

ECONOMIC AND MATHEMATICAL MODELING AND INFORMATION TECHNOLOGIES IN ECONOMICS

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DYNAMICS ANALYSIS OF SUSTAINABLE DEVELOPMENT INDICATORS IN UKRAINE

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sustainable development, indicator, index, cluster analysis, model.

The article is devoted to the study of the current state and features of the dynamics of the economic, environmental and social indicators of sustainable development in Ukraine in comparison with other countries. The need for adherence to the concept is linked to the continued economic, scientific and technological development of countries, the rapid pace of urbanization, the depletion of natural resources and excessive anthropogenic interference with the environment. “Global Competitiveness Index”, “Environmental Performance Index”, “Quality of Life Index” and “Index of Economic Freedom” are highlighted as research objects, which describe economic, environmental and social spheres of a concept. As a result of research, a trend model for the social indicator “Quality of Life Index” and forecast for it have been built; a comparative analysis of growth trends across countries has been done for the “Human Development Index”. The authors have constructed a multifactorial model based on data from 180 countries over 20 years (2000-2019) for “Index of Economic Freedom” to make a comparative analysis. That makes possible to count Index for 6 more countries that have not been introduced in the “Index of Economic Freedom” report and create 8 clusters with the help of data mining methods. That affords to highlight the place of Ukraine between other countries, found special country’s characteristics and explore features of the country’s development process. The general conclusions on the state and features of the dynamics of Ukraine in light of the concept of sustainable development have been formulated.

АНАЛІЗ ДИНАМІКИ ІНДИКАТОРІВ СТАЛОГО РОЗВИТКУ В УКРАЇНІ

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Ключові слова:

сталій розвиток, індикатор, індекс, кластерний аналіз, модель.

Стаття присвячена дослідженню стану й особливостей динаміки економічного, екологічного та соціального індикаторів сталого розвитку в Україні порівняно з іншими державами. Необхідність дотримання концепції пов’язана з постійним економічним та науково-технічним розвитком країн, пришвидшеними темпами урбанізації, виснаженням природних ресурсів та надмірним антропогенним втручанням у природне середовище. Як об’єкти дослідження виокремлено важливі індекси – «Global Competitiveness Index», «Environmental Performance Index», «Quality of Life Index» та «Index of Economic Freedom», які характеризують економічну, екологічну та соціальну сфери концепції. У результаті дослідження за рахунок використання трендових моделей для соціального індикатора «Quality of Life Index» побудовано прогноз його значення, а для індикатора «Human Development Index» проведено порівняльний аналіз тенденцій зростання для різних країн. Для проведення порівняльного аналізу динаміки економічного індикатора «Index of Economic Freedom» України з іншими країнами авторами побудована багатофакторна модель за даними 180 країн за 20 років (2000 – 2019 рр.). Це дало змогу визначити індекси ще для 6 країн, що не були відомі раніше, а також за рахунок застосування одного з методів інтелектуального аналізу даних – кластерного аналізу – здійснити групування країн у 8 кластерів, визначити місце України в цьому розбитті та виявити особливості динаміки, що впливають на існуючий стан та зумовлюють напрями удосконалення подальшого розвитку України. Сформульовано загальні висновки щодо стану та особливостей динаміки України у світлі концепції сталого розвитку.

Statement of the problem

Ukraine is moving into a new era of history associated with the Revolution of Dignity and the emergence of the opportunity to build a new Ukraine on the principles of sustainable development, the rule of law, human rights protection, democracy, solidarity, good governance.

Sustainable development is a development that addresses the needs of the present population, without compromising the ability of the future generation to meet their own needs. That is, adherence to the concept meets the needs of today and, at the same time, the needs of future generations [1].

The need for adherence to the concept is associated with the continued economic and scientific and technological development of the countries, an increase in the planet's population, rapid urbanization, depletion of natural resources, and excessive anthropogenic interference with the environment.

All this leads to an active reduction of resources necessary for the normal functioning and satisfaction of current needs of society in the conditions of overpopulation of the planet, environmental pollution and the huge number of facts of unconscious and irresponsible consumption and use of resources.

Considering the detriment, it causes to the planet and the fact that it does not allow the future generations to exist normally, there is a need to find alternative sources and methods of meeting the needs, raising public awareness and promoting the idea of responsible consumption and use.

Analysis of recent studies and publications

Among foreign authors who study various features of sustainable development, it is worth to mention D.N. Meadows and J. Randers [2], who studied the effects of rapid growth of the planet's population, the problems of providing it with the necessary resources, and modelled the consequences of human-nature interaction; J. Forrester [3], whose work is devoted to the study of the crisis of socio-economic and ecological systems presented in the mathematical model of global development; L. Brown [4], whose scientific activity is devoted to the problems of communication between ecology and social development; work [5], which reflects the state of the problem of sustainable development and environmental security at the beginning of the 21st century.

An important challenge for the implementation of the concept of sustainable development in the world was to identify key indicators for assessing its level as a whole and in each area individually. A large number of scientific works of foreign and Ukrainian researchers is also devoted to this problem. Thus, work [6] is devoted to the problem of improving the structure of sustainability assessment by

selecting indicators according to the characteristics of a particular EU country.

The work [7-11] is devoted to the justification of the composition and features of a system of indicators for monitoring the viability of systems and promoting their purposeful sustainable development. The work [12] also attracts attention; it contains an analysis of scientific works of domestic scientists and projects of development of sustainability in cities and regions.

The analysis of existing publications revealed that insufficient attention was paid to the study of the dynamics of sustainable development indicators in Ukraine. Therefore, there is a need to understand the degree of implementation of the concept of sustainable development in Ukraine in the economic, social and environmental spheres and its dynamics in comparison with other countries of the world, which will create conditions for the development and justification of programs for further development of Ukraine.

Objectives of the article

The purpose of that work is to study and analyse the state and features of the dynamics of economic, environmental and social indicators of sustainable development in Ukraine in comparison with other countries.

The main material of the research

Sustainable development is a development concept where the emphasis is shifting from short-term economic benefits to a longer-term approach, where there is a balance between economic, social and environmental considerations [13]. It requires an integrated approach to decision-making related to areas such as the economy, the environment and society. To assess the degree of implementation of the sustainable development concept in Ukraine, let us consider the dynamics of the following indicators: the Index of Economic Freedom, the Environmental Efficiency Index, the Quality of Life Index, and the Human Development Index.

The Index of Economic Freedom is an indicator that has been calculated annually by the Wall Street Journal and the Heritage Foundation for most of the world since 1995. The index is based on 12 factors, which are grouped into 4 categories and are the basis of economic freedom in the world [14]. Property and freedom of investment indicators in the Europe to which Ukraine belongs are leading the world with an average of more than 15 points, at least 10 points ahead in terms of judicial efficiency, business freedom and other measures. However, Europe is struggling with costly labour laws greater than in other countries through tax burdens, the phenomenon of public sector expansion and various market-distorting subsidies. In Fig. 1 presents the dynamics of the Index of Economic Freedom and Ukraine's position among 180 rating countries, 2000-2019 (according to [14]).

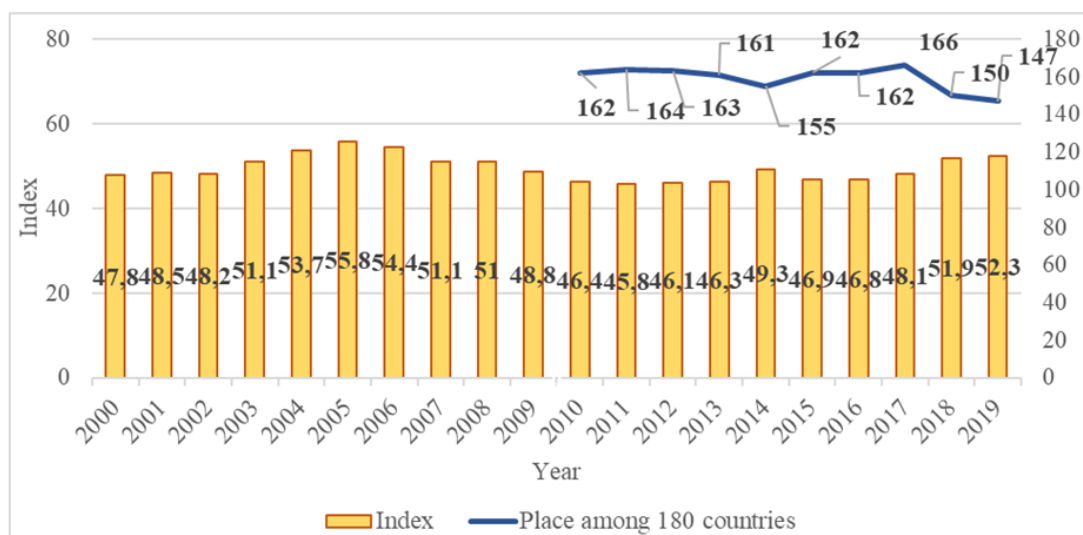


Fig. 1. Dynamics of the Index of Economic Freedom and Ukraine's Position among 180 Rating Countries, 2000 - 2019 (according to [14])

The average value of the index for the period 2000-2019 is 47.94. Since 2016, there has been a positive trend in the growth of the Index and in 2018-2019 it is possible to observe the withdrawal of Ukraine from the list of "repressed" and its transition to "mostly not free" countries. The highest index value was observed in 2005 and the lowest in 2011. The highest growth rates were observed in 2003 (6.01%), 2014 (6.48%) and 2018 (7.9%). The largest falls of the Index are observed in 2007 (6.1%), 2009 and 2010 (4.3% and 4.9% respectively) and 2015 (4.9%).

On the basis of the Index of Economic Freedom data [14], a regression analysis has been performed and a multivariate regression model has been constructed for which R²=0.99 with variables, which are Indices for estimating the overall Index of Economic Freedom:

$$Y = 0,0521 + 0,084x_1 + 0,083x_2 + 0,0834x_3 + 0,0833x_4 + 0,0834x_5 + 0,0833x_6 + 0,0834x_7 + 0,0833x_8 + 0,829x_9 + 0,083x_{10} + 0,0831x_{11} + 0,0834x_{12}$$

where x_1 - property rights, x_2 - efficiency, x_3 - justice and government integrity, x_4 - tax burden, x_5 is government spending, x_6 - fiscal health, x_7 - business freedom, x_8 - monetary freedom, x_9 - monetary freedom, x_{10} - freedom of trade, x_{11} - investment freedom, x_{12} - financial freedom.

The author-built model found indices for 6 other countries not listed in the report [14]: Iraq - 23.9, Syria - 20.6, Libya - 17.09, North Korea - 5.94, Somalia - 5, 53, Liechtenstein - 1.37. Based on the available and supplementary data, cluster analysis has been performed using MS Excel's data mining toolkit and 8 clusters have been identified.

Ukraine is in Cluster 1 – the largest, with 35 countries from 186 (Russia, Azerbaijan, India, Pakistan, Kenya, Brazil, Argentina, Tajikistan, etc.). The characteristics of these countries are presented in Fig. 2.

Index	Meaning	Relative importance
Property Rights	Medium:41,2989182272 - 56,367978528	100
Overall Score	Medium:49,7089950528 - 57,0926595072	64
Monetary Freedom	High:68,1988695808 - 77,5086827392	48
Judicial ectiveness	Medium:39,7967007168 - 51,2424738624	39
Investment Freedom	Medium:44,1516317376 - 60,1653788608	33
Trade Freedom	Medium:64,3916240384 - 77,4483268736	27
Government Integrity	Low:26,531546336 - 35,4893268608	24
Government Integrity	Medium:35,4893268608 - 49,8044384064	24
Business Freedom	High:62,1816566464 - 74,2877822336	10
Monetary Freedom	Medium:58,10061472 - 68,1988695808	6
Financial Freedom	Medium:39 - 55	6
Investment Freedom	Low:17,4699374016 - 44,1516317376	3

Fig. 2. Characteristics of the Cluster 1

Thus, Cluster 1 includes countries with medium and low values for all indicators. High rates include monetary freedom, and business and trade freedom.

Let us move on to the next indicator, the Environmental Performance Index, which is issued every two years [15].

The report presents each country's position among the ranked and the very value of the Index, which in turn consists of the quantitative value obtained by the country into categories that fall into two groups: ecosystem viability and environmental health, and reflects the achievements of countries in the field of natural

management resources and their rational use. The dynamics of the Index for the 6 selected countries and the dynamics of Ukraine's ranking change are shown in Fig. 3.

For the analysed period for Ukraine the lowest positions are in 2018 (109 place) and in 2012 (102 place). The highest position in the rating (44th place) was occupied by Ukraine in 2016 with an index value of 76.69. In 2018, the viability of the ecosystem in Ukraine was estimated at

45.16, while in countries such as Switzerland, Iceland and Norway which occupy one of the leading positions, the figure is 83.32, 65.34 and 63.91 respectively.

In order to evaluate the Quality of Life Index, which in turn consists of such indices as Purchasing Power, Quality of Life, Pollution, etc. and reflects the social sphere of sustainable development, it is worth to consider it in terms of the dynamics of these same components (Fig. 4).

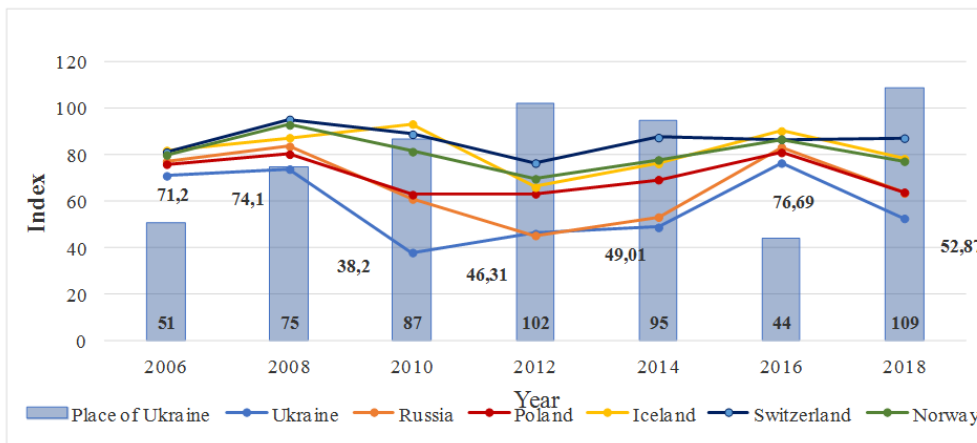


Fig. 3. Dynamics of the Environmental Performance Index and Ukraine's ranking in the ranking, 2006 - 2018 (according to [15]).

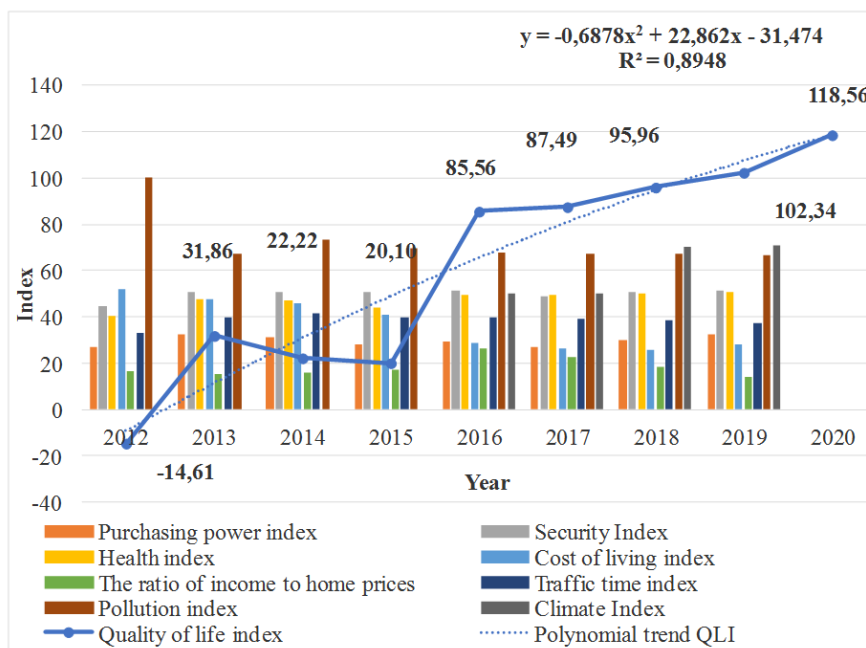


Fig. 4. Dynamics of the Quality of Life Index and its components in Ukraine, 2012 - 2019 (according to [16])

From Fig. 4 it can be seen that there is a tendency to decrease the pollution index from 100.24 in 2012 to 66.63 in 2019. That is, one can speak of a 33.5% decrease in pollution. Since 2015, there has also been a steady increase in the climate index (a positive trend). Cost of living index in 2019 compared to 2012 decreased by 45.9% (positive trend). The purchasing power index is quite low (it ranged from 27.22 in 2012 to 32, 72 in 2019), despite the positive dynamics of its increase, its average growth rate is quite small and is 0.03.

The health and safety index are steadily increasing, indicating a positive impact on the lives of the reform population in these areas. One of the best is the ratio between the price of housing and income, the only

dynamic outlier observed in 2016, which means a sharp increase in housing prices, and at the same time accompanied by a low level of purchasing power and, consequently, a low level of the real wage index of the population.

The value of the Quality of Life Index itself declined in 2014-2015, due to a difficult political situation and armed conflict in the east. Overall, there is a positive trend, with the highest growth rates in 2013 (3.18) and 2016 (3.27). At the same time, there is no positive dynamics regarding the promotion of Ukraine in the ranking. This indicates that despite the process of improving the quality of life within the country, it is slow relative to other countries, which prevents Ukraine from entering higher ranking

positions. Using the polynomial trend model (Fig. 4), a forecast for 2020 is built, according to which the index value will increase to 118.56.

The Human Development Index is a statistical tool used to measure a country's overall achievement in its social and economic dimensions. The social and economic aspects of a country are based on people's health, their educational attainment and their standard of living [17]. Figure 5 shows the dynamics of the Index for the period 1991-2017 for 8 countries, which are also analysed by the Quality of Life Index.

An analysis of the dynamics reveals that for the period 1991-2017, there is a positive trend of increasing the value

of the Index among all countries. Switzerland, Sweden and the United States are leaders in the countries listed. In 2018, these countries have index values of 0.944, 0.933 and 0.924 respectively.

For example, Russia and Poland have higher rates. The chart shows the trend lines for these countries. It can be seen that the dynamics of the Index of Ukraine replicates the dynamics of the Index of Russia. However, the starting value of the indicator for Ukraine and its speed of growth are much lower. The average growth rate for Ukraine since 1997, when there is a constant upward trend, is 0.61%, for Russia – 0.73%.

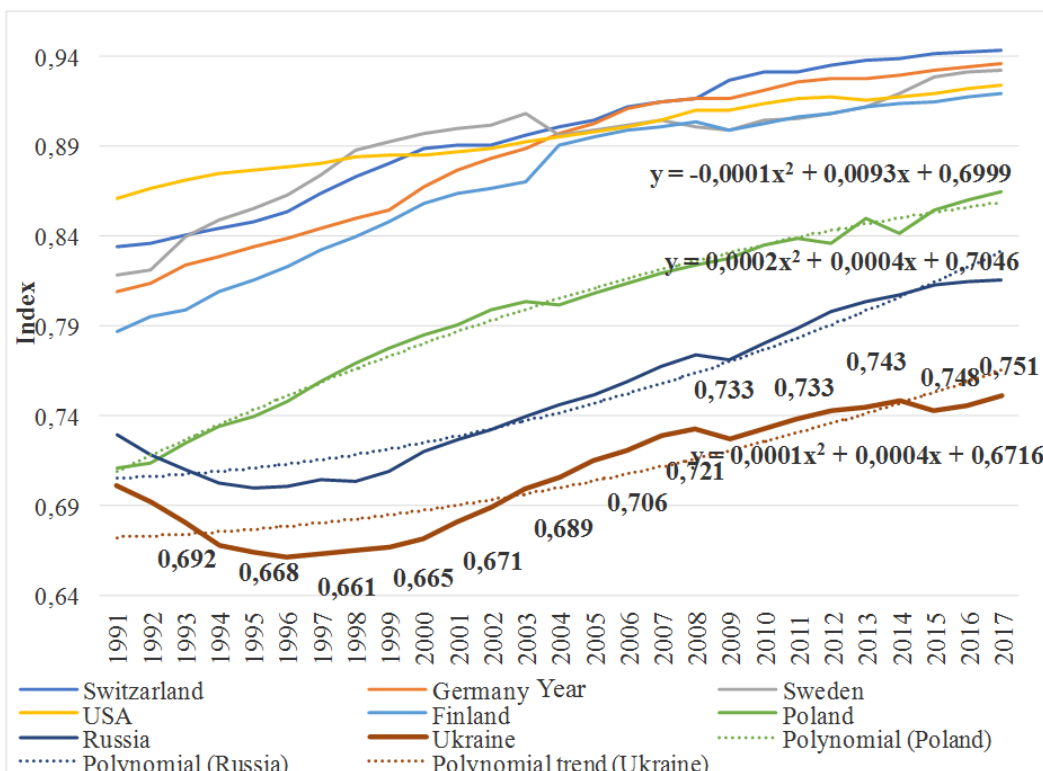


Fig. 5. Dynamics of the Human Development Index, 1991 – 2017 (according to [18])

At the same time, despite the fact that for the USA the starting index for the analysed period is much higher than for Ukraine, the growth rate is on average 0.48%, that is, we can say about the effect of glut: the greater the value, the less the speed of its growth.

Indicators for Ukraine were falling in 2009, due to the global economic crisis and in 2015, due to the difficult political situation in the country, but they were not significant and were equal to 0.6 and 0.5 % respectively. In 2018, the indicator remained at the 2017 level of 0.751, with the country at 88th place. In 2018, life expectancy in Ukraine was 72.1 years, life expectancy at school was 15 years, homicides were 6.3, and Internet users were 52.5% of the population.

Conclusions

Understanding the concept of sustainable development is essential at the present stage of society's development. There is a need for economic, state and technological changes in industry and agriculture, as well as in the world outlook.

Each of the three areas, namely environmental, economic and social, reflects the level of sustainable development of

the country, complementing one another and being closely interconnected. In order to understand the overall picture at the national level, it is worth exploring each area and comparing the indicators with other countries. At the current stage in 2018-2019, Ukraine does not occupy high positions in the ratings on indicators of all spheres.

In 2018, the Global Competitiveness Index ranks 85th out of 141 countries, and in 2018 the Human Development Index ranks 88th out of 189 countries. The Environmental Performance Index ranks 109th out of 180 countries. According to the Quality of Life Index in 2019, Ukraine ranks 62nd among 77 countries. Switzerland, Sweden, Norway, Germany and Iceland are the top leaders in all rankings.

Today, the greatest environmental threats are high forest cover loss and a high risk of potential threats to soil biodiversity. For the economic sphere, the dissatisfaction among the population with the standard of living in the country, inefficient social policy, low level of social payments (pensions, unemployment benefits), which do not provide an opportunity to qualitatively meet the needs of the first and second levels, environmental problems, problems in the field of health care and relatively low life

expectancy. Also, there is the value of the Tax Burden Index (81.8), which slows down the development of small and medium-sized businesses, encourages the population to evade taxes and therefore leads to the shadowing of the economy. For the social sphere, a low real wage index, i.e. low purchasing power and low growth rates by all indicators, is highlighted.

The positive changes include the decrease in pollution and the decrease in the Housing Price and Income Index, the Pollution Index and the increase in the Health and Fiscal Health Index.

For all the Indexes analysed, even if there is a positive tendency to increase their overall and their components separately, at the same time, there is no positive dynamics regarding the promotion of Ukraine in the ranking. This indicates that despite the process of improving the quality of life within the country, economic growth and improvement of certain environmental indicators, the introduction of the concept of sustainable development and growth of Ukraine in the ratings relative to other countries are much slower than other countries, which prevents Ukraine from entering higher ranking positions by all indexes.

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