Assessment of the Economy Structural Changes Based on the Consistency

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Abstract. This article deals with the assessment of the structural changes of the national economy of Ukraine, which proposed to implement by applying the integrated index of structural changes, assessment of the structural changes of the sectoral structure of GDP, at determining the weighting coefficients and construction which uses the "golden ratio" rule. This approach is based on the theoretical completion of the economics as for the progressive development and transformation of society and the economy of the country according to the technological criterion, as well as the sectoral division of the national economy. The choice of components of the integrated index for structural changes is due to the sectoral division of GDP into industry, agriculture and services, and further distribution according to the sectoral structure of the national economy. The proposed integrated index reflects the consistent (ideal) GDP structure inherent in the post-industrial economy, while the deviation of the values in the real structure shows structural changes in the national economy of Ukraine and 28 countries of the European Union. The research justifies the weighting coefficients for the selected sectors of the economy, depending on the technological complexity of the process of producing goods (works, services). The article deals with the results of the calculation of the integrated index of the structural changes in the sectoral structure of GDP and its structural elements, as well as the analysis of the reasons for the deviations of real indicators from the consistent ones. The calculations show the crisis phenomena in both the Ukrainian economy and the EU countries, which are explained by the debt crisis in the EU in 2013 and the release of the UK with the EU. The domestic economy shows significant deviations in virtually all sectors, indicating a low level of economy, a non-conformity between supply and demand in the labor market, a low level of innovation, and the inertia of transformational processes in the transition to the post-industrial stage of production. The application of the proposed methodology

will allow us to identify strategic directions for the development of sectors of the national economy and develop projection scenarios

1   Introduction

In the conditions of post-industrial economy, globalization transformations and informatization of society, there is a significant change, firstly, of the nature of labor, where intellectualization and the ability to work with large volumes of information are at the top, and secondly, the division of production activity by the sectoral principle being the basis for the new intellectual and creative sector, and thirdly - the change of the vector of satisfaction of material needs to the cultural and personal [1], and hence the change of the person's motivational complex [2]. As a result of these processes, structural changes in the economy are observed, which in turn requires the development and implementation of a methodology for evaluating structural changes in order to reduce their negative impact, developing scenarios for the development of the national economy and the satisfaction its needs by highly qualified specialists. On that basis, it became necessary to realize this research.

The terms "structure" and "structural changes" are widely used in the economics of foreign and domestic scholars, although they give them different definitions and interpretations. In researches on economic development and economic history, structural changes (changes) are usually understood as "... mechanisms of production activity in the national economy and the distribution of the inputs between sectors of the economy, professions, geographic regions, product types, etc. ..." [3, p. 76].

The concept of structural changes directly relates to the definition of models for the development of the national economy, one of which is sectoral, it reflects the progressive development and transformation of society and economy according to the technological criterion. By the definition of A. Chuhno specified model is based on the separation of sectors of the economy and the establishment of regularities in changing the structural relations between them, and the prevailing role of a particular sector at a particular stage of socio-economic development [4, p. 73-83].

Proceeding from the postulates of the theory of post-industrial society, each of the sectors of public production dominates at a particular stage. According to A. Chuhno, "In the post-industrial society, the sphere of services is dominant, and industry and agriculture (material production), while preserving and even increasing production volumes, occupy an entirely ratio" [4, p. 83]. According to L. Sergeeva, any structure is an inertial component of complex socio-economic systems, which is also economic, it determines the scenarios of its development in the long-term perspective and allows to create strategic directions of its development [5].

A lot of works are devoted to the analysis of structural changes in the economy, in particular, in the work of S. Kuznets, the redistribution of capital from agriculture to industry, and then to the sphere of services is investigated. He recognizes the

productivity and profitability of capital and labor [6]. Structural changes and their consequences, as well as prospects for the development of the national economy, are researched in the works of foreign authors – V. Inozemtceva [2], S. Glazieva [7], and Ukrainian authors, namely – V. Heiets [8], A. Chuhno [4], L. Sergeeva [5], O. Kuzmin [9], O. Pyroh [10], I. Pasinovych [11].

The bulk of the researchers relies on statements about the relationship between technological change and structural changes. In the article I. Pasinovych examines the cycle of structural development of the Ukrainian economy and substantiates the existence of structural changes as a mandatory stage, defines them as a change in the proportions of the structure arising as a result of the accumulation of structural changes [11, p. 83]. A. Kramarenko proves that there is a correlation of technological and economic development, as evidenced by the development of civilization is the UK economic system based on scientific and technological progress and definition of driving and leading industries. The author argues that after analyzing the tendency and changes in the economic structure, it is possible to predict the directions of further progressive development of national economies [12]. N. Pogorzhelskaia concluded that the sustainable development of socio-economic systems is determined by the tendencies of structural transformations of the economy under the influence of technical and technological potential, as well as the correlation between the genesis of technological patterns and patterns of structural development, taking into account the shallow water theory [13].

Sufficient attention in the scientific developments of domestic researchers is devoted to the analysis of structural changes in certain industries of the economy, namely: O. Kyrychenko, on the basis of analysis of world trends of industrial structural changes, concludes that their main directions are connected with the development of high-tech industries, the latest telecommunication technologies and expansion assortment of services for business and society [14, p. 30]; the authors' research is devoted to the problem of structural transformation of employment in Ukraine in the areas of economic activity [15], it revealed significant negative deviations in the structure of employment from the EU, which is explained by the backwardness of the domestic economy by technological indicators and ineffective state policy. In the article of H. Miliutin it was found that the structural changes in energy and electricity generation in Ukraine in 2000-2016 were low, with the most structural changes in power and electricity output for the analyzed period occurred in renewable energy sources, and a significant negative structural change is in the production of electricity at thermal power plants, which is explained by outdated and power generation technologies [16].

In relation to the research of the sectoral model of the development of the national economy in conditions of a post-industrial society, we should highlight the work of O. Kuzmin and O. Pyroh. They proposed an economic and mathematical model that takes into account the structural and technological requirements of the post-industrial stage of the development of the world economy, as well as predicted a sectoral model of the development of the national economy for the long-term period to achieve the level of development of the EU-27 and Poland, according to which Ukraine should increase the ratio of quaternary and quinary sectors in reducing the primary and tertiary sectors [9].

Consequently, structural changes mean changes in the sizes of the sectors of the national economy, as evidenced by such macroeconomic indicators as the structure of GDP and employment, the level of technological productivity of the industry (the percentage of high-tech, medium and low technological production), innovation of the economy, etc.

However, despite such a powerful array of scientific achievements in this regard, significant gaps in our opinion, is the lack of modern techniques of reasonable assessment of structural changes in the national economy in that sectors that will allow Ukraine in the future to move to a higher level of technological complexity and to solve the problem of forming the labor market structure that corresponds to the post-industrial stage of the national economy.

2   Research Methodology

The methodological basis for the assessment of the structural changes in the national economy of Ukraine is based on the rules of mathematical consistency, namely the "golden ratio", which allows to determine the "ideal" structure and calculate its deviations. Such an approach is proposed by a team of authors [17] and L. Sergeeva [5]. They indicate that deviations from the consistent structure lead to the emergence of specific structural risks and crisis phenomena. The author [5] determined by the consistent structure of the economy, which characterized the post-industrial stage, in the following proportion: services sector (which dominates in the structure) – 62 %, industrial sector – 24 %, agriculture – 14 %, which determined the basic coefficients in the integrated index of the assessment of the changes in the sectoral structure of GDP by the three-sector model.

In the formalized form, according to the classical approaches of the theory of post-industrial society and the "golden ratio" rules, it has next form:

$$S_{GDP} = \left|0{,}62 - S_{Serv}\right| + \left|0{,}24 - S_{Ind}\right| + \left|0{,}14 - S_{Agr}\right|, \qquad (1)$$

S_{GDP} – valuation of integrated index ($0 < S_{GDP} < 1$);
S_{Serv} – share of service sector in GDP;
S_{Ind} – share of industry in GDP;
S_{Agr} – share of agricultural industry in GDP.

But, given the current state and trends in the development of world and national economies, scientists also distinguish a five-sector model [4, 8-10]. Therefore the detailed structure of the integrated index based on the technological complexity and intensity of production, using the rules of the "golden ratio" is proposed:

$$S_{GDP} = |0.24 - S_{4.1}| + |0.14 - (S_{4.2} + S_{4.3})| + |0.15 - (S_{5.1} + S_{5.2} + S_{5.3} + S_{5.4})| +$$
$$+ |0.09 - (S_{5.5} + S_{5.6} + S_{5.7} + S_{5.8})| + |0.15 - S_2| + |0.09 - S_3| + |0.09 - S_{1.1}| + |0.05 - S_{1.2}| \qquad (2)$$

where S_{GDP} value of integral index ($0 < S_{GDP} < 1$).

Designation of sector quota in GDP:

S_1 – agriculture, forestry and fisheries ($S_{1.1}$), mining and quarrying ($S_{1.2}$) – a sector

related to the production of raw materials for other industries;

S_2 – processing industry ($S_{2.1}$), production and supply of electricity, gas, steam and air conditioning ($S_{2.2}$); construction ($S_{2.3}$) – industries that convert raw materials into ready-to-use product (commodity);

S_3 – water supply, sewage, waste management ($S_{3.1}$); wholesale and retail trade ($S_{3.2}$); repair of motor vehicles and motorcycles ($S_{3.3}$); transport, warehousing, postal and courier activities ($S_{3.4}$) – a part of the service sector that is not related to the production and use of intellectual capital;

S_4 – information and telecommunications ($S_{4.1}$); financial and insurance activities ($S_{4.2}$); real estate transactions ($S_{4.3}$) – a part of the service sector that requires the provision of highly qualified specialists capable of producing an intellectual product of high quality;

S_5 – professional, scientific and technical activities ($S_{5.1}$); public administration and defense ($S_{5.2}$); education ($S_{5.3}$); health care and social assistance ($S_{5.4}$) – a part of the service sector S_5, which provides activities for the production, processing and dissemination of knowledge; administrative and support services ($S_{5.5}$); compulsory social insurance ($S_{5.6}$); art, sports, entertainment and recreation; ($S_{5.7}$) provision of other types of services ($S_{5.8}$) – a part of the service sector S_5, which performs functions of supporting the activities of economic entities and cultural and creative components of life and personality development.

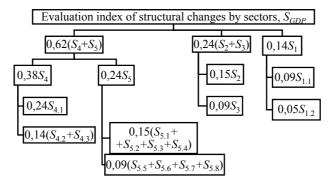The visually detailed consistent structure of the index highlights in Fig 1.

Fig. 1. Consistent structure of the integrated index of the assessment of changes in the sectoral structure of GDP.

In determining the integrated index of the assessment of changes in the sectoral structure of GDP, it should be taken into account if this index $S_{GDP} \rightarrow 1$ indicates that the structure of the sectors of the national economy does not correlate with the consistent structure as much as possible, and if $S_{GDP} \rightarrow 0$, then the structure is harmonious. The base factors used in formula (2) have the following justification: the service sector S_4 consists of indicators of economic activity, such as information and telecommunications, its share is 0.24 as the global development of information and telecommunication technologies is the basis for the emergence of new communications,

programs the processing of large amounts of data, the means of human existence in society, that is, there are qualitative changes in the structure of needs and demand, having a non-material character – recognition in society, self-realization of intellect the intellectual and creative potential of the individual. Regarding financial and insurance activities, as well as real estate transactions, the share of the sectors ($S_{4.2}+S_{4.3}$) is 0.14 because of the fact that with the development of information and communication technologies, the process of providing these services to a significant extent will adopt an electronic form. For example, Estonia has a powerful e-government system – e-tax department (submission and control of tax and customs declarations), e-notary (notary services, documentation, notary accounts), e-depository (central securities register and portfolio management of legal bodies and individuals); e-pension (self-service of individuals: applications, selection and management of funds, reporting), e-receipt (the portal for communication with banks and sellers only) [18].

The share of the part of services of the fifth sector ($S_{5.1}+S_{5.2}+S_{5.3}+S_{5.4}$) related to the knowledge economy is 0.15, because the ability of people to produce and learn new technologies, to develop high-tech products and services leads to new technological developments and occupations. The other component of the sector ($S_{5.5}+S_{5.6}+S_{5.7}+S_{5.8}$) has a share 0.09, because, first of all, the social structure of the economy of developed countries of the EU acquires a social service that allows a person to organize their leisure and protect it in society, and secondly – the receiving of the qualitative diverse services are not included in other sectors.

Relatively to industry, due to the high level of technology development in material production, there is a decrease in the resources needed to support its functioning. That's why the sector S_2 has a value 0.15.

In order to ensure its effective functioning, it is necessary for the development of services related to the development of science-intensive technologies, the latest sources of energy, robotics, etc., as the needs of companies have grown for high-quality business services connected with the diverse and complex problems of their restructuring and development.

Relatively to the utilities industry, trade, repair and maintenance of vehicles, postal services S_3, its share is 0.09, as the development of these parts of economic activities depends directly on the previous ones – the Internet and commercial electronic platforms, the application of artificial intelligence technologies for the provision of certain types of utility and transport services.

In the primary sector, agriculture have top priority $S_{1.1}$ (share 0.09), which is associated with the problem of food security, the development of molecular and biotechnology, and the production of organic products, is a priority for agriculture, which will ensure the ecological and socially balanced development of the agro-industrial complex. Due to the development of alternative energy sources (green technologies, biofuels, wind energy, the sun, etc.), as well as with the exhaustion of natural resources, the share of extractive industry is decreasing, which has led to the allocation of a weighting coefficient of 0.05 to this sector.

Consequently, the proposed integrated index of the assessment of the structural changes in the sectoral structure of GDP, which is constructed in proportion to the «golden ratio», allows state authorities, through the calculation of deviations of

individual objective indicators, to determine strategic directions for the development of promising sectors and creation of the projected scenarios.

3   Research Findings

In accordance with the methodology for the assessment of the structural changes in the sectoral structure of GDP as above, calculations of the integrated index of deviations from the consistent structure for 2010-2017 in Ukraine and the European Union (28 countries) were made. The data of calculations of components of the index and their dynamics changes are given in table 1.

Table 1. Data for calculating structural changes in the economy of Ukraine and the EU (28 countries) over 2010-2017.

Year	Ukraine					European Union				
	S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
2010	0.011	0.068	0.167	0.221	0.026	0.117	0.082	0.081	0.165	0.118
2011	0.031	0.059	0.181	0.232	0.037	0.114	0.083	0.080	0.165	0.117
2012	0.018	0.061	0.162	0.225	0.017	0.115	0.079	0.079	0.163	0.119
2013	0.024	0.040	0.162	0.217	0.009	0.127	0.034	0.004	0.269	0.433
2014	0.034	0.049	0.157	0.219	0.021	0.116	0.078	0.079	0.162	0.121
2015	0.058	0.045	0.157	0.224	0.036	0.119	0.082	0.080	0.163	0.120
2016	0.063	0.054	0.149	0.231	0.035	0.120	0.084	0.079	0.165	0.121
2017	0.051	0.053	0.153	0.236	0.020	0.119	0.086	0.081	0.169	0.121

Source: calculated by the author according to [19-20]

According to the methodology of the assessment of the structural changes in the economy of the European Union, a significant deviation of the integrated index in 2013 (Figure 2) should be noted, in our opinion it is due to the debt crisis in the EU and the fact that this year the UK announced its intention the exit from the European Union, and in 2016 – the Brexit process began, which in the opinion of G. Soros would lead both to the political and economic crisis – the pound fell to its lowest level for more than three decades, the financial markets entered the period of turbulence, there was an outflow of capital and labor from the real economy to the service sector [21].

For the structure of the national economy of Ukraine there is a significant deviation of the components of the integrated index S_3 and S_4 over 2013-2017. Since S_3 is the service sector, not related to the production and usage of intellectual capital (water supply, sewage, waste management, etc.), it should be noted that for Ukraine its state significantly deviates from the values of the index of the ideal structure during the investigated period. Firstly this is a outcome of the ineffective functioning and usage of outdated technologies, equipment in the system of centralized water supply and drainage, this industry needs to be re-equipped and carried out of restoration works. And secondly, such services as trade, move from classical to e-business, and therefore require very different resources (not shopping areas, but internet platforms, non-sellers,

and universal consultants (which can be replaced by special programs in the future), as well as, for example, logistics specialists – to develop the best routes for delivering goods in order to reduce overheads, specialists in site development and product rendering, etc.). That is, the prospect of the development of this service sector is the diversification of the methods of providing services using modern technologies.
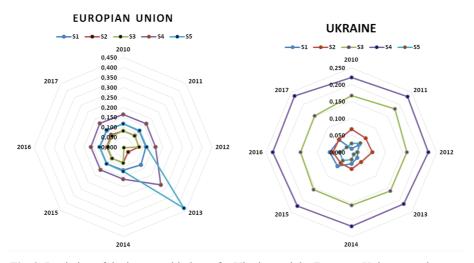

Fig. 2. Deviation of the integrated indexes for Ukraine and the European Union countries over 2010-2017. *Source*: calculated by the author according to [19-20]

The maximum deviations of the structure in Ukraine over 2010-2017 are also observed in the sector S_4, which indicates that the domestic economy needs the provision of this sector by highly skilled specialists capable of producing an intellectual product of high quality – that is, there is a demand for specialists of certain specialties, and a training institute such personnel practically does not take into account the future needs of the market, releasing specialists, the demand for which will be practically absent in the future. That is, the higher education works with the "lag" from the needs of the post-industrial economy. It should be noted that for the European Union, sectoral deviations for S_4 are significant during the research period as compared to others, also there is a similar tendency for these industries to attract additional investment and regulatory influence from the state (EU governing bodies) for their development. The smallest deviations of the integrated index for the EU countries illustrate S_2 and S_3 (0.0179-0.081), which are the reflection of effective measures to develop high-tech and green technologies, artificial intelligence and other high-tech industries. Regarding the Ukrainian economy, the primary sector is the least deviation, due to the inertial effects of the sectoral structure, as well as the sector S_5 whose development is provided with high scientific and technical potential of Ukraine.

According to the formula (2) authors calculated the integrated index S_{GDP} for the economies of Ukraine and countries of the European Union (Fig. 3, 4).
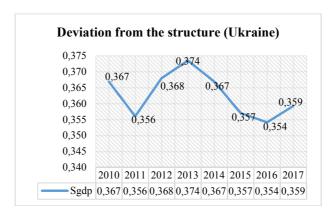
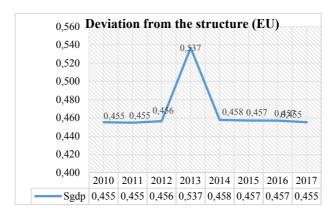**Fig. 3.** Integrated index S_{GDP} of Ukraine.

Fig. 4. Integrated index S_{GDP} of the European Union.

The calculations of the integrated index of the assessment of structural changes in the sectoral structure of GDP showed that in 2011 the Ukrainian economy was negatively affected by the cyclical economic downturn among the countries of the EU, with which Ukraine is tied to close economic ties. In 2013, both in Ukraine and in the EU countries there are significant changes in the structure of GDP, indicating the onset of crisis phenomena, which led to a sharp decline in production and redistribution of capital in the service sector. In other years, the structure of GDP in the EU countries illustrates a steady dynamic, indicating a balanced and gradual policy of the European Union regarding the sectoral development inherent in the post-industrial economy. In the Ukrainian economy, the process of transformation from the industrial stage to the post-industrial is at an initial phase, so there are significant deviations from the consistent structure in almost all selected sectors.

The reasons for the inhibition of this process are the prevalence of low-level technologies in the industry, unfavorable investment climate, political and debt crises, lack of effective policies for the development of medium and small businesses, inconsistencies in labor supply with producer needs, lack of sound public policies and

development strategies for certain industries, etc.

4 Conclusions

The calculations of the integrated index of the assessment of structural changes in the sectoral structure of GDP, which are constructed in proportion to the "golden ratio", and its deviations over a certain period, demonstrate the crisis phenomena that took place in the economic systems of Ukraine and the EU countries at certain period. The trend of structural transformations in the Ukrainian economy indicates a gradual transition from the industrial stage of production to the post-industrial, which in turn leads to a change in the quality of capital and labor. The calculation of the degree of approximation of the existing sectoral structure of GDP to the ideal allows to develop effective scenarios for the development of the national economy firstly, and secondly, to neutralize the negative impact of crisis phenomena and reduce their consequences for the economy and society.

Also, the proposed approach to the assessment of the structural changes in the economy allows the state authorities to determine the strategic directions of development of certain sectors of the economy and to develop projected scenarios by the calculation of the deviations of the individual objective indicators of the integrated index of the assessment of structural changes in the sectoral structure of GDP.

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