficiency of its production and the use of advanced technologies create favorable conditions for the development of the domestic agro-industrial complex.

The use of a systematic, well-thought-out state approach for the introduction of a new generation of digital technologies and financial technologies in agriculture should become an important and promising component of

the strategy of development of the agro-industrial complex of Ukraine.

The use of protected soil farming technologies such as vertical farms can promote Ukraine's entry into the world leaders in the application of modern agricultural technologies, and through the rapid growth of this market the production of equipment for vertical farms will promote the development of domestic high-tech agro-industrial complex.

Currently, a new technological wave is unfolding in the world economy, which will be characterized by the development of robotics; biotechnologies based on modern advances in molecular biology and genetic engineering; nanotechnology; artificial intelligence systems. The urgency of flexible automation of production is increasing, the use of renewable energy sources is significantly increasing, biotechnology will become the basis for the development of agro-industrial complex.

All this creates the preconditions for the formation of a new structure of markets for means of production and products of the agro-industrial complex.

Ukraine has a significant potential for the development of agro-industrial complex at the global level. Favorable agronomic conditions, the availability of diversified infrastructure and the availability of educated able-bodied human capital are main reasons for it.

However, the main constraints on the development of the agro-industrial complex are low wages, high levels of corruption, high inflation, import dependence, the use of outdated methods and production technologies and the imperfection of the financial and credit system.

Based on the above data, we can predict two models of development of the agro-industrial complex of Ukraine, considering the general innovative trends in the world market of agricultural products.

The first model provides for the achievement of stable growth of the sector and specialization in those market segments where the products of the agro-industrial complex of Ukraine are already competitive. The second model can be implemented under the conditions of scientific and technological development of the Ukrainian agro-industrial complex [12].

The main drivers of the development of the agro-industrial complex of Ukraine under the first model will be the gradual recovery of the economy, import substitution and further development of traditional export niches. Improving investment conditions will be because of stimulating monetary and fiscal policies.

The main condition for the implementation of the second model will be the acceleration of growth of the Ukrainian economy in the medium term due to increased public investment. This involves additional investments in the development of scientific and innovative activities, support for agricultural exports and stimulation of consumer demand for domestic goods.

The main purpose of scientific and technological development of the agro-industrial complex of Ukraine is to ensure the competitiveness of Ukrainian products in foreign and domestic markets primarily through the creation, dissemination, and application of the latest advances in science and technology. The implementation of this goal is designed to ensure the transition to high-performance (accelerated selection, active substances for modern veterinary drugs and plant protection products, etc.), high-tech (synthetic biology, food biotechnology, functional foods, etc.), resource-efficient (smart agriculture, balanced unified fodder, etc.), climate-adaptive (zoned varieties and breeds, new generation irrigation complexes, vertical farms, etc.) production of agricultural raw materials and products with a high level of processing.

Mass production and export of competitive products with high added value will be possible due to the steady growth of labor productivity and resource efficiency.

Therefore, important conditions for the development of the agro-industrial complex can be: overcoming the scientific and technological lag of the domestic agro-industrial complex from the level of the world's leading countries and cost-effective reduction of its dependence on technology imports; formation in the agro-industrial complex of an innovative system that ensures the creation and development of advanced domestic developments, as well as the adaptation of imported technologies where necessary; priority development of basic and applied research in promising areas (including by attracting private investment); increasing the availability of new technologies for medium and small businesses, farms and individual producers; leveling the technological level of large and medium-sized industries; priority development of innovations in the field of resource efficiency, storage infrastructure, processing and logistics.

An important condition for Ukraine's successful integration into the innovative model of world market development is active international cooperation in this area. This will be facilitated by the interest of a number of countries with limited agri-climatic opportunities in the stable supply of agricultural products, raw materials and food, the establishment of agricultural production in other countries with favorable agri-climatic conditions, including Ukraine.

Currently, the Ukrainian economy is facing the task of finding new sources of growth, one of which should be a high-tech and globally competitive agro-industrial complex. Progress in this direction requires the improvement of scientific and technical policy in the agro-industrial complex, improving the quality of methodological, informational, and expert-analytical support of relevant management decisions. To achieve this goal, it is important to increase the efficiency of the implementation of sectoral regulatory instruments. It is also necessary to increase the scale of funding for agricultural education and agricultural science, which today is not at a high enough level [3].

The development of the agro-industrial complex of Ukraine will provide significant changes in the socio-economic sphere, will positively affect the stability of economic growth, ensuring the economic security of the country, improving employment and quality of life.

**Conclusion.** Innovations in the agro-industrial complex are experiencing an explosive growth. In the medium term, they will determine the new leaders of the agricultural market. In recent years, the volume of innovations in startups specializing in new agricultural technologies has increased more than ten times.

The use of a systematic, well-thought-out state approach to the introduction of a new generation of digital and financial technologies in agriculture should become an important and promising component of the development strategy of Ukraine's agro-industrial complex.

The use of protected land technologies such as vertical farms can promote Ukraine's entry into the world leaders in the application of modern agricultural technologies, as well as due to the rapid growth of this market, the production of equipment for vertical farms will contribute to the development of domestic high-tech agro-industrial complex. Another new direction of technological development of the agro-industrial complex is the market of agricultural.

Ukraine has excellent prospects for successful integration into the world market of agricultural products, considering a fairly high level of innovation in the field of agriculture, as well as significant potential for the development and production of high-tech innovative products.

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## ІННОВАЦІЙНИЙ ХАРАКТЕР РОЗВИТКУ СВІТОВОГО ТА ВІТЧИЗНЯНОГО РИНКУ СІЛЬСЬКОГОСПОДАРСЬКОЇ ПРОДУКЦІЇ

***Досліджено місце та роль агроінновацій як основної рушійної сили розвитку вітчизняного ринку сільськогосподарської продукції та формування конкурентних переваг його учасників на світовому ринку. Прискорене впровадження цифрових технологій нового покоління в аграрно-промисловому комплексі визначено як ефективне використання організаційних переваг української моделі розвитку сільського господарства. Органічне виробництво є новітнім трендом світового ринку сільськогосподарської продукції. Однак, передовими технологіями, що активно використовуються фермерами з усього світу, стали на сьогодні вертикальні ферми, аквапоніка, безпілотні літальні апарати, досягнення у сфері робототехніки тощо. Такий активний попит на технологічні новації та їх активне використання у сфері сільського господарства сприяє як розвитку самої агрогалузі, так і сфер, що забезпечують розробку та виробництво інноваційної продукції. Актуальним питанням залишається державне сприяння та підтримка цікавості фермерів до технологічних новинок, що реалізується в різноманітних заходах грошово-кредитної та бюджетної політики.***

***Ключові слова: інновації, технології, агропромисловий комплекс, конкурентні переваги.***

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## ИННОВАЦИОННЫЙ ХАРАКТЕР РАЗВИТИЯ МИРОВОГО И ОТЕЧЕСТВЕННОГО РЫНКА СЕЛЬСКОХОЗЯЙСТВЕННОЙ ПРОДУКЦИИ

***Проведено исследование места и роли агроинноваций как основной движущей силы развития отечественного рынка сельскохозяйственной продукции и формирования конкурентных преимуществ его участников на мировом рынке. Ускоренное внедрение цифровых технологий нового поколения в аграрно-промышленном комплексе определено как эффективное использование организационных преимуществ украинских моделей развития сельского хозяйства. Органическое производство является новым трендом мирового рынка сельскохозяйственной продукции. Однако передовыми технологиями, которые активно используются фермерами со всего мира, стали на современном этапе вертикальные фермы, аквапоника, безпилотные летательные аппараты, достижения в сфере робототехники и т. п. Такой активный спрос на технологические новации и их активное использование в сфере сельского хозяйства способствует как развитию самой агросферы, так и сфер, которые обеспечивают разработку и производство инновационной продукции. Актуальным вопросом остается государственное содействие и поддержка интереса фермеров к технологическим новинкам, которые реализуются в разнообразных мероприятиях денежно-кредитной и бюджетной политики.***

***Ключевые слова: инновации, технологии, агропромышленный комплекс, конкурентные преимущества.***

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# ВПЛИВ ШТУЧНОГО ІНТЕЛЕКТУ НА РОЗВИТОК МІЖНАРОДНОГО ОСВІТНЬОГО СЕРЕДОВИЩА

***Проаналізовано передумови виникнення штучного інтелекту, розглянуто світові практики його впровадження у життєдіяльність суспільства. Наведено приклади стратегій успішного використання технологій штучного інтелекту в освітньому середовищі країн Близького Сходу, США, у Китаї, Індії, Японії, Німеччині, Канаді. Обґрунтовано необхідність створення єдиних стандартів розроблення алгоритмів штучного інтелекту.***

***Ключові слова: штучний інтелект, освітнє середовище, робототехніка, цифровізація, нейронні мережі, машинне навчання.***

**Постановка проблеми.** Наприкінці грудня 2019 року Стенфордський університет оприлюднив результати дослідження, згідно з яким обчислювальна потужність штучного інтелекту вже понад сім років випереджає закон Мура. Цей закон говорить, що швидкість процесора подвоюється кожні 18 місяців, а отже, розробники можуть очікувати подвоєння продуктивності додатків в ці строки за тією самою вартістю обладнання. Але звіт групи дослідників зі Стенфордського університету, підготовлений у співпраці з McKinsey & Company, Google, PwC, OpenAI, Genpact і AI21Labs, показав, що обчислювальна потужність ШІ зростає швидше, ніж потужність традиційних процесорів. Переломним моментом, коли швидкість розвитку штучного інтелекту стала ви-

переджати закон Мура, виявився 2012 рік [1]. Наприкінці січня 2020 р. компанія Інсайт зробила аналіз глобальних тенденцій в інвестуванні в ШІ і дійшла висновків, що в 2019 р. стартапи на основі технологій ШІ отримали рекордну кількість інвестиції – 26,6 млрд (2200 угод). Для порівняння: в 2018 – 22,1 млрд, 2017 – 16,8 млрд. У другому кварталі 2019 року стартапи у сфері штучного інтелекту отримали фінансування в розмірі 7,4 мільярда доларів, що є найвищим показником за всю історію спостережень. Кількість угод також зросла. Було укладено 488 угод зі штучного інтелекту. За даними Frost & Sullivan, лідером за сумою інвестицій в розвиток технологій ШІ і кількістю укладених угод залишається США, за якими слідують Китай і Велика Британія. Однак, якщо брати до уваги середню вартість угоди, то безумовним лідером є Китай, середній розмір угод якого в останні 2 роки становив більш ніж $ 100 млн проти $ 15 млн і $ 5,4 млн у США і Великій Британії відповідно.

Крім того, в 2019 році зросла кількість ШІ-компаній, чия вартість перевищила $ 1 млрд. Серед нових "єдинорогів" – розробник автономних роботів для доставки товарів Nuro і аналітична компанія DataRobot. Усі десять нових компаній-мільярдерів базуються в Китаї, Великій Британії або США. Такі венчурні інвестори, як Plug and Play Ventures, Accel і Lightspeed Ventures, увійшли в число лідерів з інвестування на ринку штучного інтелекту в 2019 році.

**Виклад основного матеріалу дослідження.** Перші дослідження в галузі ШІ, що стартували в 50-х роках минулого століття, були спрямовані на розв'язання проблем і розробку систем символьних обчислень. У 60-х роках цей напрям привернув інтерес Міністерства оборони США: американські військові почали навчати комп'ютери імітувати розумову діяльність людини. Наприклад, Управління перспективних дослідницьких проектів Міністерства оборони США (DARPA) виконало в 70-х роках кілька проєктів зі створення віртуальних вуличних карт, і фахівцям DARPA вдалося створити інтелектуальних особистих помічників в 2003 році, задовго до того, як з'явилися Siri, Alexa та Cortana.

Ці роботи стали основою для принципів автоматизації і формальної логіки міркувань, які використовуються в сучасних комп'ютерах, зокрема, в системах для підтримки прийняття рішень і розумних пошукових системах, покликаних доповнювати і примножувати можливості людини.

На думку PwC, у найближчі 5–10 років лідером з використання у бізнесі штучного інтелекту буде Китай. Істотним потенціалом володіє і Північна Америка. Західна Європа ж поки що повзе у хвості. Зростання інтересу до інноваційних розробок з боку світових інвесторів останніми роками дає хорошу перспективу на розростання тенденції масового застосування AI у базових галузях. Тож для IT-галузі України це дає колосальні шанси. Найбільшу користь від технологій AI, за даними аналітиків, отримають сфери фінансових послуг, роздрібної торгівлі, медицини, фармації, автопрому.

Визначимо найбільш перспективні галузі для монетизації ШІ.

*Охорона здоров'я*. Штучний інтелект дозволить моніторити дані про спосіб життя пацієнта, швидше діагностувати захворювання і пропонувати персоналізоване страхування здоров'я. Amazon продемонстрував ШІ-систему голосових нотаток і їх розшифровки для медичного персоналу, а перший медикамент для лікування обсесивно-компульсивного розладу, розроблений системою штучного інтелекту біотехнічної компанії Exscientia з Оксфорду, наближається до стадії тестування на людях. Зазначається, що зазвичай фаза розробки триває близько 4,5 років, однак штучний інтелект зробив це менш ніж за 12 місяців.

*Роздрібна торгівля*. Компанії вже прогнозують поведінку покупців за допомогою ШІ. Наступний етап – гіперперсоналізірованний ритейл: за допомогою штучного інтелекту і автоматизації роздрібні підприємства будуть пропонувати товари і послуги персонально для кожного споживача. Саме такі технології використовують Amazon та Netflix. Персоналізована реклама зараз є основою маркетингових стратегій багатьох компаній.

*Автомобільна галузь*. Штучний інтелект дозволяє моделювати наслідки різних бізнес-рішень і вибирати кращу стратегію. Наприклад, один провідний автовиробник за допомогою ШІ тестує понад 200 тис. сценаріїв того, як вивести на ринок безпілотні автомобілі для спільного використання [2].

Варто виокремити ШІ алгоритми динамічного ціноутворення, які посприяли успіху таких відомих компаній, як Uber and Lyft, адже ця технологія розв'язує проблеми як індустрій, так і споживачів.

*Зміст динамічного ціноутворення*. Безпосередньо кажучи, динамічне ціноутворення функціонує відповідно до деяких основних економічних принципів. Якщо відносна пропозиція стає дефіцитною, а попит високим, то існує очевидна потреба в підвищенні загальної ціни, щоб відповідати кривим попиту/пропозиції. Оскільки всі підприємства потребують постійного доходу, динамічне ціноутворення має ідеальний сенс, особливо в довгостроковій перспективі.

Динамічне ціноутворення просто забезпечує постійне постачання необхідних речей (чи то фізичний продукт, чи виклик на обслуговування) завдяки системі на основі стимулів.

Метод динамічного ціноутворення також з успіхом використовується в паливній галузі.

Сфери застосування ШІ зараз найрізноманітніші і часом дуже несподівані. ШІ застосовується в таких сферах, як, наприклад:

- оборонна та військова справа (управління стратегічним озброєнням);
- освіта (аналіз поведінки учнів);
- бізнес (виявлення "вузьких місць", рекрутинг, складання прогнозів);
- боротьба з шахрайством (виявлення підозрілої активності);
- електроенергетика (прогнозування попиту, обслуговування обладнання);
- виробнича сфера (оптимізація виробництва);
- банківська справа (управління ризиками, прогнозування, чат-боти в мобільних банківських додатках);
- транспорт (оптимізація управління автомобільним транспортом, розширення засобів круїз-контролю, автопілот);
- логістика (покращення продуктивності, зниження простоїв);
- виробництво (контроль виробничих процесів, їх оптимізація, діагностика обладнання, інформація про поломки, профілактичні заходи, автоматизація);
- торгівля (аналіз купівельної активності й ефективності маркетингових стратегій, управління закупівлями, розробка персоналізованих програм лояльності, глибока аналітика);
- ринок предметів і послуг розкошів (алгоритми, що передбачають наші культурні інтереси);
- держуправління (комп'ютерний зір для розпізнавання номерів та облич);
- сфера ЖКГ (прогнозування технічного стану будівлі, витрат ресурсів, системи "розумний будинок");