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Development System of Hierarchical Indicators for Analyzing and Measuring the Level of Growth of Information and Knowledge Economy

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Abstract: The article substantiates the necessity to develop a system of indicators for assessing the level of development of the information and knowledge economy. Main methodological approaches regarding their development and analysis have been analyzed. Some recommendations have been proposed for eliminating existing problems in this field. A methodology has been proposed for calculating the Gross Domestic Product generated by information and knowledge. A composite index of information and knowledge-based economy, as well as corresponding hierarchic indices, subindices, and indicators, have been developed. General information on global indices characterizing the information and knowledge economy is analyzed. Some countries are rated on the development of the knowledge economy. Information is provided on sub-indices and indicators that affect the formation of some global ICT, innovation, and economic indices. The main and sub-indicators used in the calculation of global indices are identified. The current situation in Azerbaijan on some global indices is analyzed, and the country's ranking on different indices on the formation of the information and knowledge economy is determined. A comparative analysis of the methods of measuring the level of information and knowledge economy is conducted. Features of the regional and sectoral approach to assessing the level of information and knowledge economy are explained. Innovation, science, and technology-intensive components of the information and knowledge economy are proposed. The interaction of the main indices and indicators that form the composite index of the information and knowledge economy is proposed. The structure of the composite index system is proposed in a multi-level form. A system of multi-level composite indicators integratively reflects the main level and the lower levels coming after it. Indicators' system includes the main composite index and ten sub-indices of information and knowledge economy. The study presents the stages of successive formation of indicators and variables upon which main indices and sub-indices of information and knowledge economy functionally depend. 1st national level consists of a composite integrative index of the information and knowledge economy; initially 2nd level consists of ten indices, 3rd level consists of 83 sub-indices and indicators; 4th level consists of 320 macro/micro indicators. Directions of future research are identified based on indicators.

Keywords: information and knowledge economy, knowledge economy index, hierarchic indicators system, economic indicators, Global Innovation Index, technological innovations, areas of technological economy, composite index, composite indices system.

Introduction

Informatization is the most important factor among modern tools, which exert an innovative influence on the globalization of economic relations and the development of the new economy. Information and Knowledge Economy (IKE) founded on this factor emerges as a future stage of economic development. Technological development and innovations represent a long-term driving force of economic growth. Information and knowledge have become the main factor in the development of society.

It is essential to point out that information and knowledge are different notions and concepts. The knowledge economy is a higher, more developed following stage of the information economy. Therefore, it was not deemed necessary to research their

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characteristics separately in this work. As the same methodological approach is proposed in this article, the "information and knowledge" phrase used can also be understood as "information". Hence, this work can be applied to the "information" or "information and knowledge" economy.

The fields of production of knowledge and innovation products play a prominent role in the development of countries going through a transition from the industrial development phase to the post-industrial development phase and their competitiveness. In other words, the development of countries in the modern world is highly dependent on the development of knowledge-intensive sectors, including technological innovations. The transition to a stage must be provided where innovations prevail to transform the country's economy into an efficiency-based economy. At the same time, the purposeful improvement of economic structure is among high-priority issues.

Global factors have penetrated the processes currently observed in all fields of national economies. In "Azerbaijan 2020: Vision of Future" Development Concept (2012, p.34), as well as In this direction, a Strategic Road Map on National Economy and Key Sectors of the Economy (2016) was prepared in Azerbaijan necessitate a new level of development and trajectory of the economy.

Twelve strategic roadmaps approved for the national economy and eleven sectors of the economy, in general, are prepared. These roadmaps are increasing the competitiveness, inclusiveness, and social welfare of the economy. Strategic roadmaps include the strategy of economic development and action plan for 2016-2020 years, long-term vision for the period up to 2025, and target vision for the post-2025 period. The targeted vision of the Strategic Road Map for the post-2025 period will provide wide opportunities, expansion of access to quality education, the basis of transition to efficiency, and an innovation-based economy.

The competitive labor force being the main driven force of the economy, regulation of labor market, application of high technologies, including smart machines and systems, is the transition of the economy from the efficiency-based model to the innovation-based model.

The impact of innovative technologies on the development of new emerging economic fields, automated knowledge creation process, "internet control", remote control technologies, artificial intelligence and robotization, an adaptation of management to the requirements of advanced technologies (bio, nano, information, communication, industry, finance) will be implemented.

In accordance with the challenges of the Centre for the 4.0 industrial revolution (World Economic Forum, 2019), the Azerbaijani economy is being built based on an innovation-oriented, knowledge, technology-based economic system. One of the main trends in the information society, as in the IV Industrial revolution, is the technology of artificial intelligence. For this reason, the creation of the Regional Center of the World Economic Forum in Baku has begun. The main goal here is to implement the tasks and capabilities of Industry 4.0 technologies, including artificial intelligence technologies in the country. The widespread use of these technologies will improve the technological infrastructure of Azerbaijan, its formation in accordance with the objectives of Industry 4.0, the creation of special data centers, supercomputer clusters, the provision of modern electronic services, and the entry into the next stage of the development of the information society and the country's global competitiveness.

Regional and country-level factors influence the development of the national economy and its position in the global world economic system. The consideration of these factors during the management of various sectors of public and economic life is essential from the point of view of the formation of effective politics. Natural resource exports have been a driving force of long-term economic growth in the country. Hence, the main duty is to eliminate

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the current dependence on the export of oil-gas reserves. The threat for a country to become an exporter of raw materials in the world economic system must be diminished. For this purpose, it is an important issue to achieve more rapid development of the non-oil sector in the republic, to boost economic effectiveness and competitiveness, and provide its innovation-based development. Information, technology, and knowledge have become competitiveness factors in the majority of countries at the age of formation of Global Information Society (GIS) perceived as the development ideology of the third millennium (Okinawa Charter on the Global Information Society, 2000).

There has emerged a need for the analysis and assessment of the level of formation of innovation economy developing as a result of their broad application. A system of specific indicators has been developed by international organizations in order to implement the assessment of the level of application of high technologies, including ICT in various fields quantitatively and qualitatively. Some methodological drawbacks and difficulties in the application are inherent for these indicators. Hence, it is essential to develop some indicators system at various levels for objective evaluation of the development level of the information economy in various countries. The development of suggestions and recommendations is deemed as one of the important issues for developing a calculation technique of such indicators and eliminating existing problems in that field.

It should be noted that, in fact, for developing a system of indicators of the information economy, it is necessary to familiarize its basics. In this regard, an overview of scientific works published in the prestigious journals and conference materials of the leading countries was carried out. Because the overview materials are in other works of the author, there is no need to submit it in this article.

Methods. In the research work system analysis methods have been used during the selection of indicators. The measurement of information and knowledge economy has been considered based on a complex approach. The indicators relevant to regional statistics bodies have been preferred. Specific statistical information has not been used. The composite index and subindices forming it have been suggested based on the analysis of international and regional approaches. Relationships between indices are based on correlation-regression analysis methods, methods for constructing linear and nonlinear production functions. In the next stages of the research, the dependency between the collection of realistic statistical information will be analyzed, and recommendations will be developed.

Research design and methodology

The article considers the development of appropriate tools to assess the level of development of the information and knowledge economy as an object of research. Measurement of economic processes based on information and knowledge is carried out based on modern methods and technologies. A system of hierarchical indicators is developed, taking into account international economic development trends, requirements of modern ICT technologies, the main trends of the IV Industrial Revolution. A methodology for calculating GDP generated through information and knowledge is proposed.

Decision-making in multi-criteria conditions, economic and mathematical modeling, econometric methods, mathematical statistics, economic analysis, and research methods are used in calculating relevant indicators and indices.

Averages, expert assessments, weight coefficients, and appropriate econometric-statistical methods are used in the calculation of new indices and sub-indices.

Systematic analysis, correlation and regression analysis, mathematical and econometric modeling methods, expert assessment method, measurement theory, a theory of fuzzy

sets, algorithmizing, and ICT tools are applied for the development system of hierarchical indicators for analyzing and measuring level growth of information and knowledge economy.

In the research process, ten sub-indices affecting the Composite Index, which reflects the assessment of the information and knowledge economy, are proposed. The structure of the composite index system is proposed in a multi-level form. The calculation of the composite index of the information and knowledge economy is proposed in a functional form. Each sub-index is evaluated by experts on a scale of [0.10].

In addition, a procedure consisting of several stages for collecting, organizing, and presenting the necessary information, is developed. Each stage of this procedure functions separately as an independent unit. At the same time, the implementation of all stages in one chain is also a part of the methodology.

Research findings/results

The recommendations proposed, the proposed composite indices, and sub-indices can make a significant contribution to the assessment of the level of development of the information and knowledge economy. The proposed system of hierarchical indicators will create additional opportunities to increase efficiency in the new economic management. The results of the assessments can be considered a new approach and methodology for assessing the knowledge, information-based economy in the country. The proposed methodology will create conditions for achieving significant results in increasing the efficiency of the country's economy on a global scale, creating ample opportunities to increase GDP generated through information and knowledge.

Originality/Added-value

A new approach to measuring the level of development of the information and knowledge economy, taking into account national and regional characteristics, has been attempted. A system of multi-level composite indicators characterizing the level of development has been proposed. The information relationships between the indices, sub-indices, and indicators that make up the system of composite indicators have been identified.

A methodology for calculating GDP formed through information and knowledge has been proposed. Based on the proposed methodology, recommendations have been developed based on relevant expert assessments at the regional and sectoral levels of the national economy. Based on the proposed methodology, relevant enterprises and organizations can improve their accountability activities.

Indicators and indices of information and knowledge economy

Various indicators are used while assessing the level of economic development. Those characterize different aspects of the economy. An issue of complex evaluation is related to some difficulties. In particular, this issue is most pronounced in the complex evaluation of the development level of the economy, assessment of the role of science, innovations, and ICT. Several approaches and assessments are present in this direction.

A generalized indicator, "Knowledge investment" of the United Nations Report of the Economic and Social Council (UN, 2019, 160 p.), has been proposed as the main indicator assessing information and knowledge economy. This indicator includes developments, research, higher education, ICT, and software investment. Countries are grouped in three categories according to this indicator: high (6% of Gross Domestic Product - GDP), medium (3-4% of GDP), and low (2-3% of GDP). Although being capable of explaining the

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economic status of countries from the investment point of view, this indicator does not describe the situation fully.

In general, the following indices characterizing information and knowledge economy can be encountered in scientific-practical literature: 1) New Economy Index, 2) Digital economy and society index, 3) Global competitiveness index, 4) Global creativity index, 5) Global innovation index, 6) Global entrepreneurship index, 7) Technology readiness index, 8) Economic incentive and institutional regime index, 9) Poverty and unemployment index, 10) Knowledge index, 11) Knowledge economy index.

A separate analysis of those indicators demonstrates that the knowledge constituting their content is different. Such that, the elements of the New Economy Index (ITIF, 2020), Information Economy Report (UNCTAD, 2017) are: 1) organizational effectiveness and human resources (14 indicators), 2) competitiveness and creativity development (11 indicators), 3) ICT infrastructure (8 indicators) and 4) innovation (10 indicators).

Digital Economy and Society Index (DESI) (European Commission, 2020) is established of 5 subindices and 28 indicators grouped in 12 groups: 1) communication in 4 groups (7 indicators), 2) Human capital, 2 groups (4 indicators); 3) Internet use, 3 groups (6 indicators; 4) Integration of digital technologies, 2 groups (7 indicators); 5) Digital service, 1 group (4 indicators).

Global Competitiveness Index (World Economic Forum, 2019) and Global Creativity Report (Cannes Lions, 2019) usually is calculated based on indicators, which can be described based on-data of World Economic Forum as below: 1)quality; 2)infrastructure; 3)macroeconomic stability; 4)health care and primary education; 5)higher education and vocation; 6) market of goods and services; 7)efficiency of the labor market; 8)development of financial markets; 9) technological level; 10)local market scale; 11)enterprise competitiveness; 12)innovation potential, etc.

Main indicators and sub-indicators used while calculating Global Innovation Index (WIPO, 2020) include Innovation Output Sub-Index, Innovation Input Sub-Index, and Innovation Efficiency Ratio.

The following indicators have been included while calculating the Global Entrepreneurship Index (GEDI, 2019) for a high rate of development, startup capacity, risky capital, probability of risk, human capital, internationalization, competition, product innovation, cultural support, startup opportunities, networks, initiative opportunities, technological advancements, process innovation. In addition, the status of countries has been analyzed according to the level of Research and development (R&D) according to the rating of countries prepared by UNESCO and the Institute of Statistics on 91 countries. The rating of 133 countries (Harvard University) has been assessed according to social development and based on 50 indicators in three groups.

Moreover, the rating of countries according to direct investments has been prepared based on the International Monetary Fund (IMF) data from 189 countries (2020, 68 p.). All such investigations show that international organizations carry out the calculations based on various methodologies according to their purposes and approaches.

In the meantime, although encountered and hereby indicated indexes have a mutual connection, their formation does not depend on one another. Their formation procedure and contents are different. Therefore, there is a need to develop a new complex index based on a synthesis of different indexes and indicators.

Comparative analysis of the assessment methodologies of information and knowledge economy

One of the indicators of the assessment of information and knowledge economy is the investment in those fields. The UN and the Organization for Economic Cooperation and Development (OECD) (2017) experts consider knowledge investment as the total expenditure in education, R&D, and software development. The United States is in a leading position according to this indicator (6% of GDP). Naturally, this indicator is not able to reflect the status of IKE comprehensively and accurately. According to the methodology of the European Economic Commission (EEC) (2017), the preparations for the formation of information and knowledge economy (IKE) is calculated based on Global Economy Index (GEI) (ITIF, 2020):

$$GEI = A^* Tech + B^*Gins + C^*Mecn$$

Where: Tech – Technology subindex, Gins – Government institutional subindex, Mecn – macroeconomic situation subindex. A, B, C – are coefficients of corresponding indices and those satisfy the following conditions:

A + B + C = 1, according to EEC, it is accepted that A = 1/3, B = 1/6, C = 1/2. Note that, corresponding indicators influence the formation of each subindex.

According to a different approach, the following information base is used for assessing (Shahid, 2015) the level of the knowledge economy (KE):

- quality of economic regulation;
- rule of law;
- royalty payments and receipts;
- publications in scientific-technical journals;
- number of patents granted;
- gross secondary enrollment rate;
- school/higher education coverage;
- total of telephones/computers;
- Internet users (per thousand people).

The methodology of the Statistical Committee of the Russian Federation (Federal State Statistics Service, 2020; Sudarkina, 2016; Jadranka & Dabić, 2017) for the calculation of the share of high-tech and science-intensive area products (SIP) is based on the following:

- HTI – total additional income from high-technology economic activity,
- SII - total additional income from the science-intensive activity,
- TI – total additional income from all economic activities,

$$SIP = (HTI+SII) / TI$$

The calculation of IKE integrated indicator can be carried out based on reported statistical input data from institutions and organizations on science, ICT, information society, innovation:
X_1 – expenditure on research and development;
X_2 – volume of innovation product;
X_3 – volume of tradable innovation product;
X_4 – ICT expenditure.

Alongside per capita indicators, structural and ratio indicators are also taken into consideration in this case.

Structural indicators. X_5 – share of high innovation product, %, X_6 – share of organizations using Internet, %, X_7 – share of computers with internet access, %. Ratio indicators. X_8 – research project staff per 10 thousand employees, X_9 – number of researchers per 10

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thousand active population, X_{10} – technological innovation expenditure per 1 employed person, X_{11} – number of patents per 100 researchers. Main group indicators of knowledge economy include research, development and innovation, technical vocational education and guidance index, pre-higher education subindex, higher education, and ICT as components of Knowledge index. The functional grouping of indicators has been carried out in 1) economic, 2) technological, 3) social, and 4) government aspects. The rating of selected countries based on the development of the knowledge economy (145 countries) is given in table 1.

The information in table 1 shows the average annual (World Bank Annual Report, 2020).

Table 1. **The country rating according to the development of knowledge economy**

Rating	Countries	Knowledge Economy index	Knowledge index
1	Sweden	9.43	9.38
2	Finland	9.33	9.22
3	Norway	9.11	8.99
5	Germany	8.90	8.83
7	USA	8.77	8.89
8	Great Britain	8.76	8.61
9	Japan	8.28	8.53
10	France	8.21	8.36
11	Israel	8.14	8.07
12	Russia	5.78	6.96
14	Georgia	5.19	4.49
17	Turkey	5.16	4.81
22	Armenia	5.08	4.84
24	Kazakhstan	5.04	5.40
25	Azerbaijan	4.56	4.96
30	China	4.37	4.57
55	Iran	3.91	4.97
68	India	3.06	2.89

As seen in this section, discussed indicators and information provided in Table 1 are not analyzed in detail, and the aggregation procedure is not explained. Here, our objective is to demonstrate the formation of indexes and indicators in wide specter and the formation of comparative table based on them, as well as justify the necessity of processing complex indicators in the future.

The corresponding rating of Azerbaijan according to the formation of information and knowledge economy can be presented in table 2 based on the above-mentioned various indices.

Table 2. Rating of Azerbaijan according to various indices on the formation of information and knowledge economy

Indices	Years	Number of countries	Value of index	Ranking
Global Knowledge Index	2019	136	45.80	66
Knowledge economy index	2018	146	4.56	20 (Eastern Europe /Caucasus)
Network Readiness Index	2016	139	4	53
ICT development index	2017	176	6.20	65
Global Competitiveness Index	2019	141	62.7	58
Human Development Index	2015	188	67.58	63
Global Innovation Index	2020	130	30.21	82
Global Entrepreneurship Index	2019	137	30.5	62
Doing Business	2019	190	78.64	25

United Nations Development Program: Education Index	2019	189	0.694	87
Education index	2013	187	0.700	76
Countries rating according to Gross domestic product (bln $)	2015	193	75.198	68
Rating of countries and states according to per capita GNI ($)	2015	187	7590	79
Countries rating according to R&D expenditure level (% of GDP)	2012	91	0.25	66
Countries rating according to social development	2015	133	62.62	76
Countries rating according to direct investments bln. $)	2014	184	2,6	57

As seen, the country retains a medium position among analyzed countries according to the assessment carried out based on various aspects and indices. This demonstrates the presence of a vast amount of unexploited potential opportunities in the country once more.

Accountability characteristics of enterprises and organizations in the information and knowledge sector

These characteristics include sectors of activity and types of enterprises, statistical reports, the classification of goods and services of those, etc. These enterprises are represented in various fields of activity. Some sectors pertain to this group:

Government sector: ministries and organizations of chief offices, organizations of the Academy of Science system, organizations of administrative entities of Republic and cities, organizations of local executive entities.

Higher education sector: universities and other higher education institutions, scientific-research institutions (centers) under higher education institutions or the Ministry of Education, development institutions under higher education institutions or the Ministry of Education, clinics, hospitals, other medical institutions under higher education institutions, experimental institutions under higher education institutions.

Private sector: 1) scientific-research field institutions; 2) technological development organizations; 3) design and design-builder organizations; 4) industrial enterprises; 5) testing facilities.

Private non-commercial sector: scientific, vocational volunteering societies and associations, public organizations, charity funds.

Similar official statistical reports are prepared in various formats and sections (State Statistical Committee of the Republic of Azerbaijan, 2020, 166 p.).-Reports devoted to the innovation activity of enterprises are presented in 7 sections.

I section. Expenditure on technological innovations according to types of activity and financial sources (thousand manats).

II section. Volume of products (services) (thousand manats).

III section. Targets of innovation activity.

IV section. Number of purchased and presented new technologies (technological advancements) and software tools in the report year.

V section. Organizational and marketing innovations.

VI section. Sources of innovation on information.

VII section. Factors hindering innovative advancements.

The following sections are included in reports devoted to scientific-research activities:

- I section. On the accomplishment volume of scientific-technical works (thousand manats);
- II section. Total expenditure on scientific research and development;

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- III section. Internal current expenditure on scientific research and development according to types of works and their financial sources;
- IV section. Number, structure, and mobility of employees engaged in scientific research and development;
- V section. Distribution of research experts in scientific areas;
- VI section. Information on qualified personnel training.

In addition, statistical data is collected in enterprises regarding the use of ICT.

- Section A. On ICT systems of enterprises and access to those;
- Section B. Internet use;
- Section C. Electronic trade;
- Statistical classification of information and communication technologies products;
- Statistical classification of information and communication technologies services;

The block of main scientific indicators includes the following: 1) Organizations; 2) Scientific personnel; 3) Accomplished material-technical works; 4) Material-technical base; 5) Financing; 6) Main regional indicators of science; 7) International comparisons.

Analysis of accountability features of institutions in the information knowledge field is not directly related to complex indication calculation. However, a multi-level hierarchic indicator system is proposed for the calculation of the composite index. Indicators in the lower level of this system are formed based on official reports provided directly by the institutions.

Main features of regional and field approaches in the assessment of the state of information and knowledge economy

It is possible to group subfields of IKE by considering the characteristic components of the fourth industrial revolution to conduct a coordinated economic analysis in a narrower field. Considering this, field classification of information and knowledge economy can be formulated as in table 3.

It is to be noted that traditional economic fields must be taken into consideration while analyzing in accordance with this classification. Hence, although agriculture, industry, metallurgy, transportation, construction, oil-gas, energetics, natural resources, etc. fields belong to traditional sectors, those can be included in the field classification of Information and knowledge economy.

Subsectors of traditional economic sectors (TES) with information, knowledge, technological and innovation intensity are to be taken into consideration as well (Shahabadi, Kimiaei, & Afzali, 2016; EBRD, 2019; Burdenko & Mudrova, 2018; Tkachenko, Rogova, & Bodrunov, 2016). Therefore, the analytical process must include science-intensive subsectors of traditional economic fields, as well as newly emerged economic sectors (Table 3).

Table 3. Subsectors of information and knowledge economy with information, innovation, science, and technology intensity

ICT subsectors	**New information, knowledge, and technological economic sector**	**Subsectors of traditional economic sectors (TES) with information, knowledge, technology, and innovation intensity**
Internet	ICT economy	Information communication technologies in management
Software engineering	Space economy	Production and service sectors technologies
Automatization technologies	Bioeconomy, Nanoeconomy	Irrigation and breeding technologies
Digital contents	Language economy	Marketing and sales technologies
IT-service	Education economy, Science economy, health economy	Know-how technologies
Telecommunication	Creative economy, art economy	Innovative technologies
Computing and electronic industry	Culture economy, sport economy	Smart technologies
Creative content and digital media	Environmental economy, Alternative energetics economy	Business and industrial services technologies
Electronics field	Patent (licensing) economy	Pharmacy and medical technologies
	Theology economy, diaspora economy	Environmental protection technologies, optical industry technologies

Data presented in the columns of this table are not related to other columns. Each column has independent content. These fields are proposed based on expert surveys, scientific literature, and statistical reports and form sections of future research.

Calculation of Gross domestic product generated by information and knowledge

The following marking and methodology are proposed for calculating the GDP generated by information and knowledge in a specific country:

1. production-service sectors corresponding to official statistical reports of a country – i=1, 2,..., n
2. GDP of the i-th sector – GDPi
3. GDP generated by industrial production in ith sector – GDPSi; GDPSi = Si · GDP
4. GDP generated by services production in ith sector – GDPXi; GDPXi = Xi · GDP
5. GDP generated by information in ith sector – GDPIi; GDPIi = Ii · GDP
6. GDP generated by knowledge in ith sector – GDPBi; GDPBi = Bi · GDP
7. GDP generated by technology in ith sector – GDPTi; GDPTi = Ti · GDP

$$0 \le \{S_i, X_i, I_i, B_i, T_i\} \le 1$$

Where,

$$0 \le (S_i + X_i + I_i + B_i + T_i) \le 1$$

The impact of weight coefficients Si, Xi, İi, Bi, Ti on GDP can be described in two ways in expert assessment (Trzcielinski, 2015; Alguliyev & Aliyev, 2017): 1) by indirectly influencing the management, organization, and decision-making; 2) as information, knowledge, sale/purchase object or final product technology, technology, services, and innovation.

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So, the GDP generated by industry, services, information, knowledge, technology (DSUDM, DXUDM, DIUDM, DBUDM, DTUDM) will be calculated as follows:

1) Country's total

$$\ddot{U}DM - Y\ddot{U}DM = \sum_{i=1}^{n} \ddot{U}DM_i$$

2) industrial sector of a country

$$DS\ddot{U}DM = \sum_{i=1}^{n} \ddot{U}DMS_i$$

3) services sector of a country

$$DX\ddot{U}DM = \sum_{i} \ddot{U}DMX_i$$

4) information sector of a country DİÜDM

$$= \sum_{i} \ddot{U}DM\dot{I}_i$$

5) knowledge sector of a country

$$DB\ddot{U}DM = \sum_{i} \ddot{U}DMB_i$$

6) technological production sector of a country

$$DT\ddot{U}DM = \sum_{i} \ddot{U}DMT_i$$

It must be noted that it is impossible to isolate and separate fields directly related to information or knowledge in the economy. All economic sectors include information and knowledge. Despite this, we cannot deny the role and importance of information and knowledge in manufacturing. In this case, it is important to advance and evaluate ideas on production volume formed directly due to information and knowledge. In the proposed approach, it is impossible to evaluate S_i, X_i, I_i, T_i variables independently. They are considered mass coefficients. Considering mass coefficients as a part of GDP during expert evaluation is meant to increase the accuracy level. In separate special cases, it is impossible to track GDP changes. Here the purpose is to explain the methodological approach from a conceptual point of view. In the future, it is expected to justify this method more strictly justified from an econometric modeling aspect and define other parameters affecting it. Fundamentally, it is impossible to determine which part of GDP is formed due to information or knowledge using accurate methods, and the application of fuzzy mathematic logic methods is planned.

Indices and subindices forming a composite index of information and knowledge economy

It is proposed the Composite index of information and knowledge economy be constructed based on indices shown in Figure 1.

Conducted observations and analysis show that, the number of subindices and indicators influencing the formation of those sectoral indices can be expressed as follows (Alguliyev & Aliyev, 2017): 1)Structure of Information society formation index (ISF) – 12 subindices and indicators; 2)Elements influencing the Science and education development index (SED) – 9 indicators; 3)Integral elements of National innovation system formation index (NIS) – 13 subindices and indicators; 4)Factors affecting technical-technological and transportation infrastructure index (INF) – 5 subindices and indicators; 5)Indicators of feasibility of macroeconomic system and business environment index (ECO) – 12 subindices and indicators; 6)Stability and dynamics of socio-political and legal environment index (SPE) – 6 subindices and indicators; 7)Indicators influencing the Socio-cultural and environmental sustainability index (SES) – 8 subindices and indicators; 8)Indicators forming the Protection of Intellectual Property index (PIP) – 5 subindices and indicators; 9)Labor market and qualified personnel index (LQP) indicators – 7 subindices and indicators; 10)Indicators forming the Science- and technology-intensive production index in economic sector (STI) – 5 subindices and indicators.

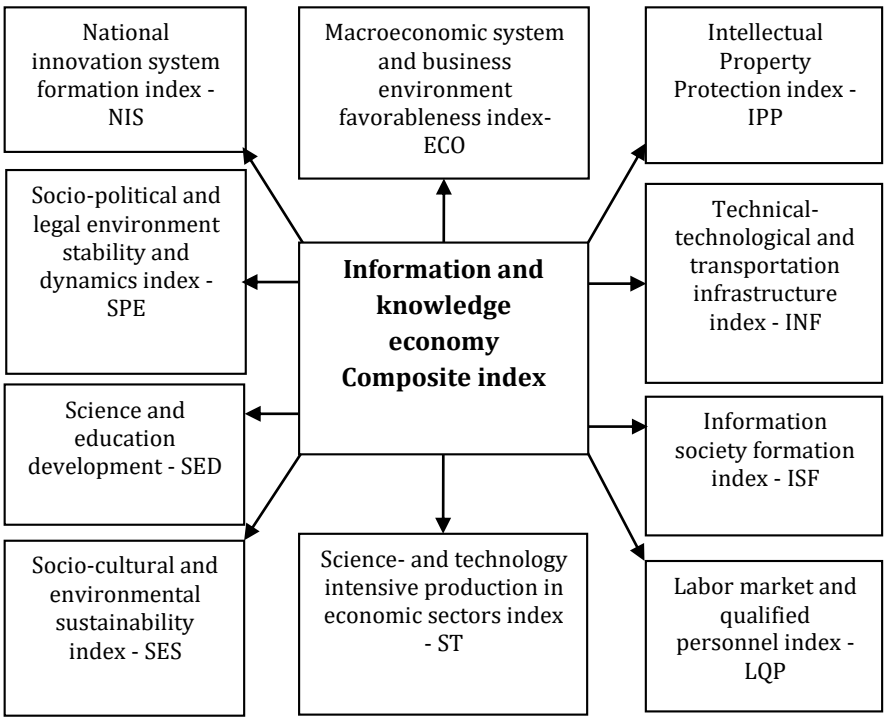

Figure 1. Indices constructing a composite index

Selection and evaluation of sub-indexes are subjective as they are based on an expert evaluation, author observation, researches, and personal intuition of the researcher. Ten field indexes, as well as other indicators affecting them, might need economic justification. These justifications are the subject of another article, which is why they are not focused on in this article. We would like to note that expert evaluation is preferred at the current level as an initial evaluation of indexes from mathematical and practical points of view is impossible. Besides, both indexes and experts are considered equal-level at an initial stage. It is considered that they do not have contradictive cases, or contradictions are eliminated by the decision-maker using known methods. Such situations will be reviewed separately.

Scientific-methodological foundations of the development of composite indices system on the comparative assessment of IKE

The structure of the Composite Indices System (CIS) is proposed as in multi-level form. The general level reflects all levels below in an integrative manner, and the parameter characterizing it is named IKE composite index (IKC). The composite index is constructed as a result of an assessment and has a leading role in a comparative analysis (Aliyev, 2020). Such that IKE obtains a specific rating as a result of this assessment.

Each sub-index is assessed within [0, 10] scale by experts. Initially, weight coefficients are taken as equal to one. A composite index is taken as a sum of subindices and varies within [0, 100] intervals.

Alongside, the calculation of the IKE composite index (IKC) can be noted as follows:

IKE = F(ISF, SED, NIS, INF, ECO, SPE, SES, IPP, LQP, STI).

Here, F denotes the dependence of the composite index on other indices.

So, it can be noted that the scientific-methodological foundations of the development of composite indices system for the comparative assessment of IKC are constituted of the

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following: 1) composite indices are useful tools for the assessment, analysis, and comparison of the level of development of society and economy. 2) Composite indices and indicators are generated by comprising separate indicators measured on multi-dimensional criteria in one index. 3) Although not directly, a composite index allows for an indirect assessment of IKE efficiency. It creates a foundation for an opinion regarding its role and share in society. 4) It is proposed that the values of the above indicator indices can be taken for constructing the composite index.

The interrelatedness of indices and indicators forming the composite index is given in figure 2.

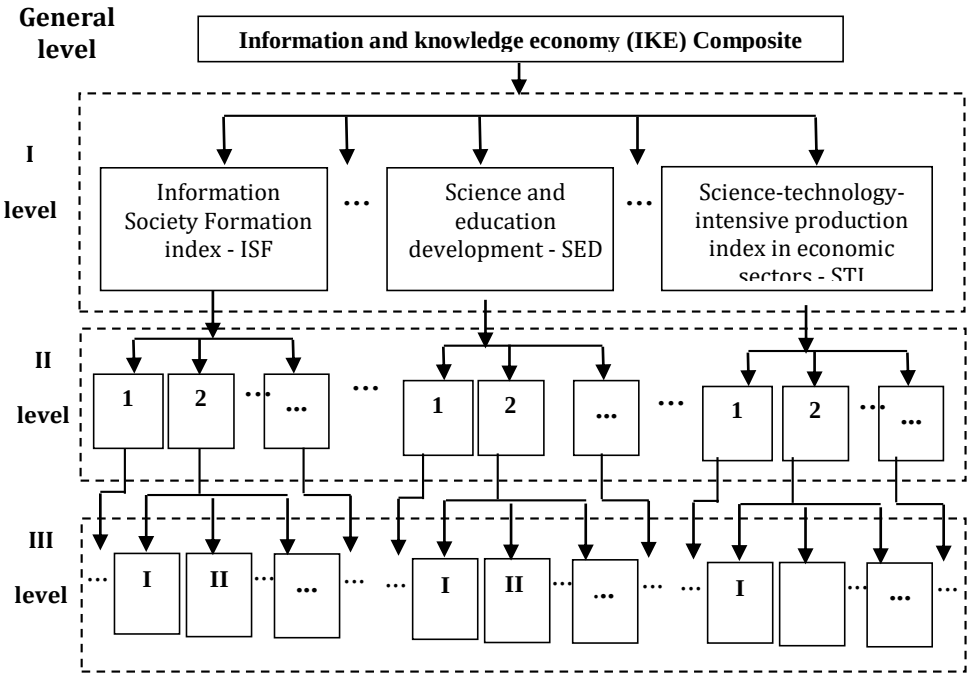

Figure 2. The interrelatedness of main indices and indicators forming information and knowledge economy composite index

The stages of successive determination and formation of information and knowledge economy indices and indicators can be described in figure 3. The following can be noted regarding the assessment of indices and subindices:

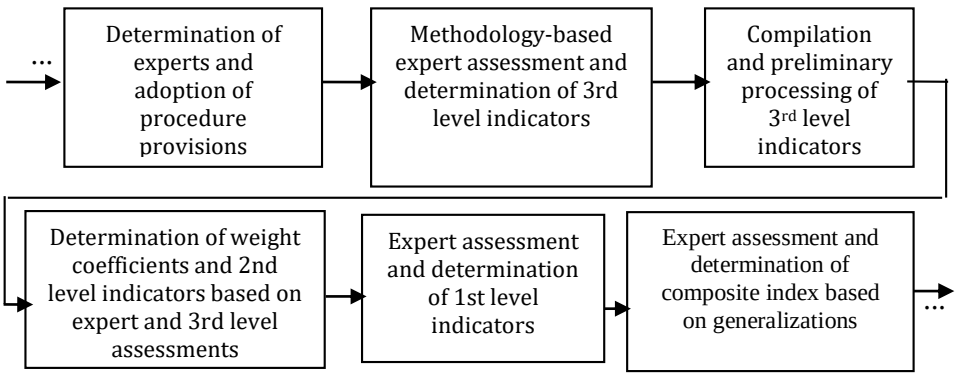

Figure 3. Stages of determination and successive formation of information and knowledge economy indices and indicators

- Average values, expert assessment, weight coefficients, corresponding econometric-statistical methods will be applied while calculating new indices and subindices. System of indices, subindices, and indicators on IKE comparative assessment are divided into various hierarchical levels.

- 1st national level is constituted of Information and Knowledge Economy (IKE) composite integrated index, 2nd level is constituted on ten indices, 3rd level is constituted of 83 subindices and indicators, 4th level is constituted of 320 macro/macro indicators. Indices and subindices at 1st, 2nd, and 3rd levels are determined based on expert assessment, as well as the parameters in the successive level.
- 4th level indicators include parameters of both official statistics and other external and internal indicators. 4th level indicators mostly act as a foundation for determining 3rd and 2nd level subindices by experts. Absolute indicators and their precise values are used in this case. The approach, in this case, is different and can be carried out individually depending on each specific situation.
- The indicators system on the comparative assessment of IKE can facilitate the complete achievement of the targeted goal in the process of IKE performance assessment at regional, as well as international levels.
- System of indices and indicators proposed for such assessment can meet existing demand as a successful model for the performance assessment of a separate region in a country.
- Composite index "monotonically increase" in [0, 100] interval, whereas 1st level indices and 2nd level subindices possess "monotonic increase" feature in [0, 10] interval; that is, the price increase denotes an improvement, while a reduction denotes a worsening.

Conclusion

It is one of the complex issues to assess the economy of the modern age; in particular, the fields with science, technology, and innovation intensity quantitatively and qualitatively. Many indices of the leading countries in the field of information and knowledge economy, also the index of knowledge and the knowledge economy, have been comparatively analyzed. Azerbaijan's position on many indices according to the international rating has been studied. Consideration of the features of new economic sectors as a result of that have emerged as a result of the application of ICT and other high technologies have been recommended.

The research shows that the majority of considered indices are not capable of assessing the economy comprehensively. Alongside, it is to be noted that composite and other composite-type indices are some of the most reliable and accepted tools allowing for the analysis of full characteristics of countries and their economies, as well as their representation. Hence, the rule, methodology, and requirements for constructing composite indices of influential organizations, as well as various methodological tools, which are justified in practice, must be applied effectively. The development and regular update of composite indices system correctly and accurately assessing the level of development of information- and knowledge-based economy is the demand of modern age. In addition, it is important to take into consideration the information and accountability characteristics of organizations active in the information and knowledge sectors. The essence of the approach comprising regional and sectoral features is clarified by taking these requirements.

The stages of successive formation of indices and indicators of the information and knowledge economy are developed. 1st national level consists of a composite integrative index of the information and knowledge economy, initially 2nd level consists of 10 indices, 3rd level consists of 83 sub-indices and indicators, and 4th level consists of 320 macro / micro indicators. Level 1, level 2, and level 3 indices and sub-indices are determined based on both the expert assessment and the parameters that make up the next level. The stages of clarifying and calculating the interaction of indices allow them to be used as real analysis, planning, and forecasting mechanisms in the future.

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A methodology is proposed for calculating the GDP generated by information and knowledge sectors in accordance with this approach. At the same time, the quantitative and qualitative structure of a composite index, as well as of indices, subindices, and indicators forming this composite index is described. The stages of clarification and calculation of interrelatedness of indices facilitate their use as a mechanism of real analysis, planning, and forecasting in the future.

In addition to the result: Besides, it should be noted that the issue of approbation of the suggested approach based on realistic statistical data is open for discussion. There are many issues to be solved and evaluated. Determination of innovative sectors of the information economy by clusterization methods, performing relevant calculations based on expert assessments, correlation analysis of the impact to the composite index factors expands the scope of the investigated problem and has a positive impact on the results.

Abbreviations

IKE: information and knowledge economy; ICT: Information and communication technology economy; GDP: Gross Domestic Product; KEI: knowledge economy index; GII: Global Innovation Index; HIS: hierarchic indicators system; EI: economic indicators; KI: Knowledge index, CI**:** Composite Index; CIS: composite indices system; subindices

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