

SECTION I. ECONOMIC THEORY

doi 10.17072/1994-9960-2019-2-198-217

UDC 338:004

LBK 65.39

JEL Code D80, D89, O10, O11

FUNCTIONS AND MODES OF INFORMATION DEVELOPMENT OF ECONOMY: METHODS AND MODELS***Oleg S. Sukharev**ORCID ID: [0000-0002-3436-7703](https://orcid.org/0000-0002-3436-7703), Researcher ID: [C-3767-2018](https://orcid.org/C-3767-2018), e-mail: o_sukharev@list.ru

Institute of Economics of the Russian Academy of Sciences (32, Nakhimovsky prospekt, Moscow, 117218, Russia)

Informatization intensification of the modern economy stresses the importance to discuss the following group of issues: 1) the establishment of criteria and measurement of the effectiveness of the information system; 2) the definition of the information potential of the agent and the assessment of effective information action; 3) information security of the social and economic system. The purpose of the study is to analyze theoretically the functions of various types of information with the determination of the efficiency of information and the modes of economic systems information development. Economic agents are known to search for relevant information that is only a part of total information in the system to make efficient decisions. The action of an agent as well as the development of an economic system is generally characterised with an efficiency coefficient that assesses the opportunity to obtain relevant information. The research methodology is the classification method that allows us to highlight the properties of information, to introduce quantitative indicators for measuring these properties and using mathematical tools to determine possible relationships between them, building theoretical models of the dynamics of information development of economy. Using this approach the functions of information, namely, notification, accumulation, cumulative amplification within the framework of consideration of the informational interaction schemes “object-agent” and “agent-agent” have been determined. The criterion of information potential of the controlled system and the information efficiency coefficient have been introduced. The latter means the ratio of information security to the level of information completeness of the system. Using the analysis of the dynamics of the efficiency and the ratio of relevant and general information, the modes of information development of the controlled system have been determined; three options for the accumulation of information with the ability to quantify the effect that determines the development of the knowledge economy have been suggested. Standard, enhanced and storage accumulations have been shown in the framework of the “object-agent” information interaction model, formal parameters for their quantitative assessment have been introduced. We have proved that one of the goals of economic policy should be the insurance of the necessary regime of information development of the economy, that is aimed at solving problems in the field of information security due to the fact that the functions of information can be violated, i. e. performed with different results, which indicates the dysfunction of the information system and economic management. Such the approach will reduce the depth of dysfunctions of economic policy measures and the application of the information security loop proposed by the author will provide the tool for comparing the damage and benefits from possible information threats, which predetermines the practical application of the conducted theoretical analysis applied to different information modes. Sustainable development of the modern economy should consider the elimination of information threats especially in the context of overcoming opportunism in the form of deliberate distortions of information in order to obtain additional benefits. At the same time, the use of the information security loop for the development of economic policy measures will allow not only to diagnose the damage and benefits within the existing information processing regime, but also to identify the dynamics of the economic system development as a result of changes in the ratio of information benefits and costs.

Keywords: information, informatization of economy, information potential of economy, function of information, information development mode, information interaction models, information security of economy, combinatory principle, information security loop, dysfunction of information system, dysfunction of economic policy.

* The main provisions of the original concept of information economy are highlighted in the article, that are precisely described in the monograph: Sukharev O.S. *Informatsionnaya ekonomika: Znanie, konkurentsia i rost* [Information economy: Knowledge, competition and growth]. Moscow, Finansy i statistika Publ., 2015. 287 p. (In Russian).



ФУНКЦИИ И РЕЖИМЫ ИНФОРМАЦИОННОГО РАЗВИТИЯ ЭКОНОМИКИ: МЕТОДЫ И МОДЕЛИ*

Олег Сергеевич Сухарев

ORCID ID: [0000-0002-3436-7703](https://orcid.org/0000-0002-3436-7703), Researcher ID: [C-3767-2018](https://orcid.org/C-3767-2018), e-mail: o_sukharev@list.ru

Институт экономики Российской академии наук (117218, Россия, г. Москва, Нахимовский проспект, 32)

В связи с интенсификацией процессов информатизации современной экономики возникает необходимость обсудить следующие три основные группы вопросов: 1) установление критериев и измерение эффективности информационной системы; 2) определение информационного потенциала агента и оценка эффективного информационного действия; 3) обеспечение информационной безопасности социально-экономической системы. Целью исследования является теоретический анализ функций различных видов информации с определением коэффициента полезного действия информации и траектории информационного развития различных экономических систем. Известно, что экономические агенты для принятия эффективных решений осуществляют поиск релевантной информации, которая составляет только часть общей информации в системе. Действия агентов, так же как и развитие экономической системы в целом, можно охарактеризовать коэффициентом полезного действия, оценивающим возможность получения релевантной информации. Методологией исследования является классификационный метод, позволяющий выделить свойства информации, ввести количественные показатели для их измерения и при помощи математического инструментария определить возможные связи между ними, построив теоретические модели динамики информационного развития экономики. Определены следующие функции информации: уведомление, накопление, кумулятивное усиление в рамках рассмотрения модели информационного взаимодействия «объект – агент» и «агент – агент». Введен критерий информационного потенциала управляемой системы и коэффициент полезного действия информации, который определяется как отношение информационной обеспеченности к уровню информационной полноты системы. Исходя из анализа динамики коэффициента полезного действия информации, соотношения релевантной и общей информации установлены режимы информационного развития управляемой системы; предложены три варианта кумуляции информации с возможностью количественной оценки данного эффекта, определяющего развитие экономики знаний. Обычная, усиленная и накопительная кумуляция показаны в рамках модели информационного взаимодействия «объект – агент», введены формальные параметры для их количественной оценки. Обосновано, что, поскольку функции информации могут нарушаться, т. е. исполняться с различной результативностью (что свидетельствует о дисфункции информационной системы и управления экономикой), одной из целей экономической политики должно быть обеспечение необходимого режима информационного развития экономики, направленного на решение проблем в области информационной безопасности. Такой подход позволяет снизить потенциал дисфункций управления, а применение предложенной автором петли информационной безопасности – обеспечить инструмент для сопоставления ущерба и выгод от возможных информационных угроз, что предопределяет практическое применение проведенного теоретического исследования вне зависимости от типа информационного режима. Элиминирование информационных угроз составляет перспективу для устойчивого развития современной экономики, особенно в отношении преодоления оппортунизма в виде намеренных искажений информации с целью получения дополнительной выгоды. При этом использование петли информационной безопасности для разработки мер экономической политики позволит не только осуществлять диагностику ущерба и выгод в рамках сложившегося режима обработки информации, но и выявлять динамику развития экономической системы в результате изменения соотношения информационных выгод и издержек.

Ключевые слова: информация, информатизация экономики, информационный потенциал экономики, функции информации, режимы информационного развития, модели информационного взаимодействия, информационная безопасность экономики, комбинаторный принцип, петля информационной безопасности, дисфункция информационной системы, дисфункция экономической политики.

* В статье освещаются основные положения авторской концепции информационной экономики, которые подробно представлены в монографии: Сухарев О.С. Информационная экономика: знание, конкуренция и рост. М.: Финансы и статистика, 2015. 287 с.

Introduction

Modern economics is turning into a “knowledge economy”, changing education [1], science, human capital [2], stylistics of decision-making in firms, innovative development [3] etc. In the multitude of scientific papers [4; 5], one or another nuance of this new reality is explored, when considerable resources are directed to processing information, obtaining new knowledge [6]. There are considered, for example, the problems of organizing e-government [7], control in information systems with the aim of eliminating conflicts that arise between agents in the process of information [8] processing or knowledge management processes within various information systems [9].

Some studies are based on questionnaires or consideration of local situations, individual tasks or are bibliometric studies [10]. Knowledge management depends on the state of the information system established in the economy of the information development mode. At the same time the aspect of ensuring information security is also important, because many types of knowledge can be used to reduce the level of security and ensure competitive victory.

Therefore, the solution of individual applied tasks, with all its utility, cannot be indicative from the point of view of examining all aspects of the information system – especially the point of view of the economic theory of the “information economy”. In addition, aggregated estimates of the mode or model of information development, applicable for comparison, including the effectiveness of obtaining knowledge and evaluating the general information potential, are even rare at the theoretical level of analysis. Quantitative estimates in recent studies relate to the measurement of the contribution of information and knowledge to economic growth and the ongoing structural changes [11], allow us to establish that a large amount of environmental information affects the distribution of resources in the economy. At the same time, the work with information, its

selection, analysis, processing is not measured at all, that is, the characteristics of the information are not taken into account and are not evaluated in an aggregated manner. Below, as part of the performance indicator, the information system will introduce the parameter allowing it to be assessed. Of course, information studies suggest the different organization of statistical accounting in the field of information. Since many data are missing, the analysis may be limited only to theoretical studies. There are theoretical works that have just been released, which make it possible to determine the direction of the information flow, taking into account expert assessments, to determine the priorities of the information system [12]. This approach takes into account training, the dissemination of information is not perfect. But it does not take into account how information systems function in the economy, what information mode they form, because the competition of firms and countries will occur precisely in terms of the efficiency parameters of working with information and knowledge in the future. This problem also requires theoretical works that reveal the meaning of the use of information potential and the functioning information development mode. Information security issues are considered not in the framework of the choice between various types of threats and their elimination, taking into account the relationship of damage and benefits, but in the framework of information security policies [13]. But there are not clear what the criteria, the parameters of this policy and the measure of sufficient accuracy are.

In order to fill the theoretical gap in the emerging information development mode, assess the information efficiency and ensure information security, the theoretical study of the information functions and information potential and the effectiveness of the information system have been undertaken. It allowed concentrating on three main aspects that are the subject matter in the article: a) extraction and measurement using the proposed indicators of information functions, especially three types of cumulative function; b) determining the information potential of the agent and the system and the coefficient of

information effective action; c) comparing various types of informational threats and benefits – according to the “information security loop” diagram.

Basic functions of information in economic systems

Emergence of the “economy of knowledge” has proclaimed in the economic theory of information [14–17] as the new form of economic relations and production of knowledge acting as a separate good. Market prices were considered as information signal to the agent defining its choice. There appeared different kinds of information sectors. Information obsolescence was considered as the reason of the prices range in the market, information asymmetry as the reason of adverse selection of decisions, opportunism and high transactional costs, and etc. Different outcomes of agents interaction in economics are determined by the properties and functions of information. Therefore, consideration of the functions of information can provide additional opportunities for studying the characteristics of various interactions in the economy. It is important not only to highlight the functions (various functions of the information is disclosed in scientific publications), but also to provide an apparatus for measuring each function and the possible application of these indicators, as well as to highlight the characteristics of the information development mode of the economy.

The functions of information influence the mode of developments of economic system greatly. It is possible to single out the following three basic information functions: notification accumulation and cumulative enhancement information. Let's consider successively the essence and value of each of the three main functions of the information in more detail to determine the indicators that would allow in the future evaluating each function.

1. **Notification.** Information is meaningful data or facts which are transferred from one agent to another in different ways, expanding the knowledge horizon of the agent about specific event, object/agent, process,

phenomenon, and etc. This information may be useless for the agent. He can even receive it against his will, not wishing to possess this information, for example, having casually heard someone's conversation or exchange of opinions, and etc. Frequently such information is casual and it is quickly forgotten by the agent, but under some circumstances when it becomes important, its value and meaning increase many times over. Notifying property of information imposes the condition of non-distortion on the agent, that can occur due to incorrect perception of information, in particular, because of the way the agent feels, or the noise effects accompanying the reception of information (much also depends on data carrier). In Figure 1 the function of information perception, processing and analysis provides change of the agent model $I_z = \Omega(I)$ where Ω is the change which is carried out by the agent receiving information I . Certainly all the functions specified in the Figure are functions of time. The agent forms the way of influence on the object. This object may be other agent in respect of which such scheme will be specular [18].

Then, $V(t) = f[I(t), \Omega(I(t))]$, or $V(t) = f[g(I_0(t)), \Omega(g(I_0(t)))]$.

Thereby, influence is defined by the complex function of change of initial information which is many times transformed by the agent as the addressee of information and the way of influence and perception of this impact by the object, that changes information on the object $I_0(t) = Z(V(t))$.

2. **Accumulation (consumption security).** Changing on a loop (Figure 1), information accumulates, because changing during processing and influence, all three elements of information chain, that is, agent, object and the channel of state and behavior correction, act not only as the tools of information change, but executing such function they become generators of new information. In other words, the state of the elements providing information passage makes certain contribution to the structure (content) of information, thereby providing generation of new information (change of “old” information). Thus, there is not simply

change of one and the same information, but emergence of new information on the basis of the previous information signal. If the information has new content, data and notification, it is new information even if it is obtained on the basis of the initial information. Hence, informationally in its elementary representation on the type “agent-agent”, or in general case “agent-object” where the object can be the agent, the economic system is an information generator in which there are information distortions, noise, but the contour is arranged so, that despite a certain deviation in its work, it rejects unnecessary information and alters it, transforming into necessary one. But any information is accumulated either in the agent’s memory, or on storage carriers of information – paper (archive), electronic carriers in the form of patents, copyright certificates, and etc. Figure 2 demonstrates mutual information interchange when there is another agent in the object’s place. In this case they exchange information, and there are two information streams, one being directed to the other agent without correcting influence on it, like $I=g(I_0)$, and the second one having correcting influence. But both information streams make up the total value I_{12} from the first agent to the second one and back I_{21} . In other words, not only the influence correcting the state and behaviour of the agent/object

bears definite information, but there is information stream which is transferred without influence (such information is taken into consideration, without changing the state of the agent and the model of his behavior. It is purely notifying function of information.

By the way, comparison of these two streams generates dual model of agents’ behavior as the agent can compare such information with the information which results in correction of his state and behavior. Such comparison can also change the agent’s behavior model. That is why, in practice these two information streams are difficult to distinguish, especially relying on the criterion of absence of behavior correction as any information, even outdated, received many years ago and then not influencing on his behavior change, can determine the change of agent’s behavior after a considerable time interval.

The function of information accumulation by each agent is presented by parameters I_0 , I_z , and each agent has its own one. Cumulative function (the effect connected with it) is caused by the directed flow of information according to functions V , W (Figure 2) which depend on notification, accumulation, and plus in a general sense on the state of the channels of information influence and characteristics of interacting agents.

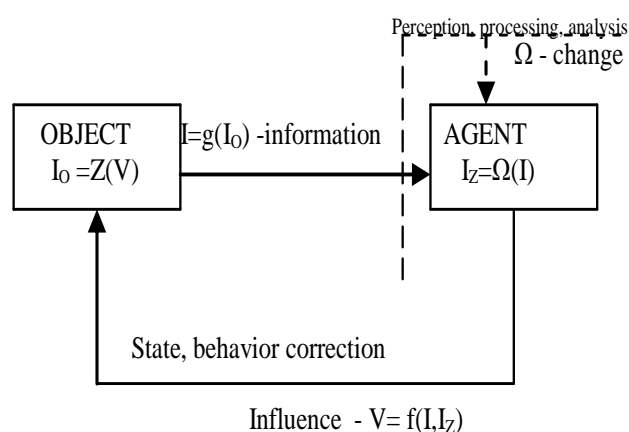


Fig. 1. Information change between the elements of economic system

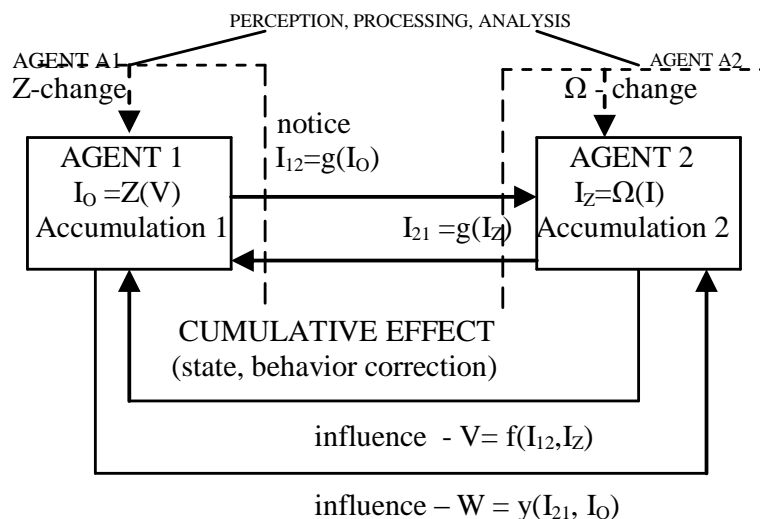


Fig. 2. Information change between the agents

On the chosen time lag the process of information accumulation can be characterized with parameter $N=I_Z(t)/I(t)$. The closer this parameter to the unit is, the better is the processing and accumulation of information. Certainly, accumulation process depends on the state of the agent and his inclination to process and store (select) the necessary information. At the moment when the agent receives information he should be able to define whether it is necessary in the future or not. The agent has protective filters at the level of perception, processing and analysis of information, which he creates himself in order to work only with potentially interesting information. If the filters have not worked for some reasons, information has the property of security [19; 20], that is, it is not lost if the agent did not delete unnecessary, not interesting or dangerous data.

Radical difference of information and knowledge from other consumer blessings is security of these blessings during consumption. Any product, especially foodstuffs, disappears during consumption. Inedible products wear out, lose value and disappear, but in the longer period of consumption. Information has the property of preservation during consumption that becomes a defining condition for its accumulation. However, as only one person is the carrier and consumer of information in the society, information also has the property of fast obsolescence and is forgotten. If the information is located on the carrier, the

probability of its security at any obsolescence is much higher, than when it is in the human memory [21]. When the worker is fired from firm, retires or dies, it is often said, that such an expert, a professional has gone, who could not be replaced. It is especially actual when only he knows a certain compounding/technology or possesses certain unique skills which are not fixed anywhere as the information intended for training and transfer. The probability of information losses in such cases is high. They often happen, especially under conditions of economic crises when the number of dismissals and excesses essentially increases. The described processes accompany information accumulation. Certainly, at estimation of accumulation it is important to consider the agents' ability to process information, that is, their inclination to accumulate and use great volumes of information. Under stressful conditions such inclination sharply decreases. It is possible to present accumulation indicator as follows:

$$N = \frac{\Omega(g(I_o(t)))}{g(I_o(t))} \quad (1)$$

As we see, it depends on the state of information reception channel which is defined by function $g(I_o)$ and on the state of the agent $\Omega(I(t))$ – information acceptor and processor – who is either inclined or not inclined to its accumulation. The process of information accumulation could be institutionally limited for the agent. Generally, indicator N changes from zero to

unit. When $N=0$, the agent rejects information in the sense of its accumulation and there are no costs for information processing, storage, and analysis. This variant is possible. Moreover, for some models of economic behavior it is immanent. The agent operates as a robot, he does not need to accumulate information. There are initial data – knowledge – and he is not inclined to increase their volume. Information accumulation is a strict condition of training and perfection of knowledge. The learning process and then the use of knowledge is impossible without accumulation. Figure 2 actually reflects the permanent process of education connected with accumulation of information and its transformation into knowledge which is used for various kinds of impact. When $N = 1$, there is a situation, when the agent does not reject any piece of information. He processes and uses it somehow. He can forget some piece of information, having set it aside in distant memory cells, but at some way of processing which can be designated as memory, this information will be used.

3. Cumulative enhancement (combinatory principle). The information arising in the conformity with the scheme of Figure 1, when two agents communicate with each other and thus transfer mutually helpful information, is not subjected to registration from the positions of modern analysis methods, but it expands agents' information potential, when it is a question of useful information. There is a form of information which we will designate as disinformation, that is, information misrepresenting the reality and the facts. One agent presents such information to the other agent because of the poverty of intellect (distribution of false information without actual basis, rumor and gossip), misconception (from one's own lack of knowledge), or to mislead the other agent on purpose, predetermining his actions favorable to the agent who uses disinformation. It is important to notice, that such information having the status of "disinformation" is also subjected to the processes of accumulation. However, if the agent's functions – perception, processing and analysis – are effective enough, such information will be

defined as low-quality and will be rejected as a condition for the influence correcting the object. Thus this information will be stored. Nothing will prevent, though the probability that it will be quickly forgotten is great. But the information about the person who presented such low-quality information will hardly be forgotten. Most likely, the agent will change his attitude to such agent, having corrected his actions concerning him in the future, either having excluded or having reduced information contacts with him. Thus, the functions of perception, processing and analysis play the most important role of information filter, providing cumulative effect concerning information. The essence of this effect is reduced to increase of this information utility which the agent possesses during its analysis and processing and reception of new information. Combinatorics in the area of information is the strongest and most unexpected. That's another matter, that it completely depends on initial knowledge of the agent, the ability to apply this knowledge, including input information, and on the efficiency of the institutions providing the work with information.

If the volume of input information sharply increases on some time lag $I = g(I_0)$, the general result of the work with information will be defined by function $\Omega(I)$, characterizing the agent's opportunities. When the agent has low initial intelligence, or the information volume sharply increases, and the agent has no experience or functioning possibilities under similar conditions, the accumulation process can be interrupted or stopped. The agent will not grasp such information. Thereby, cumulative action of even available information will be limited. Combinatorics in the area of information and cumulation strongly depend on realization of accumulation function of information. It is necessary to notice, that cumulative action of information is expressed in correction of the state and behavior of the object, relative which this information is used by the given agent.

At usual cumulative effect of information, increase of accumulation parameter for the account of this effect is observed. Hence, it is possible to speak about

“usual cumulation” (K_1), presenting it numerically with parameter $K_1 = (\Omega(I) + V(I, I_Z))/g(I_0) = N+V(I, I_Z)/g(I_0)$. In this case cumulation means information accumulation plus effective action – use of information. Enhanced cumulation (K_2) of information means essential strengthening of the significance of accumulated information at influence on the object. It is possible to present such value $K_2=N(V(I, I_Z)/g(I_0))$ – product of accumulation parameter and information efficiency coefficient¹ (the relation of the influence of the initial information from the object on the function): $V(I, I_Z)/g(I_0)$.

The third probable variant of cumulation is “accumulation cumulation” (K_3) of information, independent of the influence on the object. It is suggested to present it as follows:

$$K_3 = \frac{\Omega^N(g(I_0))}{g(I_0)} \quad (2)$$

If there is no accumulation, there is no cumulative effect (new) as well. Though it is necessary to recognize, that cumulation on the basis of “old” information is possible, but it should be estimated according to the previous accumulation of information. In each concrete economic system its permanently changing conditions and reasons forming cumulative effect of information will operate. In this connection a concrete system may have its own dependence for such effect.

Combinatory qualities of information redouble the requirements on the function of perception, processing and analysis – $\Omega(I)$. They also form qualifying requirements for the agents. After all, the lower the initial skill level and education of the agent, the less the possibilities of information processing and increase of relevance level of this information for himself and for the society. The total effect of cumulation on the information chain is stipulated by the quality (state) of each element of this chain.

In the general case information, giving cause to various interpretations or having the effect to increase the number of alternatives, promotes time dilation of its processing and

decision-making, reproducing time lag between the decision (management) and information change. The result of such changes is change of resource flows regarding redistribution and increase/decrease in the volume of consumption. Initially information potential of the object and the agent are unequal. Further dynamics of their change is defined by the contour considered above. The above three main functions of information ensure the formation of the agent or economic system information potential. Let’s consider how the information potential of an agent or system can be identified, how it is formed and how it can be assessed. Then we will move on to the problem of identifying information development modes and ensuring information security.

Types of information and information potential of the economy

Information market is highly segmented as there are a lot of types of information with different variants of its application. Though the agent needs information about the object, area of his efforts application, functions, costs (prices), and etc. before making the decision, the demand for information is a derivative of what the agent does, or what he wishes to do or what he expects to receive as a result of his choice. The person who possesses information should not suggest it on purpose, because he does not know who needs it and who will be the agent of the demand for this very information. Moreover, he cannot know, whether he is the only owner of the information, or if there are more agents who own the same information, or if the information is of higher quality. This higher quality of information is connected with better function of the agent notification with the same information volume (in bits), the ability of better accumulation and manifestation of cumulation property at the same costs of information processing.

Only the information presented on any carrier can be sold, and the carrier should be protected against recurring information replication without payment to the agent (manufacturer) offering the information. If there is no carrier, there appear at once the problems connected with information security,

¹ Similar to the output-input ratio used in engineering, in this case for information.

as from the consumer's point of view, information as a product has the property of replication and safety in consumption. The price of one types of information during consumption does not decrease, the price of others can sharply go down (information aging). Unlike information, knowledge is of great value, as it can be also used repeatedly, but it is an original factor of production which assumes either its use in production of consumer blessings, or the use of knowledge as that. Unlike information, knowledge is localized by the sphere of knowledge – within the discipline or the subject which should be studied to obtain corresponding basic knowledge. Further knowledge augmentation is the result of scientific work of those who had initial knowledge of the objects and systems. New knowledge is reproduced only in the research of experts. Information is reproduced without dependence on scientific work and not only by the experts. It is the basic difference between information and knowledge, though knowledge, of course, is the information of special type.

Besides the property of notification inherent in usual information, knowledge has the property of “notifying augmentation” and preserves two properties – accumulation and cumulation. Notifying augmentation means that it expands the horizon of the received data. If the agent possesses knowledge, it allows him to expand the perception horizon of not only obtained knowledge, but also the information received and having only notifying function. Knowledge expands the possibilities of information use. The problem is that during the analysis I have differentiated the processes of acquisition of knowledge and information. Actually, getting of usual information and knowledge occurs simultaneously, enhancing cumulative effect of their assimilation or, in case of very large volume of information and knowledge at limited time, weakening the effect due to the difficulties in assimilation or assimilation refusal.

Knowledge possesses the same effect – acquisition of some kinds of knowledge as though programs further process of cognition, increasing the expenses of its prolongation. Knowledge always has protection only

provided not by the carrier (RAM disk protected by the key, the password, and etc.), but by the procedure of knowledge fixation, be it a patent, a copyright certificate, useful model, research report or technical documentation, a textbook, a monograph or an article. The fact of information/knowledge security converts this blessing into the category of private blessings. Of course, the fact of knowledge and information consumption by one agent does not limit the consumption of the same volume of knowledge and information by other agent. Therefore before the epoch of sharp increase of information and knowledge specialization, these kinds of blessings were quite fairly considered as public goods. Presenting knowledge and information in the form of public goods, economists of classical school believed that they should have zero price because of non-competitive character of their consumption. Economic changes, reduced to special institutional regulation of these blessings consumption, resulted in the situation when they changed the status of this kind of blessings. The costs of provision of one additional unit of knowledge and information in the modern world are not zero, therefore the recommendation concerning zero price in the certificate of consumption of these blessings is not satisfactory.

Let's present possible change of general and relevant information on the diagram (Figure 3).

t – time, Tr – transactional costs,

Q – general information, Q^* – relevant information (knowledge)

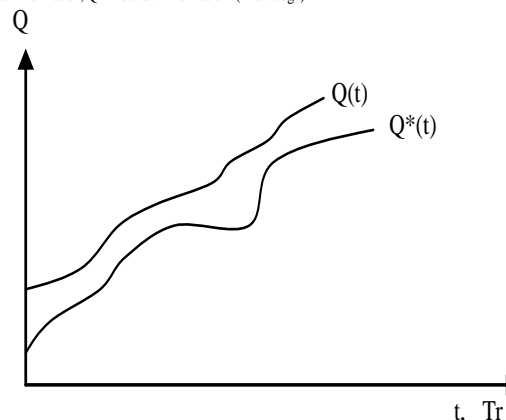


Fig. 3. Volume of general and relevant information

The volume of relevant information (knowledge) is usually less than total volume of information. Eventually it also increases, as well as the volume of general information. That happens with the growth of transactional costs. The volume of relevant information can approach and move away from the line of change of general information. Approach will mean increase of technological possibilities of information processing and education, removal means worsening of these possibilities or crisis, when relevant information is lost, and the volume of general information can continue to grow. In case of steady divergence of the lines of change of general and relevant volumes of information, it is possible to ascertain the decreasing return of information factor of the development due to the effect of knowledge saturation. However, the combinatory effect providing information cumulation and resulting in occurrence of new relevant data for the account of combination, not for the account of new discoveries can become overcoming of decreasing return. In other words, it means intensification of the received knowledge, “deep” development, instead of extensive development or “wide” development for the account of absolutely new heuristic discoveries.

Information potential of the agent is his general possession of relevant information in various fields of activity. The agents have different information potential on different reasons. It depends not only on personal qualities of the agent, his education level (which in itself is an information potential) and cognition, but also on perception, the abilities to process (choose, compare) and analyze (range, order, synthesize) information and, certainly, on his professional sphere. The last is very important, because it defines information mode as professional area can stagnate and there are no new technologies there or any active changes that will also predetermine information potential of the development of the object and the agents occupied in it.

Let's introduce the function which would connect parameters of the agent processing the information $b=f(k_1, k_2, k_3, K_m, T, s)$, where k_1 – personal characteristics of the agent (temperament property, inclination to work with information), k_2 – education level, k_3 – abilities

to digest knowledge (cognitive characteristic of the agent), K_m – indicator of combinatory effect on information blessings, influencing information potential, T – technological level (including the state of stock base), s – the state of the sector or the scope of activity of the agent (system qualities, including institutions). Each indicator in this function changes dynamically in time. Therefore function $b=b(t)$ is time function.

Let Q_I be relevant volume of information, Q – general volume, $k=Q_I/Q$, $Q_I < Q$ – efficiency coefficient of the agent, information system. A is a non-negative factor, not equal to zero (free term). It characterizes information potential of the agent/system when it possesses very low/zero abilities of the work with information or the same technological level or absence of application area of corresponding efforts regarding application of information potential. If $b=0$, the minimum information potential is equal to A . Parameters of the agent's “personal qualities” in function b will turn to corresponding parameters for the system – intra-organizational efficiency, the ability to make decisions, to process information and etc.

Then, it is possible to present information potential of the agent/system (I) as follows:

$$I = Ak^b = Ak^{f(k_1, k_2, k_3, T, s)}, \quad (3)$$

$$I = A \left(\frac{Q_I}{Q}\right)^{f(k_1, k_2, k_3, T, s)} \quad (4)$$

We will present the parameter characterizing the efficiency of information system in the following way:

$$R_I = \frac{V_I}{Z}, \quad (5)$$

where V_I – speed of information processing, depending on the processability of the work with information/knowledge; Z – costs of provision of speed, technological parameter of the system.

Let's present the possible change of information potential of the agent/system depending on function b and time (Figure 4). Growth of function b means improvement of the qualities of the agent/system in the work with information and knowledge. As a matter of fact, it is increase of “information” productivity.

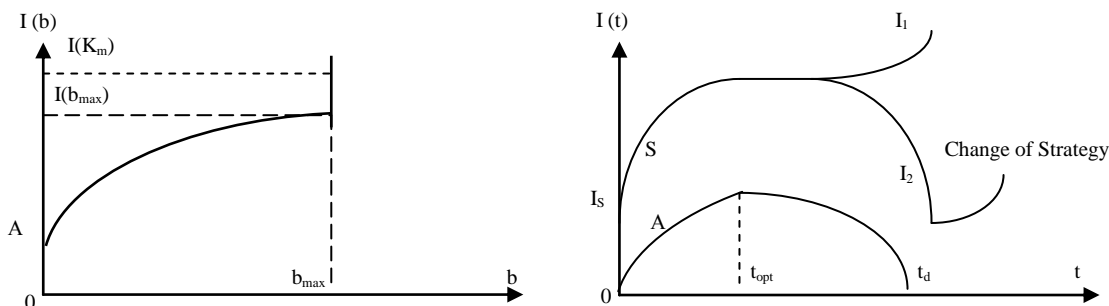


Fig. 4. Change of information potential of the agent/system

With the improvement of the parameters of the agent/system, which means expansion of possibilities of work with information and knowledge, information potential $I(b)$ increases, that is reflected in Figure 4 (on the left). It demonstrates increase of relevant data which the agent owns. But here the effect of forgetting information is not considered. It can be strong under conditions of crisis or any one-moment or short stress of the agent or the system. Certainly, in that case growth of information potential will be slowed down a little or will stop. Information potential can be invariable, or decrease, as Figure 4 shows (on the right, branch S refers to the system). When possibilities of increase of information potential are exhausted as a result of function b growth there comes the moment when they are not improved as the agent's qualities have the property of saturation. At the best they remain the same. Such effect is characteristic for the systems with many agents as well. However, the further growth of information potential is possible both for the agent, and for economic systems, as Figure 4 reflects (at the left), but for the account of information combinatorics $I(K_m)$. I have not intentionally included combinatorial coefficient in function b to separate the influence of various conditions and effects on the change of information potential of the agent/system. Certainly, combinatorial effect for economic system is considerably higher as this effect for the agent also depends on his qualities (inclinations), initial education, and etc. In the system, where there are lots of agents and there are varieties of information, combinatorial effect

is manifested with greater force. Change of information potential for the agent and the system in time (on the right) is presented in Figure 4. Information potential of the agent changes during his life from zero to zero (death of the agent). Another matter, that it is not completely lost, and information created by the agent or its part remains on these or those carriers. When the system emerges, information potential is not equal to zero and it is increased in the process. Periods of growth stabilization of information with further growth (line I_1) or decrease of information potential are possible. Crisis or stress factors for the system can also cause decrease of information potential. In particular, defeat in competition usually reduces information potential, because the firm as a system does not have market information and does not develop in the given market. Search of other information and other markets and activity reorientation will mean additional investments into extension of information potential after its decrease. But forming of new behavior strategy can overcome not only the negative tendency, but also provide further growth of information potential that is demonstrated on line I_2 in Figure 4 (on the right).

It is necessary to notice, that general utility of information is an increasing function in time and it depends on the increasing volume of information. In relation to relevant information its general utility increases for the agent depending on the volume (in the nearest period of time when it is received), but then it starts to decrease, as the importance of this information and the level of its relevance are

reduced, so the utility also decreases. If the additional volume of relevant information is received at this moment (it is necessary to bear in mind that it is different information in its content), then such addition can increase general utility of relevant information, but as for specifically received information, it is subject to the same law. At the moment of the reception the utility increases, information starts to be used and then this utility decreases. Certainly, there are such types of information and knowledge whose utility does not decrease long enough. Moreover, they form the basis for further reception of relevant information. Such kinds of relevant information (knowledge) are adsorbed into textbooks, and are passed on from father to son, making the basis for education of the agents. Mental elimination of such knowledge or impossibility to assimilate it result in big losses in the sphere of technics and technologies as the whole layers of other information become useless for the agent because this fundamental knowledge is not assimilated.

Relevant information (knowledge) provides completeness of information of the agent about the market, competitors, economic changes (governmental decisions), and etc. Hence, introducing the efficiency coefficient of “information system” with reference to the agent and the system, we have estimation of information completeness in a general view. Each type of information is unique, so such estimation on each type of information is necessary. We will address to the “dilemma of the prisoner” according to which the agents who have committed a crime, do not have information about each other and interrogations. They are kept in separate prison cells and are made to make a behavior choice according to the introduced institutions determining this choice. They have general information about their crime, they know what they have done together and who has helped whom. They can realize the degree of guilt and participation of each other, and etc. But they do not have information relevant to the choice. As a result, it is known, the dilemma reduces the situation to the choice when the agents tend to maximize the utility, but actually they

worsen their choice. Of course, with other institutions of choice or with other relevant information the choice would be different. Hence, information completeness multiplied on institutional condition of choice defines well-being of the agents who are choosing.

Neoclassics were not too right, asserting that for effective outcome of market functioning the market agents should possess full information. The quality of choice and decision-making directly depend on information completeness, i.e. the degree of its relevance. Generally, information completeness which the agent possesses mismatches the relevant volume of information which is potentially possible. In other words, the agent owns a part from possible relevant information, thereby full information for the agent $P=cQ_I$ – is a part of the relevant information (c – the degree of completeness or a part of the relevant information at the agent’s disposal), where P is the amount (volume) of relevant information which the agent possess, and Q_I is relevant information which the agent does not have for whatever reasons.

Proceeding from the presented correlations, the efficiency will be defined as follows: $k=P/(cQ)$. If we designate $u=P/Q$ as information security of the agent (system), the efficiency of information system $k=u/c$ is equal to the relation of information security to the degree (level) of information completeness.

It is easy to notice, that when the efficiency coefficient the agent k is constant and the change of this parameter is equal to zero, there is a correlation when relative increment of relevant information at the agent’s disposal is equal to the sum of relative increments of the degree of information completeness and the total amount of arriving information. This statement is equivalent to the fact that relative change of information security is equal to the relative change of the level of information completeness of economic system. Efficiency is the characteristic of the economy information potential. According to this parameter, we can distinguish the modes of any system information development. These modes, of course, are determined by the ability of the system to work with information, increase and use information potential.

Modes of information development

Unlike the agent, decision-making institutions at various levels of hierarchy are important for economy. At the same time, considering a high variety of the system, each case of decision-making will be unique or, at least, original. At the same time the efficiency coefficient of information system as an aggregate indicator (in its value) will either

limit or extend the development and make decisions possibility.

Efficiency coefficient of information for the economy as well as for the agent can increase, decrease, or remain invariable. These three variants of change give some modes of information development of the economy. Let us present them in Table and give a short characteristic (the last column on the right).

Modes of information development of the economy

Efficiency coefficient of information system, k	Volume of relevant information (knowledge), Q_i	Total volume of information, Q	The characteristic of k change	Mode of information development
k increases	Increases	Increases	Increase of relevant information outstrips the growth of the total volume of information	Hi-tech development, high combinatory effect
	Decreases	Decreases	Losses of the total volume of information exceed the losses of relevant information, reactive increase of k	Crisis/stressful development at quite good storage of relevant information, reduction of information reproduction
	Increases	Decreases	Relevant information grows for the account of better processing and reduction of the total volume of information	Increase of processing efficiency at crisis, conflict/stressful development
	Does not change	Decreases	Relevant information does not decrease, but the total volume of information is reduced, reactive increase of k	Efficiency of relevant information selection does not change at crisis development, conflict/stressful development
	Increases	Does not change	Relevant information is synthesized from the available volume of information for the account of the reserves of combinatorics	Augmentation of relevant information from the available total volume of information the supply of which is stopped due to competitive actions. Activation of combinatory effect
k decreases	Increases	Increases	The total volume of information increases by more value, than the relevant information	The efficiency of information processing decreases, development with the decreasing technological level
	Decreases	Decreases	The losses of the total volume of information is less than the losses of relevant information	Crisis development, with technological losses, and with the loss of data carriers, or sharp restriction of access to relevant information and the total volume of information
	Decreases	Increases	Relevant information reduces against the growth of total volume of information	Mode of compression of possibilities of information processing at its growth, failures in the work of information systems, technological effectiveness decrease
	Does not change	Increases	Relevant information does not change at increase of the total volume of information	The arriving information is not processed in time due to the decrease of efficiency or insufficient technological effectiveness of information processing
	Decreases	Does not change	Relevant information is reduced at invariable total volume of information	Exhaustion of educational possibilities, efficiency decrease of the means of information processing at restriction of the supply of the total volume of information - competitive influence

Efficiency coefficient of information system, k	Volume of relevant information (knowledge), Q_1	Total volume of information, Q	The characteristic of k change	Mode of information development
k does not change	Increases	Increases	Equivalent change	Increase of the total volume of information covers possible effect of selection improvement of relevant information
	Decreases	Decreases	Equivalent change. Reactive preservation of k at reduction of technological possibilities	Mode of curtailment of technological development (technologies of processing and selection) of relevant information at general crisis and reduction of the total amount of information, that is, processing needs also reduce, that reactively preserves the efficiency coefficient of the system
	Does not change	Does not change	The volume of relevant information and the total volume of information are kept at one level	The mode of relative information rest

As we see from Table, there are a lot of modes of information development on the efficiency coefficient of information system characterizing its ability to select/receive relevant information (knowledge). Relevant information is understood as received/obtained (created) knowledge or the information representing increased value relative to the general information and potentially used in production and at the solution of other management problems. Developed information modes with reference to the economic system or the agent make up the result of participation of this agent or system in competition. Institutions and market forms define each of the modes, as well as “technological effectiveness” behavior defines the possibilities to process information and to receive new knowledge, or to find new points of application for the available knowledge from the point of view of information. The process of generation of new knowledge is based on combinatory principle with the account of information accumulation, conditions of the agents notification and the agents’ abilities to process information performing the function of its augmentation which should not generally be combinatory.

Theoretically and in practice economic systems are characterized by various correlations of general, relevant information and accumulated knowledge. It is their fundamental difference which is set on the efficiency coefficient, characterizing the

developed mode of information (technological) development of economic system. The task of macro-management is to ensure the transition of the system from one development mode to the other which will be characterized by better information and technological possibilities. Thus, providing innovations [22] and a new level of technological effectiveness of economic system are, first of all, the organization of information systems of different type and the appointment. Other things being equal, the lower are the transactional costs of their functioning and management, the higher is the efficiency coefficient of information and the higher is the productivity/efficiency of the system management. Certainly, dynamics characteristic of transactional costs is not enough for defining of the necessary management model using this or that information. It is necessary to take into consideration such parameters of the economic system as the functioning purposes, the area of application of the efforts of different elements and subsystems, functional provision including information, time of action and the character of changing influences, stability to internal mutations and external influences on the system. These parameters set the dysfunction of information and economic system and controlling actions should be aimed at its decrease. Thus, economic policy should be oriented not only on the solution of the problems and substantiation of problems

statement and methods/tools of their solution. It should assume the actions on increase of efficiency of economic policy and its quality that is achieved by means of defining of arising dysfunctions and their overcoming. It also refers to information functions which are being studied here. It is the dysfunctions of information causing decrease of information potential of economic system that reduce management efficiency and prospects of the expedient development of the system when they are accumulated. At first, competitive loss on information appears, then it will be transformed to defeat in the markets and decrease in the general technological effectiveness of economic system. Taking into account the considered functions of information and development modes of economic system will allow counteracting the arising dysfunctions for the account of regulation (adjustment) of the basic institutions of economic policy and information management. The issue of information security in this case becomes decisive.

Information security of economy

Information security is associated with the threat perception and its elimination by dint of information tools. Information security threats can be potential (not accomplished) and fulfilled, that is the real threat has taken place. It is this held threat that causes damage and violates the economic security of the country. While the event has the status of a potential threat, there is no damage. Only actions ensure the realization of the threat from those who can and/or should carry them out. In order to carry out actions, there must be a motive, both of one's own benefit and of causing damage to the other side, in order to take it out of the field of competition. In the course of such actions, for example, the current operational parameters of the system deteriorate relative to the threshold safety indicators. It goes into a different state, with worse functioning and competition. This outcome is facilitated by both exogenous effects and endogenous policy mechanisms of the country. Their joint influence may determine each other, and may be completely independent, which imposes an

imprint on changing the parameters of the state's economic security.

Emerging threats, the method of their generation especially external threats is not controlled by this state. But whatever it is [way of generation], threats are basic and derivative, dependent on basic ones. The baseline ones persist for a rather long time, the derivatives change their intensity under the influence of various circumstances, including the methods of counteracting the threats. The combined strength of the derived threats may be more significant than a single basic threat. Threats have the quantitative measurement (in the form of risk and the expected losses or benefits), as well as the qualitative measurement (expert assessments). There may be threats to functioning economic institutions (rules of economic behavior), organizations and other structures in the economy with respect to the management system (disbalance of the state management system at all levels – dysfunction of institutions and management), etc.

For each threat that has come true:

$$V_k = W_{ik} - Z_{jk}, \quad (6)$$

where V_k – net losses / benefits of the threat (V_{ko} – potential threat), equal to the difference in benefits W_{ik} and costs Z_{jk} , and $i=j$, that is the benefits and costs can arise both in one sector (object), and relate to different, k – the number of threats is from 1 to N .

Similarly for a potential threat:

$$V_{ko} = p_{ik} W_{ik} - p_{jk} Z_{jk}. \quad (7)$$

It is important to note that, ideally, the economic security risk management system [23] should eliminate these risks in such a way as to not only preemptively remove threats at the level of potential, but also reduce the costs of existing threats in order to gain benefits, that is, $W_{ik} \neq 0$ and what's more, $W_{ik} > Z_{jk}$ (maximizing net gain). Such an outcome will completely destroy the possibility of a planned realization of threats against a state by third countries. Of course, the level of autonomy, the low degree of structural and other dependence increases this possibility, no matter how controversial it is regarding the trends of integration into the world economy, which are presented as a positive outcome.

Based on the presented relations, it is not difficult to write down that:

$$V_r = \sum_{k=1}^N V_k, V_o = \sum_{k=1}^N V_{ko}, H = V_r - V_o,$$

$$v_k = \frac{V_{ko}}{V_k}, w_k = \frac{W_{ik}}{Z_{jk}}, z_k = \frac{P_{ik} W_{ik}}{P_{jk} Z_{jk}}.$$

Thus, the magnitude of the total losses/benefits for the entire system is estimated to be real $-V_r$ and potentially $-V_o$. Then the difference of these values (H), is determined, the structural relations of the parameters of the basic formula for estimating the net value of losses/gains are found. Thus, it is possible to resist risks by reducing the likelihood, increasing the benefits for other sectors, activities, agents (a model of using threats for their own purposes).

The worst situation for the economy is achieved when the value of $V_r < 0, V_o < 0$, that is, there is damage both potentially and real, while the actual damage is greater than the potential damage, that is, $V_r > V_o$.

Imagine the diagram of information security (see Figure 5).

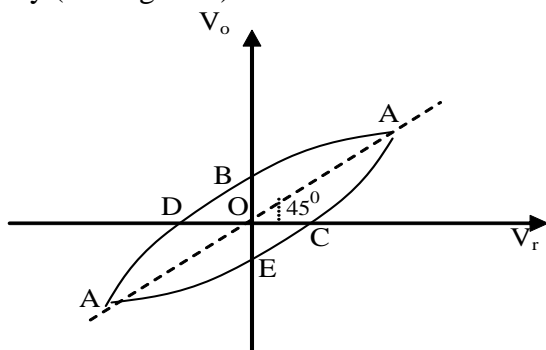


Fig. 5. Information security loop

In the first quadrant (Figure 5), there are benefits from existing and potential threats ($V_o > 0, V_r > 0$), however, in the section BA, the expected benefits are higher than the real ones, in the AC segment – the real benefits are higher than expected. Both situations are ideal, although the AU line is better, since the real benefit is higher than expected. In the third quadrant there is damage, that is, economic security is deteriorating. Moreover, in AD, the expected damage is lower than the real damage, which suggests that economic security measures do not work. In line with AE, the expected

damage is higher than real, therefore, the measures taken to eliminate the risks are more or less effective. In the second quadrant there are expected benefits, but real damage, which indicates the highest inefficiency of measures in the framework of economic security. In the fourth quadrant there is an expected damage ($V_o < 0$), but the benefits are actually $V_r > 0$, which indicates the best result of applying information security measures.

Such the chart should be used when evaluating information security measures. The usefulness of the application is determined by the objectives of the development of information and security in this area, as well as in the field of technology development.

The specifics of the “information economy”, defined by the properties of information, as well as features of the organization of information systems, lead to systemic social consequences that change the nature of the interaction between agents. These consequences of the development of the information economy include:

- information and computer crimes (cybercrime), special types of opportunism as a model of behavior of agents engaged in the information sector;
- the need for additional costs of protecting information, preventing crimes on the Internet, changing legal regulations, creation of cybersecurity technologies and cryptographic standards, etc.;
- the speculative nature of the IT sector, as well as its subordinate nature at the same time as the self-contained influence on the economy;
- the emergence of a mode of dependence on the part of agents, when information technologies are mastered by them;
- permanent changes and improvement of information technologies, which requires tension and additional efforts, which with age become a significant burden for the agent;
- manipulation of information, the use of deliberate disinformation or distortion of information as a form of damage to a competing party that perceives this information, and under the influence of this information can change its behavior in favor

of the initiators of such informational influence. This position requires a special organization of information protection and information security.

In addition, the social dangers of the information economy are seen not only in a possible increase in unemployment, an increase in some diseases associated with a slow-moving way of working at a computer, not only in a new form of inequality, when individual agents cannot master these technologies, but also in increasing the difficulty of choosing information. Solving this problem will require standardization of the information sphere and its institutional regulation, the outlines of which are already observed. This process is likely to deepen and expand, which will require consideration of the information development model, information properties, assessment of the information potential of the economy, the multiplication value of information and the efficiency of the information system. The presented theoretical development will help in the future to solve these problems, making the initial framework for the creation and application of applied techniques.

Conclusion

Summing up, we formulate the conclusions obtained during the theoretical analysis.

First, the functions of notification, accumulation of information, as well as three types of information cumulation set the parameters of the information potential of the economic system, ensuring its efficiency with respect to information.

Secondly, the efficiency of the information system determines the mode of information development, which is useful to take into account when comparing the various economies and the level of development of countries. The effectiveness of working with information and knowledge will determine future competitive advantages and the competitive process in the global economy, and manifestations of this process are already observed today.

Thirdly, the realization of information potential in the economy will depend not only on efficiency, but also on ensuring information security, which should be determined by the ratio of information benefits and threats, including both existing and potential threats. To analyze these threats, the so-called information security loop is useful, with the help of which it is possible to determine the worst situation in the information sense for an economy from a set of alternative modes of information system functioning.

Thus, the information economy, in addition to the multitude of advantages, reproduces the same, if not more, number of restrictions, unpredictable social consequences, diversity of information regimes, which are determined by various factors. In order to rationalize the approaches to the analysis of this complexity in a theoretical sense, some generalizations and proposals are made here that lay the foundation for unambiguous estimates of the number of modes of information development and their characteristics.

References

1. Thomas H. Powerful knowledge, technology and education in the future-focused good society. *Technology in Science*, 2018, no. 52, pp. 54–59.
2. Kianto A., Sáenz J., Aramburu N. Knowledge-based human resource management, intellectual capital and innovation. *Journal of Business Research*, 2017, vol. 81, pp. 11–20.
3. Shujahat M., Sousa M.J., Hussain S., Nawaz F., Wang M., Umer M. Translating the impact of knowledge management processes into knowledge-based innovation: The neglected and mediating role of knowledge-worker productivity. *Journal of Business Research*, 2019, vol. 94, pp. 442–450. doi: <https://doi.org/10.1016/j.jbusres.2017.11.001>.
4. Liebowitz J. *Successes and failures of knowledge management*. 1st ed. Elsevier, Morgan Kaufmann Publ., 2016. 240 p.

5. Tarango J., Machin-Mastromatteo J. *The role of information professionals in the knowledge economy. Skills, profile and a model for supporting scientific production and communication*. 1st ed. Oxford, Chandos Publ., 2017. 148 p.
6. Porrini P., Starbuck W.H. *Information and knowledge, Organizational*. In Book: International Encyclopedia of the Social and Behavioral Sciences (2nd ed.). 2015, pp. 72–76. doi: <https://doi.org/10.1016/B978-0-08-097086-8.73074-1>.
7. Du K., Dai Y. The doctrine of the mean: Reference groups and public information systems development. *The Journal of Strategic Information Systems*, 2018, vol. 27, iss. 3, pp. 257–273.
8. Cram W., Brohman M.K., Chan Y.E., Gallupe R.B. Information systems control alignment: Complementary and conflicting systems development controls. *Information and Management*, 2016, vol. 53, iss. 2, pp. 183–196.
9. Al-Emran M., Mezhyuev V., Kamaludin A., Shaalan K. The impact of knowledge management processes on information systems: A systematic review. *International Journal of Information Management*, 2018, no. 43, pp. 173–187.
10. Costa E., Soares A.L., Pinho de Sousa J. Information, knowledge and collaboration management in the internationalisation of SMEs: A systematic literature review. *International Journal of Information Management*, 2016, vol. 36, no. 4, pp. 557–569.
11. Hilbert M. Formal definitions of information and knowledge and their role in growth through structural change. *Structural Change and Economic Dynamics*, 2016, vol. 38, pp. 69–82.
12. Temel T., Karimov F. Information systems model for targeting policies: A graph-theoretic analysis of expert knowledge. *Expert Systems with Applications*, 2019, vol. 119, pp. 400–414.
13. Flowerday S.V., Tuyikeze T. Information security policy development and implementation: The what, how and who. *Computers and Security*, 2016, no. 61, pp. 169–183.
14. Machlup F. *Knowledge: Its creation, distribution, and economic significance*. NJ, Princeton University Press, 1982. 304 p.
15. Porat M.U. *The information economy: Definition and measurement*. Washington, DC, US Department of Commerce, 1977. 319 p.
16. Stigler G.J. The economics of information. *Journal of Political Economy*, 1961, vol. 69, no. 3, pp. 213–225.
17. Stiglitz J. *Economic organization, information, and development*. In Book: Handbook of Development Economics. Vol. 1, 1st ed. Chenery H., Strinivasan T.N. (eds.). 1988, pp. 93–160.
18. Sukharev O.S. *Informatsionnaya ekonomika: znanie, konkurenciya i rost* [Information economy: Knowledge, competition and growth]. Moscow, Finansy i statistika Publ., 2015. 287 p. (In Russian).
19. Andress J. *The Basics of information security. Understanding the fundamentals of InfoSec in theory and practice*. 2nd ed. Syngress, 2014. 240 p.
20. Iannarelli J., O’Shaughnessy M. *Information governance and security. Protecting and managing your company’s proprietary information*. 1st ed. Elsevier, Butterworth-Heinemann Publ., 2014. 210 p.
21. Vacca J. *Managing information security*. 2nd ed. Syngress, 2013. 372 p.
22. Breznik K. Knowledge management – from its inception to the innovation linkage. *Procedia – Social and Behavioral Sciences*, 2018, no. 238, pp. 141–148.
23. Freund J., Jones J. *Measuring and managing information risk. A FAIR approach*. 1st Ed. Elsevier, Butterworth-Heinemann Publ., 2014. 408 p.

Received January 28, 2019; accepted April 24, 2019

Information about the Author

Sukharev Oleg Sergeevich – Doctor of Economic Sciences, Professor, Chief Researcher, Institute of Economics of the Russian Academy of Sciences (32, Nakhimovsky prospekt, Moscow, 117218, Russia; e-mail: o_sukharev@list.ru).

Список литературы

1. *Thomas H.* Powerful knowledge, technology and education in the future-focused good society // *Technology in Science*. 2018. № 52. P. 54–59.
2. *Kianto A., Sáenz J., Aramburu N.* Knowledge-based human resource management, intellectual capital and innovation // *Journal of Business Research*. 2017. Vol. 81. P. 11–20.
3. *Shujahat M., Sousa M.J., Hussain S., Nawaz F., Wang M., Umer M.* Translating the impact of knowledge management processes into knowledge-based innovation: The neglected and mediating role of knowledge-worker productivity // *Journal of Business Research*. 2019. Vol. 94. P. 442–450. doi: <https://doi.org/10.1016/j.jbusres.2017.11.001>.
4. *Liebowitz J.* Successes and failures of knowledge management. 1st ed. Elsevier, Morgan Kaufmann Publ., 2016. 240 p.
5. *Tarango J., Machin-Mastromatteo J.* The role of information professionals in the knowledge economy. Skills, profile and a model for supporting scientific production and communication. 1st ed. Oxford, Chandos Publ., 2017. 148 p.
6. *Porrini P., Starbuck W.H.* Information and knowledge, Organizational. In Book: *International Encyclopedia of the Social and Behavioral Sciences* (2nd ed.). 2015. P. 72–76. doi: <https://doi.org/10.1016/B978-0-08-097086-8.73074-1>.
7. *Du K., Dai Y.* The doctrine of the mean: Reference groups and public information systems development // *The Journal of Strategic Information Systems*. 2018. Vol. 27, Iss. 3. P. 257–273.
8. *Cram W., Brohman M.K., Chan Y.E., Gallupe R.B.* Information systems control alignment: Complementary and conflicting systems development controls // *Information and Management*. 2016. Vol. 53, Iss. 2. P. 183–196.
9. *Al-Emran M., Mezhuyev V., Kamaludin A., Shaalan K.* The impact of knowledge management processes on information systems: A systematic review // *International Journal of Information Management*. 2018. № 43. P. 173–187.
10. *Costa E., Soares A.L., Pinho de Sousa J.* Information, knowledge and collaboration management in the internationalisation of SMEs: A systematic literature review // *International Journal of Information Management*. 2016. Vol. 36. № 4. P. 557–569.
11. *Hilbert M.* Formal definitions of information and knowledge and their role in growth through structural change // *Structural Change and Economic Dynamics*. 2016. Vol. 38. P. 69–82.
12. *Temel T., Karimov F.* Information systems model for targeting policies: A graph-theoretic analysis of expert knowledge // *Expert Systems with Applications*. 2019. Vol. 119. P. 400–414.
13. *Flowerday S.V., Tuyikeze T.* Information security policy development and implementation: The what, how and who // *Computers and Security*. 2016. № 61. P. 169–183.
14. *Machlup F.* Knowledge: Its creation, distribution, and economic significance. NJ, Princeton University Press, 1982. 304 p.
15. *Porat M.U.* The information economy: Definition and measurement. Washington, DC, US Department of Commerce, 1977. 319 p.
16. *Stigler G.J.* The economics of information // *Journal of Political Economy*. 1961. Vol. 69, № 3. P. 213–225.
17. *Stiglitz J.* Economic organization, information, and development. In Book: *Handbook of Development Economics*. Vol. 1, 1st ed. Chenery H., Strinivasan T.N. (eds.). 1988. P. 93–160.
18. *Сухарев О.С.* Информационная экономика: знание, конкуренция и рост. М.: Финансы и статистика, 2015. 287 с.
19. *Andress J.* The Basics of information security. Understanding the fundamentals of InfoSec in theory and practice. 2nd ed. Syngress, 2014. 240 p.
20. *Iannarelli J., O'Shaughnessy M.* Information governance and security. Protecting and managing your company's proprietary information. 1st ed. Elsevier, Butterworth-Heinemann Publ., 2014. 210 p.
21. *Vacca J.* Managing information security. 2nd ed. Syngress, 2013. 372 p.
22. *Breznik K.* Knowledge management – from its inception to the innovation linkage // *Procedia – Social and Behavioral Sciences*. 2018. № 238. P. 141–148.
23. *Freund J., Jones J.* Measuring and managing information risk. A FAIR approach. 1st Ed. Elsevier, Butterworth-Heinemann Publ., 2014. 408 p.

Сведения об авторе

Сухарев Олег Сергеевич – доктор экономических наук, профессор, главный научный сотрудник, Институт экономики Российской академии наук (Россия, 117218, г. Москва, Нахимовский проспект, 32; e-mail: o_sukharev@list.ru).

Просьба ссылаться на эту статью в русскоязычных источниках следующим образом:

Sukharev O.S. Functions and modes of information development of economy: Methods and models // Вестник Пермского университета. Сер. «Экономика» = Perm University Herald. Economy. 2019. Том 14. № 2. С. 198–217. doi: 10.17072/1994-9960-2019-2-198-217

Please cite this article in English as:

Sukharev O.S. Functions and modes of information development of economy: Methods and models. *Vestnik Permskogo universiteta. Seria Ekonomika = Perm University Herald. Economy*, 2019, vol. 14, no. 2, pp. 198–217. doi: 10.17072/1994-9960-2019-2-198-217
