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INTERNATIONAL INDICES: MEASUREMENT AND USAGE ISSUES

МІЖНАРОДНІ ІНДЕКСИ: ПИТАННЯ ВИМІРУ ТА ВИКОРИСТАННЯ

The article considers the correctness of the construction of international indices and the possibility of their use in analytical practice. The interconnection of such concepts as: assessment of accuracy of the source information - assessment of accumulation of errors during its processing - assessment of accuracy of quantitative estimates obtained based on analysis of main advantages and disadvantages of international indices, is tracked. The emphasis is made on scaling as a method that allows combining the general principles of mathematical analysis and specific methods of data collection. The expediency of selecting a method of data conversion during the transition from the ordinal scale to the interval one is determined, which is a necessary condition for the possible comparability of ranking positions in the presence of various research objectives and arrays of the data collected. The relationship between the methods of data classification as the basis of their primary systematization is considered. To determine the possibility of comparing international indices with regard to the general characteristics of a cluster and the changes within this cluster, the method of cross-clustering is used. The issues of the correctness of aggregate estimates are raised. There proved the erroneousness of revealing dynamic patterns at failing to meet the conditions when the quality of the research tools used is determined by their validity and reliability, and the quality of the results obtained is determined by the accuracy of measurements. It is found that the stability of the socio-economic system should be confirmed by the statistical stability of the indicators that characterize this system. A scheme of relationships of requirements for data in the construction of international indices is proposed.

Статтю присвячено питанням коректності побудови міжнародних індексів й можливості їх використання в аналітичній практиці. Відстежено взаємозв'язок понять: оцінка точності вихідної інформації - оцінка накопичення помилок при її обробці - оцінка точності отриманих кількісних оцінок на основі аналізу базових переваг та недоліків міжнародних індексів. Зроблено акцент на шкалюванні як методі, що дозволяє поєднати загальні принципи математичного аналізу й специфічні прийоми збирання даних. Визначено доцільність підбирання методу перетворення даних при переході від шкали порядку до шкали інтервалів, що є необхідною умовою можливого зіставлення рейтингових позицій за наявності різної мети дослідження та масивів зібраних даних. Розглянуто взаємозв'язок методів типології даних як основи їх первинної систематизації. Використано метод перехресної кластеризації для визначення можливості зіставлення міжнародних індексів з урахуванням загальної характеристики кластера та динаміки зміни в межах кластера. Порушено питання коректності агрегованих оцінок. Підтверджено помилковість виявлення закономірності динаміки, коли не виконуються умови, що якість інструментів дослідження визначається їх обґрунтуванням і надійністю, а якість отриманих результатів – точністю вимірів, що здійснюються. Визначено, що стійкість соціально-економічної системи повинна підтверджуватися статистичною стійкістю показників, які цю систему характеризують. Запропоновано схему взаємозв'язаних вимог до даних при побудові міжнародних індексів.

Ключові слова: *міжнародні індекси, перехресна кластерізація, інтегральний показник, точність виміру, статистична стійкість*

Key words: *international indices, cross-clustering, integral indicator, measurement scales, measurement accuracy, statistical stability.*

Introduction. Modern society is a complex socio-economic system. The effectiveness of the system development is determined by the ability of the economy to maintain the stability of system elements over the relatively long periods of time. The existing market relations are characterized by the inability to return the system to a state of equilibrium. Therefore, both government and business need to employ new more advanced methods aimed at obtaining objective information to ensure making high-quality decisions.

The availability of timely and reliable information about the existing relationship of macroeconomic indicators enables assessing the level of stability of the process of social reproduction as the basis for the formation of the state economic policy.

The international harmonization of the methodology of macroeconomic analysis facilitates determining a country's place in the global economy, and the construction of a system of indicators characterizing the conditions and results of the national economy development allows to assess the state and develop measures to adjust the processes of economic transformation.

In modern analytical practice, for assessing the level of national economic development, international indices are widely used. Being composite indicators, these indices make it possible to summarize the most essential properties of complex socio-economic phenomena and processes that cannot always be measured directly.

But, at the same time, the problem of correctness of mathematical description of the economy arises. On the one hand, mathematical models that ignore phenomena important for understanding the economy are developed and used, and, on the other hand, assumptions and limitations put forward in these models are refuted by empirical studies [7].

Therefore, the basis of the analytical work on the assessment of complex socio-economic systems from the standpoint of meaningfulness and mathematical correctness is the observance of the requirements for the source data and the process of their measurement.

Analysis of recent researches and publications. Any research is a sequential process of collecting, processing and analyzing the information necessary for both formulating and testing the hypotheses put forward, as well as for making conclusions. The use of international indices as complex characteristics is based on a measurement procedure that is justified from the standpoint of analytical correctness.

The issues of measuring socio-economic phenomena and processes were dealt with by A. Marshall, K. Ainabek, V. Klistorin, A. Orlov, V. Faltsam, and others.

International rankings are covered in the works of I. Dubina, S. Zakharchenko, V. Koziuk, L. Lohvynenko, Yu. Khvatov, A. Erina, and others.

However, both the measurement result and the conclusion formulated determine the knowledge of the rules according to which the measurement should be carried out. Compliance with these rules when assessing the attractiveness of national economies is neglected.

The aim of the article is a review of international indices through assessing the quality of measurement and measuring instruments.

Presentation of the basic material of the research. In modern economic practices, the universal indicators used for assessing the state of the economy are international indices. As a tool to simplify complex reality, these indices make it possible to rank states according to their degree of compliance with certain criteria.

The advantage of rankings is the combination of qualitative and quantitative assessments in one indicator. But often the lack of theoretical foundations and the qualitative analytical approach to the selection of individual components of the composite indicator prejudices the completeness of the reality reflected by it.

Based on the mentioned basic advantages and disadvantages of the international indices, we consider those ones that have a multidirectional substantive basis, but are similar in a construction scheme: The Global Competitiveness Index (GCI), Index of Economic Freedom (IEF), Human Development Index (HDI), World Uncertainty Index (WUI).

The database of information support for constructing the indices under the consideration is constituted by data from national statistical services and expert estimates. But statistics reflects the past idea of socio-economic reality and, therefore, does not always allow to correctly assess the closeness of the relationship between indicators calculated based on the same data. The expert method is one of the main in the methodology for compiling world rankings. But its accuracy and reliability are determined by the consistency of experts, their professional competence and objectivity, consideration for the number of objects under consideration, as well as their interest in the results of the study.

Therefore, a compromise arises between the need to obtain data for different countries in a compressed format and over a long period of time, and the economic and mathematical correctness of the data obtained that are aimed at identifying certain patterns.

It is well known that dynamic patterns allow tracking the level of development stability of a particular country and carrying out a comparative analysis of countries. Therefore, we will track the changes in international indices by countries for 2010 and 2019

To organize data, we use the classification methods: grouping method as the basis of the primary data generalization, and the Data Mining module of the Statistica package –to determine the optimal number of clusters when organizing information on international indices.

In order to confirm the presence of dynamic patterns, we will carry out the cross-clustering of the indices under consideration (Tab. 1.), which, taking into account the time factor, allows to combine the information repeated within the cluster.

Table 1

The matrix of correspondence of cluster characteristics to the values of international indices

Cluster feature	**Cross clustering result**			
	GCI	**IEF**	**HDI**	**WUI**
1	2	3	4	5
Very high Level	Singapore; United States; Hong Kong; Netherlands; Canada; Switzerland; Australia; Germany; Sweden; Japan; United Kingdom; France; Denmark; Finland; Taiwan;	Hong Kong; Singapore New Zealand Switzerland Australia Ireland	Norway; Australia; Netherlands; Canada; United States; New Zealand; Ireland; Liechtenstein; Germany; Sweden; Japan Switzerland; Iceland; Hong Kong, China (SAR); Korea; Denmark; Israel; Belgium; Austria; France; Slovenia; Finland; Spain	
High Level	New Zealand; Israel; Iceland; United Arab Emirates; Malaysia; China	United Kingdom; Israel; Czech Republic; United Arab Emirates; Taiwan; Luxembourg; Lithuania; Rwanda; Qatar; Latvia	Greece; United Arab Emirates; Cyprus; Andorra; Brunei Darussalam; Slovakia	Moldova
Level above the average	Italy; Portugal; Slovenia; Poland; Malta; Lithuania Slovakia; Russia; Cyprus	Botswana; Jamaica; Oman; Colombia; Indonesia; Barbados; Fiji; Slovenia; Kazakhstan; Turkey; Portugal; Philippines; Brunei Darussalam; Dominican Republic		Honduras
Average Level			Dominican Republic; Saint Lucia; Lebanon; Jamaica; Venezuela; Dominica; Fiji; Paraguay; Suriname; Jordan; Belize; Maldives; Tonga; Turkmenistan; Libya; Samoa; Bolivia; Gabon; Salvador	**Ukraine;** Peru Lebanon Turkey; Russia France; Brazil
Level below average	Trinidad and Tobago; Jamaica; Albania; Egypt; Argentina; **Ukraine**; Moldova; Lebanon; Algeria; Botswana; Namibia; Guatemala; Iran	Guyana; Swaziland; Benin; Egypt; Malawi; China; Haiti; Lesotho; Nigeria; Tajikistan; Mali; Nepal; Pakistan; Vietnam; Cameroon; Senegal; **Ukraine**; Mauritania	Kiribati; Vanuatu	Croatia; Benin; Venezuela; New Zealand Georgia; Togo; Namibia; Congo; Uganda Bulgaria
Low level	Mongolia; Tajikistan; Bangladesh; Cambodia; Bolivia; Pakistan; Ghana; Senegal; Uganda; Nigeria; Tanzania; Zambia; Cameroon; Benin	Timor-Leste; Chad; Togo; Angola; Congo,Dem.Rep. Burundi; Algeria; Central African Republic	Solomon Islands; Papua New Guinea; Rwanda; Nigeria; Tanzania; Uganda; Mauritania; Madagascar; Benin; Lesotho; Senegal Togo; Haiti; Djibouti	Tanzania; Mauritania
Very low level	Zimbabwe; Mali; Burkina Faso; Lesotho; Chad; Mauritania; Burundi; Angola; Mozambique;	Venezuela	Ethiopia; Guinea; Liberia; Guinea-Bissau; Congo; Mozambique; Sierra Leone; Burkina Faso; Eritrea; Mali; Burundi; South Sudan; Chad; Central African Republic	

Source: developed by the author based on [14-18]

The analysis of the data in Table 1 showed that the matrix of correspondence of cluster characteristics with the clusterization data on the indices under consideration is ambiguous. The highest consistency in terms of cluster characteristics with a very high level of GCI, IEF and HDI values are simultaneously observed in Hong Kong, Switzerland and Australia. Whereas the consistency in changes in terms of GCI and HDI is characteristic of Netherlands, Canada, the United States, Japan, Germany, Sweden, Denmark, Finland, France, and in terms of GCI and IEF – to New Zealand and Ireland.

The cross-clustering values for the indicated indices for Ukraine are consistent in terms of GCI, IEF, and WUI. If in terms of GCI and IEF Ukraine demonstrates a below average level, then in terms of uncertainty – it has the average level for the studied period.

The smallest level of the countries' crossings within a cluster is observed with WUI. The absence of one or another characteristic of the cluster by other indices initially implies a deviation of the values of composite indicators from the normal distribution.

Ensuring and verifying the normal distribution of the results obtained is always related to choosing a measurement scale. Determining the type of data obtained and the list of operations that can be performed with this data, the applied measurement scale solves the problem of measurement quality.

The main idea of international indices is the ranking of objects. The ranking can be made using ordinal scales.

The peculiarity of the measurement procedure using ordinal scales explains the situation in Table 1 – the presence of uneven sensitivity to a property, which is measured within different boundaries in the process of its estimation.

Based on the fact that the structure of any data set is dynamic, we determine the structural shifts by groups of countries based on the characteristics of a cluster (Di) and the degree of coincidence of countries within the cluster (di) according to the results of cross-clustering (Tab. 2.).

Table 2

Structural shifts of cluster characteristics by international indices

Cluster feature	Year	International Indices							
		GCI		IEF		HDI		WUI	
		$D_{i,}$ %	$d_{i,\%}$	$D_{i,}$ %	$d_{i,\%}$	$D_{i,}$ %	$d_{i,\%}$	$D_{i,}$ %	$d_{i,\%}$
1	2	3	4	5	6	7	8	9	10
Very high Level	2010	14,4	75,0	20,1	30,0	12,3	100	1,4	-
	2019	11,4	93,8	55,6	100,0	15,9	76,7	-	-
High Level	2010	11,5	37,5	24,8	26,3	7,0	46,2	4,1	16,7
	2019	9,2	46,2	16,1	34,5	13,8	23,1	3,5	20,0
Level above the average	2010	21,6	30,0	17,6	51,9	5,9	-	12,6	5,6
	2019	10,6	60,0	32,2	24,1	16,9	-	5,7	12,5
Average Level	2010	-	-	14,4	100	33,2	30,6	20,3	24,1
	2019	22,7	-	-	-	22,2	45,2	21,5	46,7
Level below average	2010	22,3	41,9	17,0	69,2	12,7	8,3	23,1	33,3
	2019	16,3	56,5	33,9	29,5	11,6	9,1	39,2	19,6
Low level	2010	21,6	50,0	10,5	50,0	18,7	40,0	20,3	6,9
	2019	18,5	38,5	12,8	34,8	10,6	70,0	30,1	4,7
Very low level	2010	8,6	75	2,6	25,0	10,2	73,7	18,2	-
	2019	11,3	56,3	1,7	33,3	9,0	82,4	-	-

Source: developed by the author based on [14-18]

The analysis of the data in Table 2 confirms the asymmetry of the distribution of numerical values of international indices taking into account the characteristics of the cluster and its ambiguity over the years. So, in 2010 the relative uniformity of distribution based on the characteristics of the cluster was shown by IEF, HDI, and in 2019 – by GCI, HDI and WUI. As for the structural shifts, taking into account the cross-clustering, the relative uniformity of distribution in years is characteristic of WUI and IEF. While the maximum allowable spread is demonstrated by GCI and HDI. This situation implies an ambiguity in the interpretation of the final values of indices even within the limits of the corresponding characteristics of the clusters.

The assessment of the quality of measurements of international indices is significantly influenced by the opinion of experts. The significance of the problems of using expert methods can be reduced to the consideration of the following provisions:

in order to get reliable conclusions from unreliable sources, it is necessary to correctly formulate questions when conducting surveys;

in determining weights, specialists from different fields of activity demonstrate different styles of problem solving;

in order to obtain aggregate estimates for an international index, it is necessary to mathematically correctly measure the indicators that make up the individual elements of the index.

The most correct measuring of the respondents' attitude to the research subject using the categories of importance, agreement, frequency and quality is provided by the Likert scale. But, being a simple and convenient data collection tool, this scale, even if normalized, does not allow to correctly switch to more powerful interval scales.

It is possible to solve the problem of representing data in ordinal scales as a compromise between the mathematical rigor of the collected data and practical convenience by converting data from the Likert scale into an interval scale – the Rasch model [4].

The distinctive feature of the Rasch model is that it allows tracking the relationship between:

the probability of the correct answer to the question of the questionnaire and the complexity of the question;

the choice of the questionnaire item and the degree of compliance of this item with the real situation.

Both the Likert scale and the Rasch model in terms of frequency responses make it possible to track the weight, i.e. the complexity of the questionnaire items, which is a weighted characteristic in assessing the accuracy of measurements.

In general, accuracy and reliability both depend on the degree of consistency of the answers to the questionnaire and on the price relations when considering economic issues. The averaging of data both in terms of origin and quality of data does not allow taking into account possible relationships between data types, especially their cause and effect nature. Therefore, the validity of the choice of weight characteristics during any study has a significant impact on the size of the error in measuring result indices

In addition, when studying the same phenomenon, composite indicators are often built on repeating data. When averaging, the result index is distorted towards these particular data.

Another problem in constructing international indices is an understanding of the essence and method of measuring their basic components. A different set of constituent elements for constructing an aggregate indicator for a country as well as the absence of one, several or all constituent elements for the time period chosen for comparison significantly affects both the ranking result and the correctness of the assessment of its changes.

Thus, the real accuracy of measurements is always limited, and it is impossible to change accuracy boundaries by processing data. The existing approaches [3] to characterizing measurement accuracy are based on measurement errors and measurement uncertainties. While random and systematic errors are due to the nature of their occurrence and appear during the measurement, uncertainties are largely conditioned by the method of their calculation

Let us track the dispersion of cluster characteristics according to the results of cross-clustering of the considered international indices using the data from Table 1. Based on the fact that the absolute use of the arithmetic mean as a characteristic of the center of distribution of random variables for ordinal scales is not correct, let us determine the deviation of the values of the cluster characteristics in terms of the indices considered, taking into account the median values. This will reveal the influence of the calculation method on the interval of statistical stability of the indices under consideration.

The analysis of Table 3 showed that the boundaries of the statistical stability corridor for the cluster characteristics vary depending on whether the average or median is used. This change is not unique both in terms of the characteristics of clusters and the type of a composite indicator. A greater spread is observed for the countries with characteristics of an average level cluster and below.

WUI determines the opposite trend in cluster characteristics: with a decrease in the level of uncertainty, the spread of standard deviations for the mean and median values is negligible.

Therefore, the use of composite indicators without taking into account the substantive and mathematical rigor of the procedures for obtaining them is not correct for comparing the dynamic patterns in the ranking positions of countries

Table 3

Estimation of the statistical stability of the characteristics of intersecting clusters by the composite scores of international indices

Cluster feature	$\sigma_{\bar{x}} - \sigma_{Me}$			
	International Indices			
	GCI	IEF	HDI	WUI
Very high Level	+ 0,86	- 0,37	- 0,09	-
High Level	- 1,42	+ 0,19	- 0,07	- 0,09
Level above the average	- 2,68	- 0,52	-	+ 0,76
Average Level	-	-	+ 0,05	- 0,53
Level below average	- 3,10	+ 0,46	- 0,08	-0,03
Low level	+ 2,78	- 0,90	- 0,07	+ 0,02
Very low level	- 2,35	- 0,83	+ 0,09	-

Source: developed by the author based on [14-18]

The pace of development of the global economy determines the need for more detailed data. These data should have a high detection rate, a large volume, and, at the same time, be reliable. The combination of traditional and modern requirements for data sources, assessment of their quality is reflected in the IMF Staff Discussion Notes, in particular "Big Data: Potential, Challenges and Statistical Implications" [13]. Big data are usually a by-product that results from business and management activities, using social networks and the Internet.

The main advantage of such data is the ability to crosscheck indicators and more quickly obtain analytical conclusions.

However, indicators based on big data:

are most often poorly structured;

are not aimed at reflecting causal relationships;

exist only for a short period of time;

contain data that do not obey the normal distribution law;

most often are not the result of random sampling.

The appropriateness of using big data in calculating international indices is due to the possibility of early warning of the risk of instability in the development of countries.

A comparative assessment of current requirements for the source information and characteristics of the quality of measurements with regard to big data is presented in Figure 1.

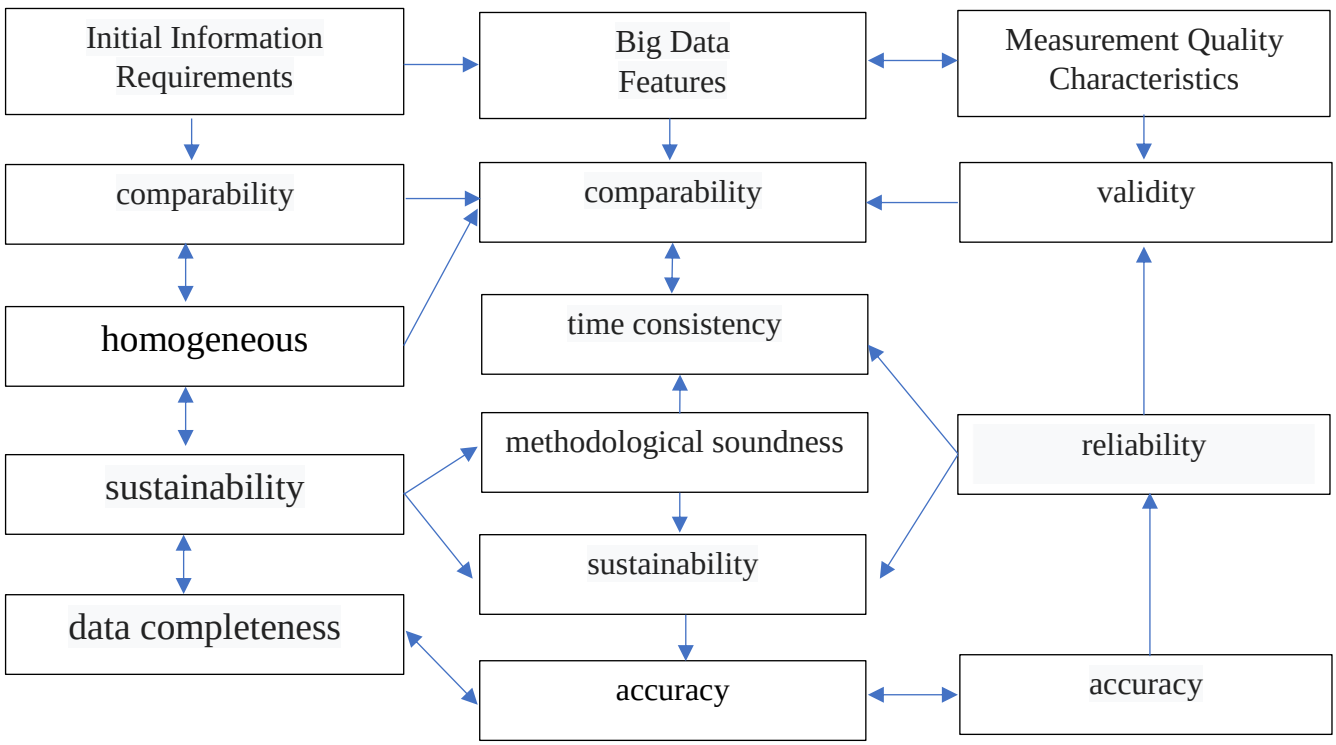

Fig. 1. Scheme of the relationships of general data requirements in the construction of international indices

Thus, obtaining information from several sources and processing it using several methods make it possible to reduce the level of uncertainty and to increase the reliability of estimates in calculating international indices.

Conclusion. The process of globalization of the economy determines using new approaches to assessing its development. To measure the degree of globalization, to evaluate the related changes and the impact on the level of socio-economic development of a particular country, artificial indicators – international indices — are used.

From an economic point of view, these indices should reveal certain dynamic patterns. From the mathematical point of view – they should ensure the correct selection of methods for collecting and processing source information based on the purpose of the study. But, within one indicator, it is impossible to take into account even the general requirements for source data, the rules for their measurement and processing. Therefore, the reality of a pattern revealed based on inaccurate data and, as a consequence, the methods for their calculation are doubtful.

Trends in the development of national economies and, at the same time, the possibility of comparing them are reflect in dynamic patterns.

The use of different data processing techniques in the analysis of international indices confirmed the incorrect use of these indices not only for the process of comparing them across countries but also for tracking dynamic patterns for an individual country.

Data processing techniques have limited possibilities for obtaining reliable results if the data have systematic errors or biases, and the methodology for their measurement and subsequent aggregation is based on subjective characteristics.

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