The Development of Indicators and Indices System Characterizing Information and Knowledge Economy

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Abstract: **In this article, comparative analysis of different indicator system in accordance with formation and assessment of development level of information and knowledge economy is given. Main methodological approaches related to their development and analysis are analyzed. Some recommendations about elimination of problems existing in this field are given. A methodic for calculating GDP which forms at the expense of information and knowledge is suggested. The composite index and forming indices, subindices and indicators system of information and knowledge economy is developed.**

Keywords: information and knowledge economy, indicators system, economic indicators, composite index, subindices.

I. INTRODUCTION

The most important of the modern tools innovatively influencing globalization of economic relationships and development of new economy is informatization. Information and knowledge economy (IKE) formed as a result of it reveals itself as the next stage of economic development. Technological development and innovations act as long-term driving force of economic increase. Information and knowledge become the main development factor of society. The fields of production of knowledge and information products play extremely important role in the development and competitiveness of the countries going from the industrial development stage to post-industrial stage. In other words, nowadays development of the countries highly depends on the development of science-intensive fields, including technology innovations.

The factors of global character have influenced the processes going on in all fields of national economy. "Azerbaijan 2020 – A look into the Future" Development Concept [1, 2], also Strategic Road Maps of National economy [3] preconditions new development stage and trajectory of the country. In order to transform the economy of the country into the economy based on efficiency, a transition to the stage characterized by advantage of innovations must be provided. At the same time, the purposeful improvement of the structure of economy is one of the priority issues.

In the period of formation of Global information society (IS) accepted as the development ideology of the third millennium information, technology and knowledge have become competitiveness sustainability factor of the most world countries. Serious need for analytical analysis and assessment of the level of innovative economy developing as a result of their wide implementation appeared. For implementation of quantitative and qualitative evaluation of the application of high technologies, including ICT in different sectors some indicators system was developed by international organizations. They have some methodological defects and application difficulties. That`s why for objective assessment of the development level of information economy in the countries there`s a need for development of indicators system in different levels. Creation of calculating methods of these indicators and development of suggestions and recommendations about eliminations of the existing issues in this sector is also one of the important problems.

II. COMPARATIVE ANALYSIS OF MEASUREMENT METHODS OF THE LEVEL OF INFORMATION AND KNOWLEDGE ECONOMY

There are different indices characterizing information and knowledge economy found in scientific literature [4, 5]: 1)Economy index, 2)Digital economy and Society index, 3)Global competitiveness index, 4)Global creativity index, 5)Global innovation index, 6)Global ownership index, 7)Technological readiness index, 8)Economic stimulation and institutional conditions index, 9)Poverty and unemployment index, 10)Knowledge index, 11)Knowledge economy index etc.

Separate analysis of these indices shows that the information that provides their structure and content are different. In particular, the elements of economy index [6-8] include: 1)organizational effectiveness and human resources (14 indicators), 2)competitiveness and creativity development of economic structure (11 indicators), 3)ICT infrastructure (8 indicators), 4) innovation (10 indicators).

One of the measurement indicators of IKE is the investment in KE. Experts of UNO OECD evaluate the investment in knowledge as a collection of national expenses for education, R&D and software [9-11]. USA (6,6% of GDP) is a

leader for this indicator. Of course, this indicator can't reflect the conditions of IKE completely and correctly.

According to the method of European Economic Commission (EEC) readiness of formation of IKE in the country is calculated on the basis of Global economy index (GEI) [12]:

$$GEI = A*Tec + B*SISI + C*Mec$$

Tec – technological subindex, GISI – State institutional subindex, Mec – subindex of Macroeconomic conditions. A, B, C are the mass ratio of the proper indices and they meet these requirements:

A + B + C = 1, according to EEC it is accepted that A = 1/3, B = 1/6 C = ½. It should be noted that proper indicators impact on the formation of each subindex.

According to a different approach this kind of information base is used in Kazakhstan to evaluate KE level [13, 14]:

- Quality of economic regulation;
- The degree of execution of laws;
- Royalty and license fees;
- Publications in scientific and technical journals;
- Number of patents;
- The average duration of education;
- Secondary / higher education coverage;
- Number of phones/computers;
- Number of internet users (per 1000).
- 2013-year method of Russian Statistics Committee under calculating of the part of high technology and science-intensive sector products (SIP) in GDP [15] is based on the following:
- HTI – total extra income on high technology economic activity;
- SII – total extra income on science-intensive activity;
- TEI – total extra income on all economic activity

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

Calculating of integral indicator of IKE can also be implemented on the basis of relevant statistic report indicators incoming on science, ICT, Information society, innovation etc. from institutions and organizations [16].

X_1 –the expense on research and development, m/person

X_2 – volume of innovative product, m/person

X_3 – volume of innovative product for export, m/person

X_4 – ICT expenses, m/person

In this case, in addition to the per capita indicators, ratio and structural indicators are also taken into account.

Structural indicators. X_5 – specific weight of high innovation product, %, X_6 – specific weight of organizations using internet, %, X_7 – specific weight of computers with internet access, %.

Ratio indicators. X_8 – researcher project staff per 10 thousand employees, X_9 – researchers per 10 thousand economically active people, X_{10} – costs of technological innovation per 1 employed person, X_{11} – number of patents per 100 researchers.

Constituent elements of knowledge and knowledge economy index suggested and applied by the World Bank can be given as on the figure 1.

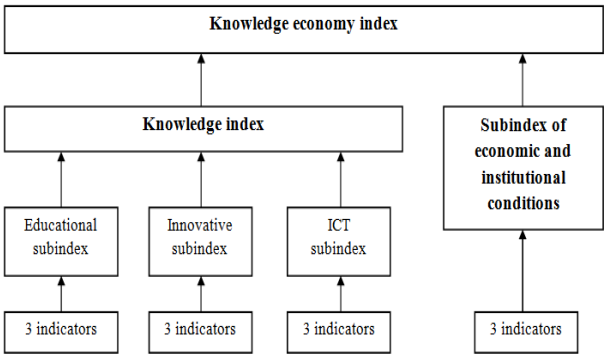

Fig. 1. Formation structure of knowledge and knowledge economy index

Knowledge economy index is a complex indicator. It is developed by proper department of WB since 2004. Calculating of the index is implemented on the basis of "Knowledge assessment methodology" of the WB. A rating on 109 content and quality indicators in 4 groups from 146 countries in 2012 was calculated [16].

In the I group, indicators like 1)economic development conditions, 2)economic, legal environment, 3)quality of regulation, 4)development of business, 5)initiatives, 6)society's ability of using knowledge are used in formation of subindex of economic and institutional conditions.

In the II group education level, literacy indicators, attitude to education are taken into account in calculating of Educational index.

NIS level, research centers, universities, technoparks, scientists, patents, scientific journals are accepted in calculating of the Innovation subindex in the III group.

Information such as ICT level, regional infrastructure, information broadcast is required in calculating of ICT index in the IV group.

The countries in each indicators group get 1-10 points. 2 common indices are calculated according to methodology:

1) KI – knowledge index. KI is an average of the 3 indices.

$$KI = (EI + II + ICT)/3;$$

2)KEI – knowledge economy index. KEI is accepted as an average of 4 indices.

$$KEI = (EI + II + ICT + KI)/4,\ 0 \le KI \le 1,\ 0 \le KEI \le 1.$$

The main group indicators of knowledge economy index include research, development and innovation, technical profession education and instructions index, pre-higher school education subindex, higher education, ICT as the components of Knowledge index. Functional alignment of indicators is realized in 1)economic, 2)technological, 3)social, 4)state directions.

As we can see, the country has an average position among the groups of countries approximately analyzed in the assessment from different aspects, on the basis of different indices. And this confirms one more time that still many unused potential opportunities exist in the country.

II. The Characteristics Of Regional And Sectoral Approach To The Assessment Of The Level Of IKE

Analyses show that different approaches, indicators, methods, indices etc. exist in the assessment of IKE level. There's disunity in the conduct of comparative analyses. The base groups that will be chosen for comparison don't completely meet the requirements, regional characteristics. That's why during economic analysis of the condition of the formation of IKE it's suggested that from the functional point of view economic development stages should be accepted as: agrarian, industrial, information, knowledge, smart technologies. This division should be taken into account during analyses and assessments.

Besides, guiding developed countries (G7, G10, G20), Post-soviet, former USSR, CIS countries, regional countries, developing countries, countries with similar conditions will be included into the group of the countries chosen for comparative analyses and assessments [17-21]. From this point of view, in particular, countries such as USA, Great Britain, Germany, France, Italy, Canada, Japan, China, Russia, India, Korea, Turkey, Switzerland, Sweden, Austria, Iran, Malaysia, Singapore, Israel, Ireland, Pakistan, Hungary, Bulgaria, Kazakhstan, Ukraine, Azerbaijan, Belarus, Uzbekistan, Georgia and Armenia are added to the group of the countries chosen for comparison. At the same time regional levels of the country as: Baku, Nakhchivan, Karabakh – Shusha, Sumgait, Mingachevir, Shirvan, Lankaran, Guba, Shamakhi, Gabala, Shaki and Ganja are accepted as economic-administrative division.

For conduction of economic analyses in a more compact area reconciled to each other, sub-sectors of IKE can also be classified. Taking this into account, sectoral classification of Information and knowledge economy can also be formed as following: Internet; Software engineering and automatization technologies; Digital contents; IT-service, telecommunication; Computing and e-industry; Creative content and digital media; Electronics sector; Military industry; Aerospace and aircraft industry; Management services; Bio, nano and high technologies; Business and industrial services;

Pharmacology and medical industry; Environment and ecology; Optical industry; Transport and communication; Energy sector; Chemicals and oil chemistry; Scientific research and experimental design works; Scientific technological-intensive service sectors; Education; Media sector.

It should be noted that while carrying out analyses by this division spheres of Traditional economy shouldn't be forgotten, either. That's why although Agriculture, Industry, Metallurgy, Transport, Construction, Oil-gas, Energetics, Natural resources etc. belong to Traditional spheres they also can be included into the sectoral classification of Information and knowledge economy.

Besides, science-intensive sub-sectors of traditional economy spheres and newly formed economic spheres should also be included into the analysis process:

Information-communication technologies in management, production and service processes technologies, irrigation and cultivation technologies, marketing and sales technologies, know-how technologies, innovative technologies, smart technologies.

IV. Calculating of GDP Forming by Information and Knowledge

To calculate GDP forming by information and knowledge in any country the following marking and methods are suggested.

1. Production and service sectors according to official statistical reports of the country- $i = 1,2,\ldots,n$
2. GDP of the i^{th} sector – GDP_i
3. GDP of the i^{th}sector forming by the industrial production – $GDPI_i$; $GDPI_i = I_i*GDP$
4. GDP of the i^{th} sector forming by the service production – $GDPS_i$; $GDPS_i = Si*GDP$
5. GDP of the i^{th} sector forming by the information – $GDPIn_i$; $GDPIn_i = In_i*GDP_i$
6. GDP of the i^{th} sector forming by the knowledge – $GDPK_i$; $GDPK_i = K_i*GDP_i$
7. GDP of the i^{th} sector forming by the technology – $GDPT_i$; $GDPT_i = T_i*GDP_i$

$$0 \le (I_i, S_i, In_i, K_i, T_i) \le 1$$

$$0 \le (I_i + S_i + In_i + K_i + T_i) \le 1$$

Weight ratios – I_i, S_i, In_i, K_i, T_i are determined on the basis of expert assessment. Their impact on GDP can be assessed in two ways: 1)indirectly by impacting management, organizing, decisions; 2)as a shopping object of technology, information, knowledge or as a last product, technology, service, innovation.

So, GDP formed by industry, service, information, knowledge, technology across the country (SIGDP, SSGDP, SInGDP, SKGDP, STGDP) will be calculated as following: 1) country total

GDP – TGDP = $\sum_{i=n}^{n} GDP_i$

2) by the industrial production across the country

SIGDP = $\sum_{i=n}^{n} GDPI_i$

3) by the service production across the country

SSGDP = $\sum_{i=n}^{n} GDPS_i$

4) by the information production across the country

SIGDP = $\sum_{i=n}^{n} GDPIn_i$

5) by the knowledge production across the country

KIGDP = $\sum_{i=n}^{n} GDPK_i$

6) by the technology production across the country

TIGDP = $\sum_{i=n}^{n} GDPT_i$

V. Indices And Subindices Forming Composite Index Of Information And Knowledge Economy

Forming of Composite index information and knowledge economy (CIK) is suggested by indices shown on the figure 2.

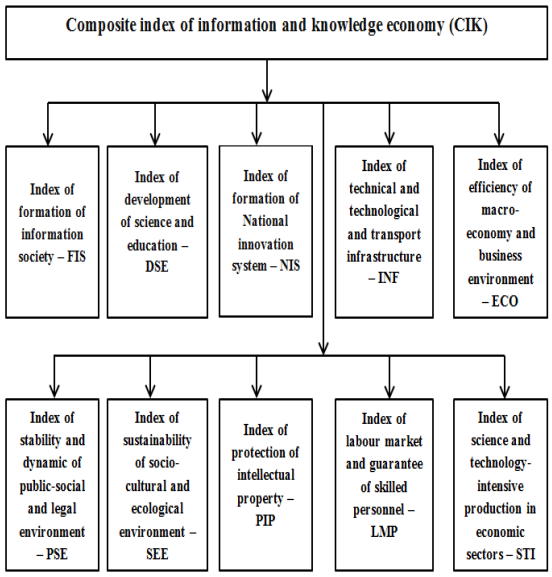

Fig. 2. Indices forming composite index

The observations and analyses show that the number content of subindices and indicators that impact forming those sectoral indices can be expressed as following:

1. Content of index of formation of information society (FIS) – 13 subindices and indicators
2. Indicators that impact index of development of science and education (DSE) – 9 indicators
3. Components of index of formation of national innovation system (NIS) – 13 subindices and indicators
4. Factors that impact index of technical and technological and transport infrastructure (INF) – 5 subindices and indicators
5. Indicators of index of efficiency of macro-economy and business environment (ECO) – 12 subindices and indicators
6. Components of index of stability and dynamic of public-social and legal environment (PSE) – 6 subindices and indicators
7. Factors that impact index of sustainability of socio-cultural and ecological environment (SEE) – 8 subindices and indicators
8. Indicators forming index of protection of intellectual property (PIP) – 5 subindices and indicators
9. Factors that impact index of labour market and guarantee of skilled personnel (LMP) –7 subindices and indicators
10. Indicators forming index of science and technology-intensive production in economy sectors (STI) – 5 subindices and indicators.

VI. Scientific-Methodological Basis Of Development Of The System Of Composite Indices On Comparative Assessment Of IKE

The structure of the system of composite indices (SCI) is suggested in multilevel form. Main level integratively reflects all the lower coming after it and the parameter which characterizes it is called composite index of IKE (IKC). Composite index forms as a result of assessment and has a leading position in comparative analysis. So that it's as a result of this value that IKE gets proper ratings.

Each subindex is evaluated in the [0,10] scale. Weight ratios as first are accepted as 1. Composite index is accepted as the sum of subindices and varies between [0,100]. Besides, calculating of composite index of IKE can be alsofunctionally noted as following:

IKC = F(FIS, DSE, NIS, INF, ECO, PSE, SEE, PIP, LMP, STI).

F expresses dependence form of composite index from other indices.

Thus, it can be noted that scientific-methodological basis of development of composite indices system on comparative assessment of IKE consists of the following:

- Composite indices are a useful instrumentario for assessment, analysis and comparison of development level of society, economy.

- Composite index and indicators form due to a combination of separate indicators measured on the basis of multidimensional criteria.
- Composite index although not directly, but indirectly allows to evaluate efficiency of IKE, gives ground to conclude on its role in the society, the extent of its part.
- To form composite, index the values of the indices above are suggested to be taken as a basis.
- The following can be noted on the assessment of indices and subindices:
- Average numbers, expert assessment, weight ratios, proper econometric and statistical methods will be used in calculation of new indices and subindices. Indices, subindices and indicators system on comparative assessment of IKE is divided into different hierarchical levels.
- 1st national level consists of composite integrative index of IKE, firstly 2nd level consists of 10 indices, 3rd level – 83 subindices and indicators, 4th level – 320 indicators of macro/micro nature. Indices and subindices of the 1st, 2nd and 3rd levels are determined on the basis of both expert assessment and the parameters forming the next level.
- 4th level indicators include both official statistics and other external and internal indicators. 4th level indicators mostly serve as a basis for determination of the 3rd and 2nd level subindices by experts. In this case, absolute indicators and their concrete values are used. The approach here is different and can be realized individually in accordance with every concrete situation.
- Indicators system on comparative assessment of IKE can response to complete provision of the aim in the assessment of activity of IKE both in regional and international levels.
- The indices and indicators system suggested on such comparative assessment, being a successful model, can meet existing modern requirements in assessment of the activity of a separate region in Azerbaijan.
- Composite index in the interval [0,100], all 1st level indices and 2nd level subindices in the interval [0,10] have "monotonous increase" characteristics, i.e. the increase of the values shows better conditions while the decrease shows worsening of the conditions.

VII. CONCLUSION

The quantitative and qualitative assessment of the economy of the modern era, especially science, technology, innovation-intensive areas is one of the very difficult problems. Researchgives reason to note that most of the viewed indices can't implement the assessment of economy comprehensively. Besides, it should be noted that composite and other complex nature indices are one of the trusted and accepted means allowing to analyze and present the whole characteristics of the countries and their economy. That's why the rules, methodology and requirements of creating of composite indicators of influential organizations, different methodological approaches proven in practice should be used effectively. The development and improving of the composite indices implementing the accurate and precise assessment of the development level of the economy based on the information and knowledge on a regular basis is the requirement of the modern era. Besides, it is also important to take into account information and accountability characteristics of the organizations operating in the information and knowledge sectors. The essence of the approach reflecting regional and sectoral features is explained by taking these requirements as the main. According to this approach the calculation method of GDP forming by information and knowledge is suggested. At the same time the quantitative and qualitative content of the composite index of information and knowledge economy, the other indices, subindices and indicators forming it is explained. The stages of explaining and calculating of indices allow to use them as real analysis, planning and forecasting mechanisms in the future.

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