

ECONOMIC AND MATHEMATICAL MODELING AND INFORMATION TECHNOLOGIES IN ECONOMICS

UDC 330.4:[339.138+005.95/.96]

DOI <https://doi.org/10.26661/2414-0287-2022-1-53-06>

THE CONCEPT OF INTELLECTUAL ECONOMIC SYSTEMS IN THE ERA OF INDUSTRY 4.0

Ivanov S.M.

Zaporizhzhia National University
Ukraine, 69063, Zaporizhzhia, Zhukovsky str., 66
flydaiver@gmail.com
ORCID: 0000-0003-1086-0701

Key words:

digital economy,
information system, management,
human resource, marketing

In the article the author gives an analytical review of the application of information systems and technologies in the modern economy. The author determined that the activities of modern economic facilities require new approaches and the construction of a new concept in the era of digital economy – Industry 4.0. The author proposes a structure of interaction of economic entity management models, which combines a set of systemic, resource approaches to human resource management (Kobe Douglas function) and marketing analytics, which allows to form a strategy for economic entity (enterprise) to take into account market needs. The economic entity in the digital economy in the form of a multi-agent system, for which the correction factor for the value of the usefulness of the product. There is also a model for assessing consumer efficiency as part of a digital marketing system in the management of economic facilities. Thus, the concept of building intelligent economic systems in the era of Industry 4.0 is proposed, which aims to solve problems and problems of building intelligent economic systems and their effective use in the era of Industry 4.0 in marketing management, personnel, predictive management. For the developed conceptual model of intelligent economic systems in Industry 4.0, the axiomatics of processes is formulated, which consists of four points: components of the model level are equivalent in terms of general approach, formation of multidimensional forecasting solution, construction of intelligent economic system from functionally independent subsystems intellectual economic system as a means of analysis and forecasting of individual processes of the subject of economic activity.

КОНЦЕПЦІЯ ІНТЕЛЕКТУАЛЬНИХ ЕКОНОМІЧНИХ СИСТЕМ В ЕПОХУ ІНДУСТРІЯ 4.0

Іванов С.М.

Запорізький національний університет
Україна, 69063, Запоріжжя, вул. Жуковського, 66

Ключові слова:

цифрова економіка,
інформаційна система,
менеджмент, кадри, маркетинг

У статті автор наводить аналітичний огляд застосування інформаційних систем і технологій в сучасній економіці. Автором визначено, що діяльність сучасних економічних об'єктів вимагає нових підходів та побудови нової концепції в епоху цифрової економіки – Індустрія 4.0. Автором запропонована структура взаємодії моделей управління економічним суб'єктом, яка поєднує сукупність системного, ресурсного підходів управління людськими ресурсами (функції Коба Дугласа) та маркетингової аналітики, яка дозволяє формувати стратегію розвитку суб'єкта господарської діяльності (підприємства), що дозволяє враховувати потреби ринку. Розглянуто економічний суб'єкт у цифровій економіці у вигляді багатоагентної системи, для якого наведений поправочний коефіцієнт вартості корисності товару. Також представлена модель оцінки споживчої ефективності як складової частини цифрової маркетингової системи в управлінні економічними об'єктами. Запропонована концепція побудови інтелектуальних економічних систем в епоху Індустрія 4.0, яка спрямована на вирішення задач та проблем побудови інтелектуальних економічних систем та їх ефективного використання в епоху Індустрія 4.0 в управлінні маркетингом, персоналом, предикативного управління.

Для розробленої концептуальної моделі інтелектуальних економічних систем в умовах Індустрія 4.0, сформульована аксіоматика процесів, яка складається з чотирьох пунктів: складові модельного рівня є рівноцінними з погляду загального підходу функціонування, формування багатомірного рішення прогнозування, побудова інтелектуальної економічної системи з функціонально-незалежних підсистем, та використання інтелектуальної економічної системи як засобу аналізу та прогнозування окремих процесів суб'єкту економічної діяльності.

Statement of the problem

The digital economy (Industry 4.0) opens up new directions, which opens up new opportunities for economic actors. In modern conditions, when the dynamics of economic processes are high enough, where operational data are needed, and the strategy of production and promotion, as well as pricing depend not only on producers but also on consumers becomes a very important factor. Therefore, an increasingly important task is to build a concept for modeling intelligent economic systems in the era of Industry 4.0.

All activities of modern economic entities are aimed at forming an effective strategy for the development of enterprises to meet the needs of consumers. These requirements directly affect the construction of the concept of intelligent economic systems in the era of Industry 4.0. Therefore, the concept has direct links with the consumer, where real-time information comes from consumers and allows you to respond quickly to rapidly changing demand.

Analysis of recent studies and publications

In his work, Academician of the National Academy of Sciences of Ukraine, Doctor of Economics, Professor A.A. Chukhno [1] explored the problem of determining the laws of society, which determined the essence of formational and civilizational approaches [1, p. 52–55]. The author also noted that the industrial revolution of the XVIII and early XIX centuries carried out a technical revolution and gave development to industrial enterprises. This led to the creation of new technologies that gave rise to the post-industrial era (post-industrial society) [1, p. 56–67]. For post-industrial society, the characteristic features are the deepening of the international division of labor and specialization of labor. The paper also notes that the post-industrial society is the basis for the introduction of information and intellectual technologies [1, p. 144], which achieves a high level of development of productive forces. This development is to increase creativity (intellectual activity), which is aimed at forming new knowledge [1, p. 181–182].

A study of the current state, problems and prospects for the development of information systems in the economy was given in the work of Ustenko S.V. [2; 3]. The works also consider the role and place of information systems in the emergence of a new economic system, which makes new demands on the organization of enterprises, production systems and knowledge orientation, innovative nature of production, virtualization of production, dynamism, globalization and others.

In the works of Chornous G.O. [4; 5] the problem of building proactive management of economic entities is studied, as well as the agent model of information

management system in the economy is proposed. It is established that the proposed models have a high level of flexibility, efficiency, productivity; adaptability to changes in economic conditions.

In the works of Bashnyanin G.I. [6] and Kononova K.Yu. [7] systematized approaches and analyzed economic systems. The problems of formation and development of economics as a special theory of economic systems and applied economics are studied. These studies have taken into account changes in relevant sectors of the economy, informatization and growth of scientific knowledge and its value to ensure the development of society.

In his works Gritsenko A.A. [8; 9] it was proved that economic and information changes require a new statistical paradigm, where the modern statistical system is formed on the basis of a market economy. The general methodological basis of the paradigm is the understanding of the time of life of systems and man as a fundamental dimension of individual and social wealth. Factors that cause an unstable socio-economic environment were also studied. The contradictions of digital and socio-economic development, as well as possible forms of their solution have been identified. The effects of digital transformations on economic relations and production efficiency are shown.

In the works of Lysenko Yu.G. [10], Bizyanova E.E. [11], Levitsky S.I. [12] and Vovchak I.S. [13] studied the areas of information systems design, features of various information technologies, trends in their development and examples of application in different sectors of the economy. The research of economic systems is continued and the problems of formation and development of the theory of economic systems as applied economy are analyzed.

In the work of Voynarenko M.P. and Yemchuk L.V. [14] the essence and definition of control technology in information systems are considered. The relevance of the introduction of management technology on the basis of modern information systems for the purposes of improving the efficiency of the management system of the enterprise is substantiated.

But the issue of creating a holistic concept of intelligent information systems in the economy is not given enough attention.

Objectives of the article

The purpose of the work is to build the concept of intelligent economic systems in the era of Industry 4.0.

The main material of the research

From the analytical point of view it is determined that a great contribution to theoretical and practical developments, as well as to the formation of scientific directions of economic development, business process

management, information systems models, models of price optimization and sales in consumer markets, functions and approaches management in marketing, problem-based management of business processes, modeling of cooperative relations in the digital economy have contributed to the work of many domestic scientists.

Let's present the economic entity in the digital economy in the form of a multi-agent system. The subjects of economic activity act as agents. The total number of agents is not limited to the Internet market. Agents have access to information about resource opportunities (human resources), product market, range, competitors and other commercial information.

The developed concept proposes a model of images, which is the basis for building the structure of interaction of models. The structure of interaction of models corresponds to the decisions in the knowledge base as a set. In fig. 1 presents the structure of model interaction.

In the structure of interaction of models of management of the economic subject the model of fuzzy modeling of HR in the conditions of the fourth industrial revolution can be presented in the form of set:

$$P = \{p_i = (op1, op2, ep1, ep2, ep3)\}, i = \overline{1, N}, \quad (1)$$

where *op1* – it is a generalized indicator of job compliance, which characterizes the degree of compliance of qualifications and experience in the position, the level of responsibility, as well as the quality of current work and

responsibilities; *op2* – generalized indicator of diligence, which characterizes the effectiveness of tasks (complexity, quality, timeliness); *ep1* – ambition, indicator of personality characteristics; *ep2* – the quality of the leader, an indicator of personality characteristics; *ep3* – the level of attitude to the team, indicator of personality characteristics.

Then the model of digital marketing system in the management of economic objects can be in the form of a model for assessing consumer efficiency, defined by plural $P = \{P_i, i = \overline{1, N}\}$ as an expert assessment of the usefulness of the product.

Then the correction factor for the usefulness of the product can be written:

$$K = \{K_i = (k1, k2, k3) \in [0, 1]\}, i = \overline{1, N}, \quad (2)$$

where *k1*, *k2*, *k3* – signs of a consumer willing to pay for utility in addition, interest and the consumer will not pay for utility.

So the set of system M can be written in the form of a tuple:

$$\langle K_i, p_i, R_\Sigma, Z \rangle, \quad (3)$$

where $\langle K_i, p_i \rangle$ – the image of the subject of economic activity; R_Σ – related to solution models; *Z* – action on management decisions.

The search for typical configurations is not limited to solving problems of information analysis with further management of the economic entity. The decisions obtained

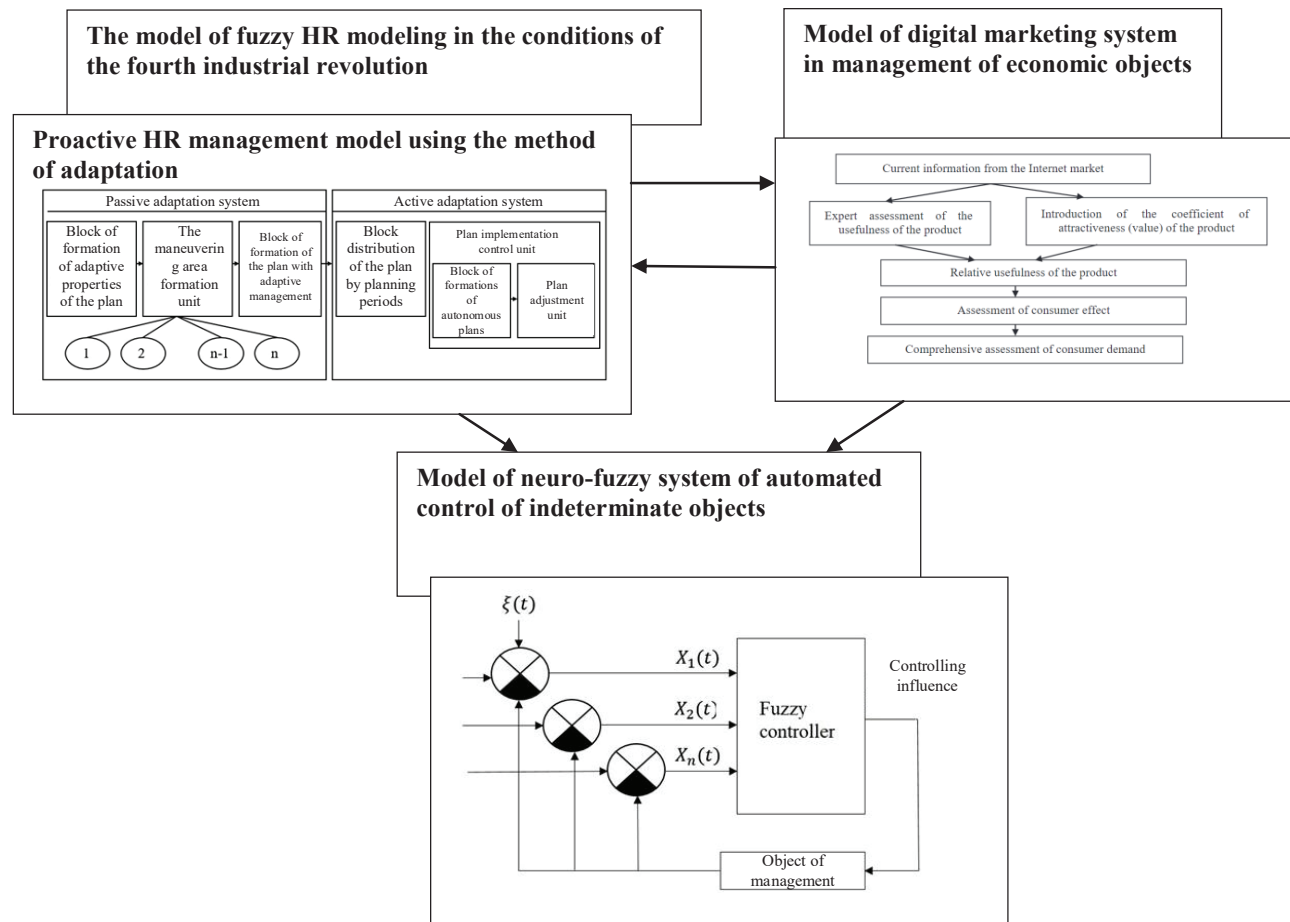


Fig. 1 – The structure of the interaction of management models of the economic entity

for them can not always be positively assessed by the next management action, so the decision-making system should include monitoring the effectiveness of decisions and the corresponding update of the knowledge base.

The task of updating the images of models with the subsequent formation on the basis of their analysis of the set of precedents can be realized by mapping Y of the set X to the set R :

$$Y : X \rightarrow R_{\Sigma}, \tag{4}$$

where $X = \{X_1(t), X_2(t), X_3(t)\}$ – the set of images of the process of forecasting the environment, respectively, which are analyzed separately over time $t \in [0, T]$,

$R_{\Sigma} = \{R_1, R_2, R_3\}$ – the set of decisions given through the decisions of models, processes and environments.

Y – type display allows you to use to provide automated management of the economic entity.

As a result of interaction of models the concept which is presented in fig.2 is constructed.

Interaction of intelligent economic systems with the external environment is carried out at the level of models: synchronization of works, invariant control system, data exchange models in HR management, fuzzy HR modeling in Industry 4.0, marketing analytics, multidimensional forecasting based on neural networks, order distribution data. and sales, evaluation of marketing activities of the enterprise and economic management system (controller in the management of economic object.

The conceptual model of intelligent economic systems in the conditions of Industry 4.0 is developed, presented

on fig. 2 allowed to formulate the following axiomatics of processes:

1. In intelligent economic systems (IES) all components of the model level are equivalent in terms of the general approach to operation and do not have a «core». That is, if the functional model (set) $M(n)$ has properties $A(\beta)$, then there is a model for which $nM(n)$ is true:

$$M(n) : A(\beta) \supset M(n) \rightarrow \exists nM(n). \tag{5}$$

On the basis of the analyzed works [2,3,5] IES is built, which is a model-analytical system with functional models that are practically inseparable from the whole information system (IS). The system is set up by selecting the input values of the economic entity. The number of factors used in the process of modeling economic indicators can be quite large, which increases the efficiency and, consequently, the effectiveness of IS.

Formation of a multidimensional IES forecasting solution. In IES for the economic entity is the key direction that determines the decision R_{Σ} . That is, all intersections of many solutions of models in the IEC system (marketing (R), human resources (R_{HR}) and other R_n , where $n = 1, \dots, N$.) is not an empty set then there is a real solution R_{Σ}

$$2. (R_{\Sigma} \rightarrow R_M \cap R_{HR} \cap R_n \neq \emptyset) \vee \{(R_M \cap R_{HR} \cap R_n | R_{\Sigma}) \neq \emptyset\} \tag{6}$$

3. Ability to build IES from functionally independent subsystems (models). So in the set R_n the advantage of S_n an be determined:

$$x : S_n \rightarrow R_n., \text{ден} = \overline{1, \dots, N}. \tag{7}$$

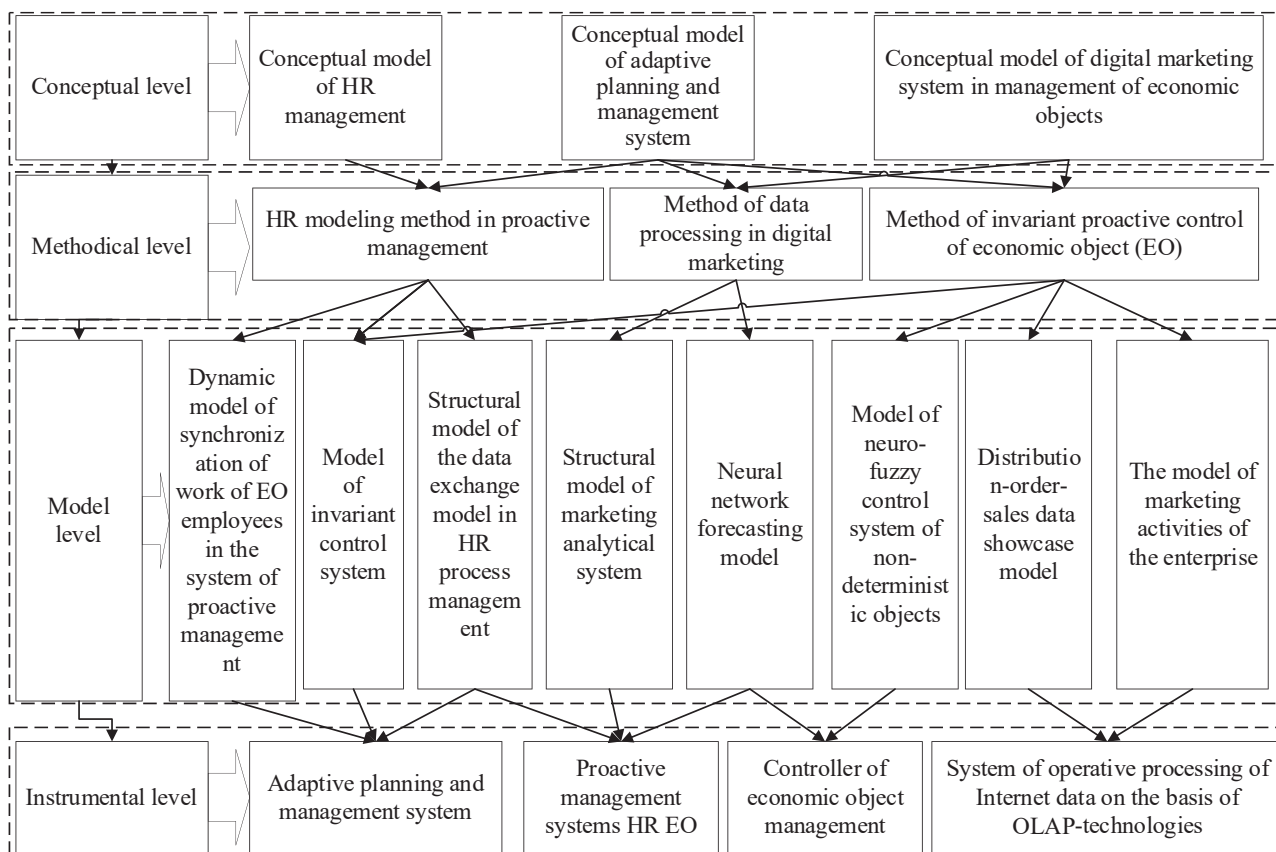


Fig. 2 – The concept of building intelligent economic systems in the era of Industry 4.0.

4. Possibility to use IES as a means of analysis and forecasting of individual processes of the subject of economic activity in marketing S (m), human resources management S (HR) and other S (T) for sustainable development of the subject of economic activity:

$$S_{\Sigma} = \{S_M, S_{HR}, S_N\}. \quad (8)$$

Conclusions

Thus, in the process of analytical review, the changes taking place in the economy of Ukraine make significant changes in the management of economic entities in the digital economy.

It is established that in the digital economy, IECs must respond quickly to changes in the economic environment

based on the modeling of Big Data (financial and product flows, marketing and others) with the ability to forecast, evaluate and manage. This will increase the efficiency of economic management.

Thus, the application of new approaches and the use of new economic and mathematical models and methods is a necessary condition in the strategy of IEC development in the activities of economic entities in the era of Industry 4.0.

Based on the proposed conceptual, methodological, model and instrumental levels and the developed axiomatics, a fundamentally new conceptual model of building intelligent economic systems in the era of Industry 4.0 was built.

References

1. Chukhno, A.A. (2006). Informatsiina postindustrialna ekonomika: teoriia i praktyka [Information post-industrial economy: theory and practice]. Kyiv : KNU. [in Ukrainian]
2. Ustenko, S.V., Bereza, A.M., & Haluzynskiy, H.P. (2012). Informatsiini systemy v ekonomitsi [Information systems in economics]. Kyiv : KNEU. [in Ukrainian]
3. Ustenko, S.V. (2019). Informatsiini upravliaiuchi systemy ta tekhnolohii [Information control systems and technologies]. Kyiv : KNEU. [in Ukrainian]
4. Chornous, H.O. (2014). Proaktyvne upravlinnia sotsialno-ekonomichnymy systemamy na osnovi intelektualnoho analizu danykh: metodolohiia i modeli [Proactive management of socio-economic systems based on data mining: methodology and models]. Kyiv : VPTs "Kyivskiy universytet". [in Ukrainian]
5. Chornous, H. (2016). Ahentna model intelektualnoi informatsiinoi sys-temy upravlinnia v ekonomitsi [Agent model of intelligent information management system in economics]. *Bulletin of Taras Shevchenko National University of Kyiv. Series: Economics*. No. 1(178). P. 41–47. [in Ukrainian]
6. Bashnianyn, H.I. (2014). Ekonomichni systemy [Economic systems]. Lviv : Liha-Pres. [in Ukrainian]
7. Kononova, K.Yu. (2015). Informatsiina ekonomika: modeliuвання evoliutsiinykh protsesiv [Information economics: modeling of evolutionary processes]. Kharkiv : KhNU imeni V.N. Karazina. [in Ukrainian]
8. Hrytsenko, A.A. (2020). Ekonomiko-informatsiinyi imperatyv novoi statystychnoi paradyhmy [Economic and information imperative of the new statistical paradigm]. Kyiv : DU "In-t ekon. ta prohnozuv NAN Ukrainy". [in Ukrainian]
9. Hrytsenko, A.A. (2020). Komplementarnist informatsiino-tsyfrovykh i sotsialno-ekonomichnykh peretvoren yak umova stabilnoho rozvytku suspilstva [Complementarity of information-digital and socio-economic transformations as a condition for stable development of society]. Kyiv : DU "In-t ekon. ta prohnozuv NAN Ukrainy". [in Ukrainian]
10. Lysenko, Yu.G., & Bizyanov, Ye.Ye. (2012). Komplementarnist informatsiino-tsyfrovykh i sotsialno-ekonomichnykh peretvoren yak umova sta-bilnoho rozvytku suspilstva [Fuzzy model of efficiency of subsystem of rationing of information system of management of the industrial enterprise]. *Ekonomichna teoriia – Economic theory*. No. 4–6. P. 16–25. [in Ukrainian]
11. Bizianov, Ye.Ie., & Zaitsev, I.S. (2009). Reinzhyriynh orhanizatsiinoi struktury infor-matsiinoi sluzhby pidpriemstva [Reengineering of the organizational structure of the information service of the enterprise]. *Naukovo-vyrobny-chyi zhurnal "Derzhava ta rehiony" – Research and Production Journal "State and Regions"*. No. 5. P. 17–21. [in Ukrainian]
12. Levytskyi, S.Y. (2004). Proektyrovanye ynformatsyonnoi systemy VED metallurhycheskoho predpriyatya [Design of the information system of foreign trade of the metallurgical enterprise]. *Problemy ekonomichnoi kibernetiky – Problems of economic cybernetics*. P. 61–65. [in Ukrainian]
13. Vovchak, I.S. (2001). Informatsiini systemy ta kompiuterni tekhnolohii v menedzhmenti [Information systems and computer technologies in management]. Ternopil : Kart-Blansh. [in Ukrainian]
14. Voinarenko, M.P., & Yemchuk, L.V. (2012). Informatsiini systemy yak osnova rozvytku tekhnolohii upravlinnia [Information systems as a basis for the development of management technologies]. *Biznes Inform*. No. 10. P. 70–73. [in Ukrainian]