A Composite Indicator of K-society Measurement

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Abstract. The development of K-society theories leads to necessity of finding an approach of measuring the progress of each country. The paper presents the composite model which based on OECD and UN methodology. The hierarchy model consists of three dimensions and 14 indicators and gives a possibility to calculate K-society Index for 87 countries. The analysis of the results presents country's current rating and dynamics. The data for Top-20 countries, the last twenty countries and North America are introduced in the paper. K-society Index for Ukraine is described in details. The future state's strategy can be based on K-society measurement.

Keywords: MathematicalModeling, Knowledge, Methodology, DecisionSupport.

1 Introduction

The fundamental concept of sustainable development requires the review of the classic studies about the world. Knowledge as a higher value of informational process forces the progress in sustainability. Also, the knowledge is one of the factors of production in modern economy. That is why, the theory about knowledge-based economy and society becomes wide shared among scientists. For example, knowledge society is described as sustainability concept by N. Afgan and M. Carvalho [1]. M. Kulin studies learning and knowledge influence as a factor of global competitiveness [2], the impact of knowledge for society is the main focus of G. Bohme and N. Stehr research [3]. Thus, the theoretical aspects of Knowledge society are well-studied.
At the same time, the questions about applied evaluation of knowledge in a country, comparison of different countries and knowledge dynamics research are still open.
Taking into account the complex character of knowledge, it can be presented as the set of indicators which are gathered in a hierarchy model.
Therefore, the main idea of the research is to draw out a composite indicator for measurement knowledge as a sophisticated category with a purpose of country development analysis.

2 K-society as a New Mode of the World Developing

Classic economic theory presents three factors of production that are used in a production process, which leads to finished goods. These three basic resources are land, labor and capital. Nowadays this fundamental approach was divided into several complex theories that include additional factors of production, for example, technological progress, human capital and social capital. Basically, those resources can be aggregated into one category – knowledge. More than this, knowledge and information become the most significant factors of production and form the basis for new technological mode.

Knowledge society (K-society) is widespread concept, but scientists still investigate its nature [4]. The mass production of knowledge changes the economy in global world in quite short terms. However, this process is dissimilar in different countries.

The research of K-society is undertaken by all developed countries for more than 40 years but there are still a lot of controversial question. First of all there is no agreement about terminology. Such terms as “K-society”, “Informational society”, “Technogeneous society” serve the purpose of science communication in this topic. The term “K-society” was used by M. Zgurovsky to mean a where institutions and organizations give possibilities to people and information to develop without any barriers and open opportunities for mass production and mass usage of all kind of knowledge in global scales. Therefore, the development of technologies is an important part of K-society, but not the main purpose. Thus, the term “Technogeneous society” doesn’t describe these processes in full measure.

The question about links between K-society and information society is more complicated. The first one is based on definition of knowledge, the second one uses information as a basic category. The development of new computing technologies has not influenced to significancy of common paradigm, but the possibility to get, safe, analyze and transfer knowledge was changed cardinally. That led to increasing velocity of information circulation. Moreover, it is difficult to divide information and knowledge. But in the purpose of this research it is assumed that knowledge includes information, and it is a product of information processing.

According to theoretical research the concept of K-society is ambiguous. On the one hand it is a philosophic theory, which has no practical meaning, on the other hand it is the set of instruments and methods for providing sustainable development of modern society [5]. In accordance to the second opinion K-society proclaims the active usage of knowledge, which is the main asset.

The main accent is education, which forms a human capital and guarantees the access to information. But the measurement of educational level cannot give a complete picture of knowledge in society. Therefore, K-society must be formalized more manifold system of indicators. Likely, such system includes the description of current situation in economy, perspectives and information transactions. It is obvious that the development of model for describing K-society is a nontrivial issue.

3 Methodology

According to the UNO methodology, the index of K-society should be based on three dimensions: Assets, Advancement and Foresightedness [6]. The first one describes the level of education, especially, among young people, and the development of information streams. These two main directions include such indicators as: expected schooling, proportion of young people, the diffusion of newspapers, the Internet, main phone lines and cellular phones. The second dimension represents human and informational resources, which are indicated by public health expenditure, research and development expenditure, military expenditure, pupil/teacher ratios in primary education, and a proxy of the "freedom from corruption" indicator. The last dimension shows the external influence on K-society dynamics in the state. This dimension consists of low child mortality rates, equality in income distribution (GINI Index), protected areas as percentage of a country's surface, and CO2 emissions per capita indicators. This approach was officially accepted for approximately 45 countries in 2005.

Taking into account the existent basic specification of the main categories, it becomes possible to continue this research in terms of current informational mode. Thus, new hierarchical model for K-society measurement should be built.

Therefore, it is necessary to clarify the approaches for drawing out this model. The OECD presented methodology and user guide on constructing composite indicators [7]. According to this, there are several obligatory steps in models' creation.

Firstly, the full understanding of processes that can have influence on K-society needs to be represented in theoretical framework. This step concludes with the number of selection criteria. As referred to listed above, the framework is based on UN model.

Secondly, the very important step is data selection. It includes the availability and quality data checking. In addition, the question about strengths and weaknesses of indicators must be resolved. Not least important is to find the reputable source for each data set. Theoretically, all data must be provided by international world-known organizations.

In view of these two steps the UN approach has some disadvantages that are caused by following reasons. On the one hand, last ten years have brought significant changes in informational development. As a result of this process some of indicators lost their relevance. On the other hand, not all data sets are still gathered by authoritative organizations. That is why the original model needs revision and modernization.

Thirdly, the modeling needs complete data sets. Thus, the problem of empty cells that usually appears after the data selection requires imputation of missing data. The various kinds of methods for working with complex models are established in World Data Center for Geoinformatics and Sustainable Development [8]. Therefore, the recommendation for this case is to augment the empties by previous period information.

The step includes multivariate analyses. This phase gives the possibility to double check the starting hypothesis about the set of indicators. The significance of sampling should be checked. Other important question is to evaluate relations between indicators. That is why the elements of principal components analysis and cluster

analysis influence the final decision about model structure. This step identifies statistically similar indicators. Thus, the additional explanation of internal relations or model's rebuilding can be required. As a result of this issue the model can be amplified by additional explanation.

Taking into account the miscellaneous nature of indicators the next step is normalization. There are more than ten typical approaches to its implementation. It is necessary to underline that there is no goal to make the estimation more complex. For this reason, the standardization is the optimal variant for this step. The formula of this type of normalization is as below:

$$Value_{norm} = (Value - Value_{min})/(Value_{max} - Value_{min}) . \quad (1)$$

In case when it is necessary to represent the inverse coupling this formula converts to:

$$Value_{norm} = 1 - (Value - Value_{min})/(Value_{max} - Value_{min}) . \quad (2)$$

As a result, all indicators values lie in interval from 0 to 1.

To express the theoretical framework and relations underlined at the previous stages, the sixth step includes finding out the way of indicators aggregation and their weights establishment. For instance, the model's hierarchy is constructed.

Each dimensions' index consists of several indicators and can be presented as the average value of its components. In the same manner K-society Index equals to the all dimensions indices aggregation.

At the next step uncertainty and sensitivity analysis emphasize the reasons of the differences between results of using variety of aggregation, imputation and normalization methods. This step identifies all possible sources of uncertainty and determines what sources have more influence to the overall score.

Eighthly, detecting dominant and critical indicators for objects or their groups provides the information about the levels of influence for the assessed system. It is also very important for policy making problems.

Then, for modeling results validation developed index is compared to others that describe the phenomenon of similar nature. The comparison base consists of well-known indices that authoritative organizations and institutions provide. Thus, two indices were chosen for purposes of final analysis: Fragile State Index [9] and Index of Economic Freedom [10].

Finally, the last step is to present the results in a clear and accurate manner. That is why visualization is the part of this algorithm. It is necessary to choose the correct tools that provide total understanding of the obtained results. Thus, the final step of modeling becomes the element of a decision making support system.

Taking into consideration the UN approach and OECD methodology the new model was drawn out. The indicators, data providers and data sources are presented in Table 1.

Table 1. List of indicators

Indicator	Institution	Source	Type of influence
School life expectancy	UNESCO Institute for Statistics	http://www.uis.unesco.org	Positive
School enrollment, secondary (% net)	World Bank	http://data.worldbank.org/indicator/SE.SEC.NENR	Positive
Internet subscriptions per 100 inhabitants	ITU	http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx	Positive
Main phone subscriptions per 100 inhabitants	ITU	http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx	Positive
Cellular subscriptions per 100 inhabitants	ITU	http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx	Positive
Gov't Health Expenditures (% of total gov't exp)	World Health Organization	http://apps.who.int/gho/data/?theme=main	Positive
R&D expenditure as % of GDP	UNESCO Institute for Statistics	http://www.uis.unesco.org	Positive
Military expenditures (% of GDP)	SIPRI	http://www.sipri.org/	Negative
Pupils per teacher in primary school	World Bank	http://data.worldbank.org/indicator/SE.PRM.ENRL.TC.ZS	Negative
Corruption perception	Transparency International	http://www.transparency.org/research/cpi/overview	Positive
Child mortality (children under 5 years per 1000 births)	World Bank	http://data.worldbank.org/indicator/SH.DYN.MORT	Negative
Gini Index	World Bank	http://data.worldbank.org/indicator/SI.POV.GINI	Negative
Terrestrial and marine protected areas (% of total territorial area)	World Bank	http://data.worldbank.org/indicator/ER.PTD.TOTL.ZS	Positive
CO2 emissions (metric tons per capita)	World Bank	http://data.worldbank.org/indicator/EN.ATM.CO2E.PC	Negative

Data for 87 countries were gathered and complemented in the process of model development. Thus, the results of estimations are described in the next paragraph.

4 Results

According to the algorithm each of the dimensions were counted based on their components. It is necessary to mention that it gives the possibility to measure Assets, Advancements and Foresightedness as separate indices. Such evaluation brings an opportunity to additional comparison of countries in terms of the dimensions. But in accordance with the main purpose of the research the K-society Index has to be measured. That is why the procedure of linear convolution is implemented twice.

Collected data give a possibility to provide the calculations for period from 2008 to 2013.

The results for 2013 year show that the Top 10 countries for K-society Index consists of Switzerland, Denmark, Netherlands, Sweden, Slovenia, France, Austria, New Zealand, Japan and Finland. The values for the final index and three dimensions are presented in Table 2.

Table 2. Top 10 countries by K-society Index 2013

	The Assets Index	The Advancement Index	The Foresightedness Index	KS Index	Rank
Switzerland	0,801	0,827	0,780	0,803	1
Denmark	0,758	0,794	0,785	0,779	2
Netherlands	0,764	0,757	0,789	0,770	3
Sweden	0,722	0,809	0,766	0,766	4
Slovenia	0,670	0,642	0,949	0,754	5
France	0,789	0,636	0,792	0,739	6
Austria	0,703	0,749	0,765	0,739	7
New Zealand	0,744	0,737	0,711	0,731	8
Japan	0,719	0,777	0,687	0,728	9
Finland	0,692	0,773	0,722	0,729	10

The analysis of representatives shows that Top 10 involves high-developed countries with sustainable economic, ecological and social conditions. The variance between the first and the last states from the list described above equals to 0,074. Moreover, the gap between top possible value of the index, and the value for Switzerland is 0,197.

The last 10 countries of the ranking for 2013 year are presented in following table (Table 3).

The last one, Nigeria, has a high level of Fragile States Index, which is caused by alert meaning of such indicators as Demographic Pressure, Group Grievance, Uneven Economic Development, State Legitimacy, Public Services, etc. Even more, the conflict barometer, which is counted by HIIK [11], shows that this country has the value 5. That means the existence of the war in Nigeria.

According to the same sources Pakistan is under the inter-ethnic violence and conflict with India that were classified as limited war and violent crisis. Also the problems with Demographic Pressure, Refugees, Group Grievance, State Legitimacy

Human Rights, Security Apparatus, etc. exist in the state. Moreover, the situation, described by Fragile States Index, is even worse than in Nigeria.

Table 3. Last 10 countries by K-society Index 2013

	The Assets Index	The Advancement Index	The Foresightedness Index	KS Index	Rank
Paraguay	0,280	0,359	0,569	0,402	78
Senegal	0,145	0,432	0,633	0,403	79
India	0,278	0,327	0,589	0,398	80
Madagascar	0,133	0,334	0,543	0,337	81
Gambia	0,145	0,359	0,455	0,320	82
Kenya	0,206	0,249	0,492	0,315	83
Ethiopia	0,052	0,284	0,637	0,324	84
Mozambique	0,183	0,260	0,494	0,312	85
Pakistan	0,107	0,182	0,578	0,289	86
Nigeria	0,074	0,304	0,433	0,270	87

The next one is Mozambique. In accordance to the Fund for Peace methodology the state's current pressure assessment is "Very High Warning". The more dangerous indicators are: Demographic Pressure, Uneven Economic Development, Economy and Public Services.

Ethiopia is in a group of countries, which have "alert" status. The greatest problems of Ethiopia are Social and Economic Fields, External Intervention and Factionalized Elites. Such tendency has been continuing since 2009.

Kenya has a limited war, which is connected with inter-ethnic violence. In addition this state is 18 from 178 countries in Fragile States Index. The problems with Political and Military, Social and Economic fields lead to high negative rating.

The next country is Gambia. It has growing tendency from stable to very high warning assessment in Fragile States Index.

India is the neighboring country for Pakistan. Thus, problems with conflicts, which were described above, also concern India. Furthermore, India has to worry about Demographic Pressure, Group Grievance, Uneven Economic Development and Security Apparatus. The less number of problems gives India higher value of K-society Index. The fact of common knowledge is that India tries to develop IT sphere. But it seems that it is not enough for building K-society.

Senegal has stable, very high warning assessment since 2006. The long-term tendencies show that the situation in the country becomes more and more dangerous. Madagascar is near Senegal in rating and the common tendencies almost the same, except the reduction of Group Grievance and Refugees. Such situation has been occurred since 2008. However, Paraguay is the only country from the bottom part of the rating that has been increasing in Fragile States Index in terms of improving situation.

This analysis shows that K-society Index reflects much more information than IT or science alone. It correlates with current political and economic situation in the country. Moreover, it is impossible to build K-society in unsustainable environment.

It is essential to discover the relations between K-society Index and other well-known indices. Fig. 1 shows the correlation between Fragile States Index and K-society Index.

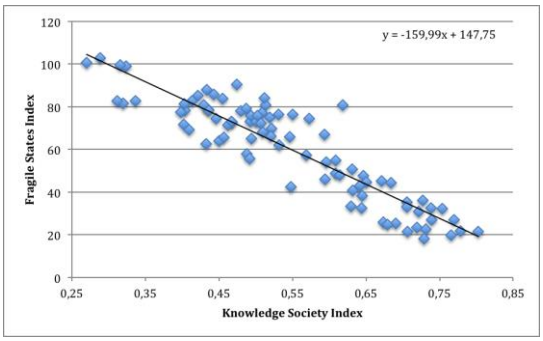

Fig. 1. Correlation between Fragile States Index and K-society Index

It describes high linear relation between indices. Thus, it is an additional proof of state instability influence to knowledge establishment.

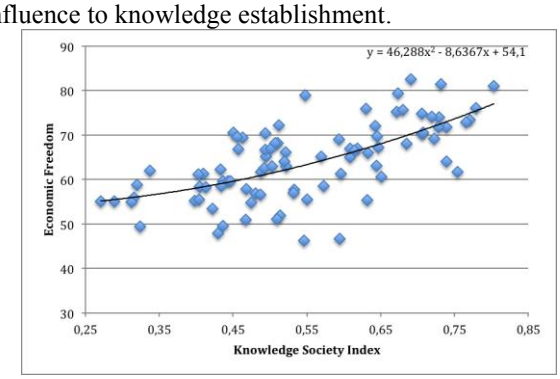

Fig. 2. Correlation between Economic Freedom and K-society Index

Probably, more interesting results were obtained from K-society Index and Economic Freedom relations. Fig. 2 shows that the economic component is not fundamental for processes in K-society. The truth is that economy is rather important.

The results of the research show that K-society can be unequal in neighboring countries. Also there is no dependence between the leading positions in the world and absolute success in K-society creation. For instance, the comparison of Mexico, USA and Canada is a good illustration of mentioned above thesis (Fig. 3).

The graph illustrates the North America countries' values. The first place has Canada. The USA shows almost the same tendency but with lower score. Both countries have falling K-society Index tendency in 2012-2013. It is noteworthy that Mexico's tendency corresponds to others but the values of index are much lower on all period of research.

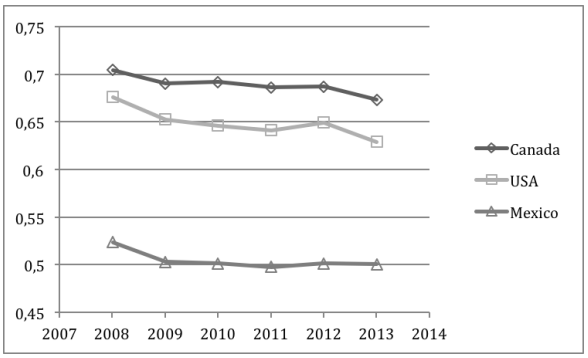

Fig. 3. K-society Index for Mexico, USA and Canada

The challenging issue is to find out Ukraine's situation with K-society development. Ukraine had good infrastructure, science and educational bases but it is necessary to clarify it is still competitive or not in the international area.

The first step in this direction is to compare Ukraine with neighboring countries. Taking into account that all neighbors are from post-Soviet area, this sample is congeneric. Thus, the results in the index form should describe the Ukrainian success in K-society development. In addition, the qualitative information about neighbors gives a possibility to verify calculations. The existence data let to find values of index for Poland, Russia, Moldova and Hungary. The dynamics of K-society Index for these countries and Ukraine is introduced on one graph. This approach allows demonstrating the differences obviously (Fig. 4).

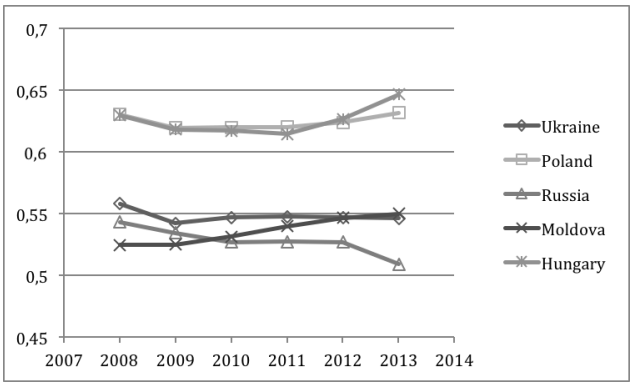

Fig. 4. K-society Index for Ukraine's neighbors

Firstly, it is necessary to mention that Russia confirms the significant fall of index' values in 2012-2013, that USA and Canada showed. Secondly, two countries, Hungary and Poland, have almost equal dynamics of index' values. Ukraine shown higher estimations than Moldova and Russia in 2008 and outstripped those countries until 2012. The situation was changed in 2013 when Ukraine got lower position than Moldova. In general, Ukraine takes the 40th place from 87 countries in 2013. Its value

of K-society Index equals to 0,546. It is to be recalled that the value for Switzerland is 0,803.

It is useful to discover the components of index for Ukraine to define the weak part of it. Fig. 5 illustrates the Assets, Advancement, Foresightedness and K-society Indices' dynamics from 2008 to 2013.

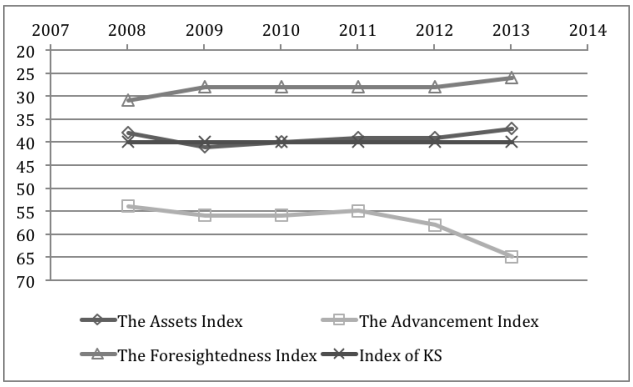

Fig. 5. Ukraine's values of K-society Index and its components

In the purpose of this analysis all components are described by places rating. This gives the opportunity to show relative measures and ranking. The Advancement dimension shows the worst values in all period. Thus, let's consider from what indicators this dimension consists of. Obviously, Ukraine has a great problem with freedom from corruption indicator. In addition, research and development expenditures, pupil/teacher ratios in primary education and public health expenditure are lower than generally accepted (for example, in Europe) norms. This issue can be an opportunity to significant development of K-society in future. Accordingly, these fields need to be modernized and get all possible funding for improving the situation. Thuswise, this analysis shows the preconditions of strategic planning and decision making in Ukraine in case it is necessary to reach the leading countries. The last hypothesis is based on the fact that the leaders in K-society Index are the most developed countries.

5 Conclusions

In paper it was shown that K-society is a probable next mode of economy development that leads to changes in institutional and organization structure inside each country and over the world.

K-society is a complex category, which can be considered as a strategy goal for country. Therefore, it needs to be measured in quantitate form. The analysis of existence approaches shows that it is possible to use OECD methodologies for creating composite indices and UN methodology for K-society Index. The

improvement and combination those two sources give the base for model of K-society Index.

The K-society Index was drawn out as a combination of three dimensions and 14 indicators. The values of index were calculated for 87 countries that provide all necessary information.

The analysis of results shows that there is no direct dependence between K-society development and the country leadership in the world.

The situation for Ukraine was analyzed deeply. Firstly, Ukraine has lower meaning of index than it's neighbor countries Moldova, Poland, Hungary. Secondly, the less developed dimension is "Advancement". Thus, the strategy of its extension must be provided.

Some common tendencies were found for all countries. The index decreased rapidly its value in 2008. The values of index have high correlation with Fragile State Index and Economic Freedom.

References

1. Naim Hamdija Afgan, Maria G. Carvalho. The Knowledge Society: A Sustainability Paradigm. Cadmus. Volume 1. Issue 1 (2010)
2. Michael Kuhn, Massimo Tomassini, P. R. J. Simons. Knowledge Based Economy: Knowledge and Learning in European Educational Research (2006)
3. Gernot Bohme, Nico Stehr. The Knowledge Society: The Growing Impact of Scientific Knowledge on Social Relations. Springer Science & Business Media (1986)
4. UNESCO World Report: Towards Knowledge Societies. UNESCO, France (2005)
5. Understanding Knowledge Societies in Twenty Questions and Answers with the Index of Knowledge Societies. New York: UNPAN (2005)
6. Understanding Knowledge Societies. Department of Economic and Social Affairs, United Nations, New York (2005)
7. Handbook on Constructing Composite Indicators: Methodology and User Guide. Organization for Economic Co-Operation and Development, France (2008)
8. World Data Center for Geoinformatics and Sustainable Development, http://wdc.org.ua/
9. Fund for Peace: Fragile State Index, http://ffp.statesindex.org/
10. Terry Miller, Anthony B. Kim, Kim R. Holmes: Highlights of the 2014 Index of Economic Freedom: Promoting Economic Opportunity and Prosperity. The Heritage Foundation, New York (2014)
11. Conflict Barometer 2013. Heidelberg Institute for International Conflict Research, Germany, №22 (2013)