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CONCEPTUAL PROVISIONS OF ECONOMIC COMPLEXITY IN THE SYSTEM OF INNOVATIVE THEORIES: DETERMINANTS, ECONOMIC MODELS, INDICATORS

Summary. The article proposes and substantiates conceptual provisions for economic complexity, which are based on a systematic approach to its main components: indicators, methods and models, the main determinants. Economic complexity is one of the most common scientific concepts in economics, which characterizes innovative countries with diversified products. The main advantage of economic complexity is that it is interconnected and closely linked to such important macroeconomic categories as inequality, employment, environmental lag, added value, shadow economy, and economic growth. The relationship is formed on the basis of analytically sound methods and models: modified least squares methods FMOLS, DOLS, two-stage system model GMM, Johansen's cointegration approach, structural empirical model of added value of F. Koch. The main analytical indicators that assess economic complexity and are used to form econometric models of the relationship: ECI is the average PCI of goods exported by a country, PCI is the average of ECI countries that export this product, GENEPY is used to track economic growth countries in time. The main determinants of economic complexity, which are formed and substantiated in the work: economic complexity is defined as the basic basis of many phenomena and processes in the economy; specialization and diversification are complementary categories in the concept of economic complexity; complex systems tend to be unequal, ie economic complexity creates processes of inequality in the world economic system; significant differences in the values of indicators of economic complexity can affect the destructive processes of capitals in the global world.

Key words: economic complexity, added value, shadow economy, economic growth, models, determinants, indicators.

Problem statement. Modern conditions of economic growth are considered as a multifaceted process of formation of an innovative product and the development of its complex structure in order to obtain an export competitive advantage. Eventually, this theory became widespread in scientific community and was transformed into the economic complexity of a country's export potential. Economic complexity offers a potentially innovative concept of explaining the socially significant problems of contemporary, and is that growth and innovation change, poverty and stratification, structural imbalances, adaptability and security are the basis of hidden transformational and systemic interactions. The study of economic complexity is aimed at revealing the essence of the structure of these interactions and identifying their socio-economic processes. The concept of economic complexity is innovative, and economic research in this area is still quite limited. For example, the systemic components of the concept of economic complexity still remain unexplored in scientific publications.

Analysis of recent research and publications. The following scholars have made a significant contribution to the development of theoretical and methodological foundations for the formation of economic complexity: W. Brian Arthur, Muhammad West Rafik, Abdul Majid Nadim, Wanjun Sia, Majid Ikram, Hafiz Muhammad Shoaib, D. Hartmann, M.R. Guevara, K. Hara-Figueroa, M. Aristarn, K. Hidalgo, A. Lapatinas, H. Seperdoust, S. Zamani Shabhane, R. Hausmann, Pierre-Alexander Ballan, Tom Brookel, Dario Diodato, Eliza Giuliani, Neve O'Clare, David Rigby et al.

Despite the significant scientific achievements of scholars, to date there are no common conceptual provisions of economic complexity, which should be formed on an integrated systems approach and allow to identify the main determinants, indicators, methods and models of the research area.

Purpose of this work is to substantiate the conceptual approach to economic complexity, which is based on a systematic approach to its main components: indicators, meth-

ods and models, the main determinants. To solve this goal, the following tasks are substantiated: key theoretical foundations and principles of economic complexity are generalized; the main tools and indicators developed in the scientific literature on economic complexity are considered; the ultimate goal is to identify a conceptual approach based on a systematic consideration of the main components of economic complexity.

Results of the research. Economy that is always under the influence of macroeconomic laws of equilibrium and in the constant transformation of institutions, mechanisms and technological innovations. All these changes form a new direction of economic science – economic complexity. The main paradigm in this area was research at the Santa Fe Institute, which revealed and substantiated the following fundamental questions: What is economic complexity? Will it be part of neoclassical economic theory? What logical processes apply to economic complexity?

From the point of view of Brian Arthur, complexity is not a theory, but a flow that in various sciences studies how interacting elements of a system create common patterns, how these common patterns, in turn, cause changes or adaptations of elements. It may explore how individual cars move, jointly forming patterns of behavior in traffic jams, and how these models, in turn, lead to a change in the position of cars. The approach in terms of complexity explains the process of formation of structures – and even how this formation affects its objects [1].

From the beginning, economists tried to make complex economic development simpler and clearer, and then tried to use this power to achieve results. Their result is aimed, in most cases, at keeping the economic system under control, eliminating cycles, creating enough jobs and, ultimately, building a just society in which people could live in peace and harmony with each other and with nature [2, p. 35].

The group of authors D. Hartmann, Miguel R. Guevari, Christian Hara-Figueroa claim that economic complexity is the main inverse factor to income inequality and this relationship, which is established through multidimensional regression analysis, is the basis for monitoring total income, economic institutions, human capital and exports of goods. The authors have proposed an indicator that helps to establish the relationship between the product and income inequality. Researchers use this indicator in conjunction with a network of related products to illustrate how new product development correlates with changes in income inequality. The results show that economic complexity includes information about the level of economic development and is related to the ways in which the economy generates and distributes its income. Moreover, the production structure of the country may limit the range of income inequality [3, p. 76].

H. Sepehrdust and Z. Shabkaneh believe that innovative development, formation of revolutionary technologies and formation of human capital are the key to economic growth. In their opinion, basic and applied research is the main indicator of product and logistical innovations of the country, and the level of knowledge of the country correlates with the types of products produced in the country. The authors determine that the more knowledge and revolutionary innovations, the more diversified the production structure of the country's goods [4, p. 151].

According to the research of K. Hidalgo and R. Hausmann, economic complexity means the production potential of any economy that has a specific structure of the economy and energy consumption, has a specific impact on the environment. The authors believe that economic complexity is a system of knowledge that society uses to build the pro-

duction structure of the economy. According to the authors, economic development is conditioned by knowledge and occupies the position of an accurate predictor of growth, it has close ties with environmental conditions and more complex economy provides a platform for knowledge-intensive production structure and environmental protection through the introduction of knowledge and technology [5, p. 312].

As countries continue to evolve in science, technology and culture, they are constantly raising standards to the point where they are gaining global markets, introducing their new knowledge and technologies in the transnational arena. The application of knowledge and best practices in technology is a key approach to the development of society. One of the indicators that has successfully compared countries with the knowledge-based economy and the productivity of all factors of production at the international level is the indicator of economic complexity. According to the algorithm for calculating the index of economic complexity, the amount of knowledge and productivity factors of economic entities of all countries directly correlates with the types of export policy [6].

The ECI index and PCI metric are fundamental indicators of measuring economic complexity. Annual data on these indicators are published on the official resources: The Atlas of Economic Complexity and the Observatory of Economic Complexity [7; 8]. The logical basis of these indicators is to reflect the complexity of individual products and countries, which is based on the global structure of exports. The fact is that innovative products with complex technologies have a low prevalence and in most cases are distributed in a diversified trade, this is the main algorithm for calculating indicators. PCI is an indicator that is calculated based on a two-dimensional network of products and countries using the reflection method. A country is complex, according to the ECI, if it produces a lot of products, especially those that have a low ubiquity. The final ECI value is the average PCI of the goods exported by the country, and the PCI is the average ECI value of the countries that export this product.

A. Takcella and M. Christelli argue that the complexity of a product cannot be calculated as the average complexity of the countries that produce it, because countries with high economic complexity produce almost all products, and countries with low economic complexity produce only low-quality products. Using sophisticated analytics, the authors criticize the calculation approach and suggest improving the ECI by introducing the concepts of «exporter of fitness» and «product quality» based on an iterative scheme that assigns lower weight to exporters of fitness when assessing product quality [9, p. 683].

A group of authors C. Schiarra, G. Chiarotti, L. Ridolfi, F. Laio formed the GENEPY index to assess economic complexity, it differs significantly from the existing ones. The GENEPY index arises from the eigenvectors of a symmetrical proximity matrix describing the similarities in countries' export baskets. Moreover, the multidimensionality of the approach can be used to track the process of economic growth of countries over time [10, p. 3].

Many models have been built and applied in practice with indicators and characteristics of economic complexity. Most of them use such categories as: inequality, poverty, employment, health, eco-destructive impact, value added, economic growth, shadow economy. Even the Internet and gender politics correlate with economic complexity and affect its indicators. Let us consider in more detail the most significant models.

It is worth noting the work of Can Phuc Nguyen, who insists that the four main dimensions of gender inequality

(employment, health, education, law) contribute significantly to the formation of economic complexity, what is analytically justified using a two-stage system-GMM approach. As a result of a study of panel data from 119 countries (from 1991 to 2017), a pattern was found: unemployment and self-employment of women, optimal health, gender equality in education, empowerment of women in terms of socio-economic and political rights are positive factors of economic complexity. Also, the author, reflecting the geography of economic activity, argues that economic complexity has a significant impact on the reduction of the shadow economy. The study was conducted on the basis of a panel method using data from more than 115 countries with three samples (countries with high, middle and low income), as a result, a pattern was formed of the influence of economic complexity and exports of innovative goods on reducing the shadow processes of high-income countries and reverse processes of countries with low incomes [11; 12, p. 211].

Wanghai Yu, Yue Zhang, Chien-Chang Li conducted a similar study, but the category of influence on economic complexity was eco-destructive ecological condition. The aim of this study was to investigate the causal relationship between economic growth, economic complexity and CO₂ emissions using panel data from 95 countries over the period 1996–2015. (Granger's new panel approach was used). Economic complexity in high- and middle-income countries can effectively reduce CO₂ emissions, and CO₂ emissions may significantly increase economic complexity. The reverse trend will be observed in low-income countries, where the economic complexity of goods will significantly reduce the level of GDP [13, p. 113].

A group of authors led by Muhammad Zahid conducted a research on the impact of destructive processes (ecological footprint) on economic complexity with a large coverage of time series (data from 10 countries from 1980 to 2017 were used). The study aims to explore the relationship between economic complexity, human capital, renewable energy production, urbanization, economic growth, export quality, trade, and environmental impact based on panel data evaluation based on fully modified FMOLS, DOLS, and long-term system-GMM evaluation. The scientists concluded that: economic complexity, economic growth, export quality, trade and urbanization increase the ecological footprint; human capital and renewable energy production help reduce environmental impact; investment in more renewable energy production and consumption, and efficient use of human capital, will improve economic complexity, export quality, and the environment in developed and developing countries [14, p. 4658].

José Miguel Natera and Fulvio Castelacci created a dynamics model with a breakdown of economic complexity into categories (transformational complexity (TC) and systemic complexity (SC)) based on time series data from 134 countries over the period 1970–2015. and is based on Johansen's cointegration approach. The authors argue that transformational complexity is positively correlated with GDP per capita growth over a period, while systemic complexity is positively correlated with the level of GDP per capita at the end of a time period. The results show that there can be different paths to achieve a high level of economic complexity and economic growth, depending on the core set of capabilities that each national system has and is able to develop over time, from the amount of taxes in the country to structural changes in the sectoral composition of the national economy [15].

From the point of view of Philipp Koch, in the economic literature, economic complexity is usually estimated based

on the structure of the economy's gross exports. However, in times of increasingly integrated global value chains, gross exports can give an inaccurate indication of a country's economic performance, as it also includes foreign value added and double counting exports. Thus, Philip Koch proposes a new empirical model for assessing economic complexity based on the structure of a country's value-added exports. This approach leads to a significant change in the difficulty rating compared to the established indicators [16].

Athanasios Lapatinas argues that the implementation of policies that expand Internet access accelerates the productive capacity and complexity of the economy, as shown by his model. In addition, by combining two scientific directions on the relationship between the Internet and economic development and the relationship between economic complexity and economic development, this study of the author improves the developed methodology of economic complexity, and shows that the direct positive impact of the Internet on economic growth is accompanied by an indirect effect by increasing complexity of product. In addition, this study introduces another determinant that may increase the complexity of the economy [2].

Thus, it is possible to form the main determinants of economic complexity, as one of the innovative concepts of the modern globalized world:

- economic complexity is defined as a complex multi-dimensional concept that correlates with most strategically important categories: inequality, poverty, employment, health, environmentally destructive impact, value added, economic growth, shadow economy;

- specialization and diversification in the concept of economic complexity become complementary concepts and are considered on two different scales: the specialization of people, cities, firms leads to the diversification of countries;

- one of the adverse effects of growth and concentration of economic complexity is the growth of inequality. By nature, more complex systems also tend to be more unequal: attachment, compounding, self-reinforcing feedback loops, and multiplicative processes inherent in complex adaptive systems reinforce inequality;

- countries with a significantly diversified structure of goods have a huge baggage of intellectual capital and revolutionary innovations, which in turn affects the deformation of the capital structure of the global world.

Summary. It should be noted that in the modern conditions of the development of economic science, new concepts and theories are emerging that allow us to view the state of the national economy in a different way, one of them is economic complexity. Economic complexity can be defined as an economic scientific concept that shows manufactured products in terms of the structure of intellectualization and innovative growth, and is the basis for controlling total income, economic institutions, human capital and export of goods. The fundamental and scientifically recognized indicator for measuring economic complexity is the ECI index and the PCI metric. Data based on these indicators is published on official resources: The Atlas of Economic Complexity and The Observatory of Economic Complexity. Economic complexity is a concept that correlates with most scientific categories (inequality, poverty, employment, health, environmentally destructive impact, value added, economic growth, shadow economy), thus forming its strategically important determinants.

In conclusion, it can be stated the conceptual provisions of economic complexity that have been formed, which were based on a systematic approach to its main components: indicators, methods and models, and the main determinants.

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КОНЦЕПТУАЛЬНІ ПОЛОЖЕННЯ ЕКОНОМІЧНОЇ СКЛАДНОСТІ У СИСТЕМІ ІННОВАЦІЙНИХ ТЕОРІЙ: ДЕТЕРМІНАНТИ, ЕКОНОМІЧНІ МОДЕЛІ, ІНДИКАТОРИ

Анотація. В роботі запропоновано та обґрунтовано концептуальні положення економічної складності, які засновані на системному підході до основних її складових: індикаторів, методів та моделей, основних детермінантів. Економічна складність пропонує потенційно інноваційну концепцію пояснення соціально значущих проблем сучасності, і полягає в тому, що зростання та інноваційні зміни, бідність та стратифікація, структурні диспропорції, адаптивність та безпека є базою прихованих трансформаційних та системних взаємодій. Вивчення економічної складності спрямоване на розкриття сутності структури цих взаємодій та виявлення їх соціально-економічних процесів. Економічна складність є актуальною, тому що є однією з найпоширеніших наукових концепцій в економічній науці, яка характеризує інноваційно активні країни з диверсифікованими продуктами. В роботі розглянута основна перевага економічної складності: цільний зв'язок з найважливішими макроекономічними категоріями (нерівність, зайнятість, екологічний лаг, додаткова вартість, тіньова економіка, економічне зростання). Обґрунтовано методи та моделі економічної складності: модифіковані методи найменших квадратів FMOLS, DOLS, двоетапна системна модель GMM, підхід коінтеграції Йохансена, структурна емпірична модель додаткової вартості Ф.Коха. Розглянуті основні індикатори, які оцінюють економічну складність та використовуються для формування економетричних моделей взаємозв'язку: ЕСІ – це середній РСІ товарів, які експортує країна, РСІ – це середнє значення ЕСІ країн, що експортують цей продукт, GENEPU – використовується для відстеження процесу економічного зростання країн у часі. Запропоновані детермінанти економічної складності: економічна складність визначається як базове підґрунтя багатьох явищ та процесів в економіці; спеціалізація та диверсифікація є комплементарними категоріями у концепції економічної складності; складні системи мають тенденцію бути нерівними, тобто економічна складність породжує процеси нерівності в світовій економічній системі; значні різниці в значеннях індикаторів економічної складності можуть впливати на деструктивні процеси капіталів глобального світу.

Ключові слова: економічна складність, додаткова вартість, тіньова економіка, економічне зростання, моделі, детермінанти, індикатори.