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CHAPTER 3

LEVELING BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

ABSTRACT

The chapter accounts for the problem of identification and leveling breaks in the innovative development of socio-economic systems in example of Ukraine in the face of new challenges for the state in the process of developing relations with the EU.

The aim of the chapter is to assess the level of innovation competitiveness of the Ukrainian economy and determine the most important factors for leveling breaks in its innovative development in the conditions of association with the EU.

The analysis of world rankings has shown that the innovative development of Ukraine determines comparative factor advantages in coverage of higher education, availability of scientific staff, and quality of research institutions, but low state support, lack of stability, and problems in institutional development hamper the country's innovative potential. Cluster analysis showed that Ukraine is in the same cluster as Poland. Bulgaria and Romania, which have not yet fully consistent with the level of technological competitiveness of EU leaders. Among the strengths of Ukraine is the development of human resources and labor effect. The correlation analysis between the components of the Global Innovation Index and the factors of increasing Ukraine's competitiveness indicates a moderate link between the development of clusters, the ratio of expenditures on R&D to GDP, and the export of ICT services. In order to level breaks in the innovative development of Ukraine it's necessary: to increase both foreign investments and state financing; improvement of regulatory acts, reduction of corruption, institutional improvement; support of technologies through of regional cluster programs or "smart specialization"; integration into the European Research Area.

KEYWORDS

Breaks in the innovative development, Global Innovation Index, high-tech products, socio-economic systems, EU-27 and Ukraine.

Presently, in a highly globalized and competitive world, technological change and innovation are the basis of the long-term economic growth of any successful country. As a consequence, the

development of economic policy-based countries, based on the development of the scientific, technological, and innovation environment, will contribute to their sustainable economic growth and global competitiveness. At the same time, in the conditions of competition's intensification in foreign and domestic markets for the leading countries of the world, the problem of advanced production technologies' introduction of the XXI century new industrial revolution is substantially aggravated.

In a highly globalized and competitive world, the basis for a country's long-term economic growth is technological change and innovation. At the same time, the core of technological change and innovation is scientific development. In this context, countries should formulate economic policies to develop a science, technology, and innovation environment in society and the economy that will promote sustained economic growth and global competitiveness [1].

Technological readiness is a key element in the growth of each national economy. It is impossible to imagine any aspect of human activity without technological tools. In addition, technology plays a significant role in shaping lifestyles, work, and communication in modern societies. Given this important role in social life and business, the results achieved in technological readiness largely determine the quality of life of citizens and the attractiveness of the economy of a given country. Consequently, the level of competitiveness in terms of technological readiness largely determines the overall competitiveness of a national economy in the global world. These are the main reasons why technological readiness requires special treatment in the formulation of a country's strategic development and why it should be monitored and improved in every national economy that advocates an open development model [2].

Thus, competitiveness now is the ability to manage change and adapt to it through innovation. Achieving and maintaining competitiveness requires a constant increase in productivity and constant adaptation to changes in the economic environment [3].

When change is the only constant, an economy that can attract new ideas, methods, or products faster than others will have an advantage. That is why the use of technological opportunities and innovations can accelerate the growth and development of any economy [4].

According to the European Commission definition, technological competitiveness is the ability of a national economy to generate long-term economic growth, productivity, and well-being, through technological and innovative development. Such development requires an environment for innovation and has the following elements: a high level of education; investment in research and development; and a developed innovative infrastructure, including high-quality research institutions capable of generating knowledge and supporting new technologies; extensive cooperation in scientific and technological development between universities and industry; protection of intellectual property rights, high levels of competition and access to venture capital and finance [5].

The importance of traditional competitive advantages has diminished considerably in the twenty-first century, and it is only through participation in technological competition in the world market that the competitiveness of national economies is now substantially enhanced. According to Holroyd, K., supporting scientific and technological innovation in the long term constitutes the main source of competitive advantage [6]. In most cases, the technological competitiveness of

an economy is described by researchers in the context of the impact of a technological factor on the dynamics of foreign trade, innovative competitiveness or innovative support for industrial modernization [7].

Research is gradually reflecting technological competitiveness in the measurement of the domestic development potential of a country's economy. According to Momaya, K., technological competitiveness is the ability to develop, transfer, absorb, produce, or commercialize technologies to maintain competitiveness [8]. Fagerberg, J. linked technological competitiveness with innovation potential [9]. This is also the position of Cassidy, M., O'Brien, D., who, by technological competitiveness, understand the innovative and adaptive potential of the economy [10]. Howells, J. defines a country's scientific and technological competitiveness as a country's ability to create and retain competitive advantages in the generation, diffusion and application of new knowledge through efficient use, building and modernizing its scientific and technological capacity in the context of globalization [11].

In our view, an approach to analyzing the competitiveness of the economy in terms of technological capabilities suggests that competitive differences among countries arise because of differences in their technological capabilities, that is, their ability to absorb, adapt, and efficiently use technology for development, efficiency and productivity.

By 2030, world-renowned institutions and international industry associations are predicted to be able to launch a revolution in industrial production only by introducing, first and foremost, high-tech industries. The wave of the new industrial revolution will drive the rise of new digital industrial technologies known as Industry 4.0, based on industries such as nanomaterials, 3D printing, genetic engineering, molecular biotechnology, cloud computing, multidimensional modeling, the Internet of Things, and artificial intelligence [12, 13].

Exports of high-tech products are the main indicator measuring technological competitiveness, i.e., the commercialization of research and development and innovation in international markets. It is the development, exploitation, and commercialization of new technologies that are vital to a country's competitiveness in the modern economy. High-tech products are a key driver of economic growth, productivity, and welfare, and tend to be a source of high value-added and well-paid employment [14].

The aim of the study is to assess the level of innovation competitiveness of the Ukrainian economy and determine the most important factors for leveling breaks in its innovative development in the conditions of association with the EU.

3.1 LITERATURE REVIEW

The impact of technological changes and industrial revolutions on the country's international competitiveness is the subject of study by a wide range of foreign economists and analysts. In addition, many well-known scientists offer their own methods for assessing the country's technological

competitiveness depending on the influence of various factors of the macro-environment, as well as the direct impact of export volumes and structure on competitiveness.

In their works, Jonson et al. [15] show that Western European nations, along with the USA and Japan, have been recognized as the most competitive economies in the world. Eastern European countries are generally considered to be lagging. They are examining the accuracy of these descriptions and the prospects for change in the coming decade. Georgia Tech 'High Tech Indicators' (HTI) contributes to the National Science Foundation (NSF) Science & Engineering Indicators. They cover 33 highly developed and rapidly industrializing countries. Our model of technological competitiveness contains four components: National Orientation, Socioeconomic Infrastructure, Technological Infrastructure, and Productive Capacity that promote 'Technological Standing'. They present indicator values, derived from survey and statistical panel data, for 13 European nations (plus the USA as a benchmark), for 1993–2005, and draw inferences about future high tech competitiveness. We are witnessing limited technological progress in the Eastern European States. The outlook for Europe is somewhat uncertain, given the sharp increase in competition from Asia.

Porter et al. [16] showed that the Georgia Institute of Technology, with the support of the National Science Foundation, had completed a decade of developing national high-tech competitiveness indicators. This chapter reports on the standing, emphasis, and rate of change of high-tech competitiveness for 28 nations. Results show strong standing for the '4 Asian tigers', comparable to many Western European countries. Their five '6 Asian Cubs' are experiencing rapid growth in high-tech production and export opportunities; the four tigers are no longer growing fast. Patterns are presented and discussed as well for 'the Big 3' (Japan, USA, Germany), three non-European developed economies, two former Eastern Bloc countries, and three Latin American nations. Their group of 180 experts predicts a surge in global high-technology export competition over the next 15 years.

At the same time, today all countries must take into account the influence of the main factors of the new industrial revolution. The most widespread concept today, Industry 4.0, was named in 2011 by German businessmen, politicians, and scientists, who identified it as a way of increasing the competitiveness of the German manufacturing industry through the enhanced integration of "cyber-physics systems" (or CPS) into production processes. In the report, Kagermann et al. [17] the main points of this concept were formulated, and its further development was described in the works of Ross [18], Schwab [19], which emphasize that today advanced production technologies are mainly 3D-printing, cloud technology, Internet things, new materials, robotics, and artificial intelligence.

Thus, we can conclude that Industry 4.0 technologies, combining the factors Smart TEMP (T (technology) – smart technologies, E (environmental) – smart environment, M (manufacturing) – smart production, P (products) – smart products), create new markets and industries, contribute to the growth of labor productivity, the competitiveness of sectors and national economies [20–22].

The Fagerberg paper [23] provides an overview of the literature on technology and competitiveness. First, the concept of a country's international competitiveness and various theoretical approaches to the relationship between trade and growth are discussed. A few empirical studies on the impact of technology (as evidenced by R&D, patents, etc.) on exports are then examined.

As a result, the author summarizes the findings and discusses lessons for policy. Moreover, América and Zamora Torres [24], based on foreign experience, argue that the share of high-tech products delivered to world markets is directly dependent on the development of national innovation infrastructure.

The question of improving the economic performance in the EU countries and finding an effective response to the current global challenges is directly linked to the widespread introduction of these advanced industrial technologies by the new industrial revolution in European countries [25–28].

Many economists have examined specific aspects of the impact of a country's export capacity on its competitiveness in world markets. Thus, Hausmann and Clinger [29] used one approach to assess the export potential for competitiveness. Looking at the "commodity space" of world exports, they note that a country's level of competitiveness depends on the food basket it exports. The greater the share of a country's high-tech products in world exports, the more competitive it will be. This position has been confirmed by the analysis of statistics from more than 100 countries. Building on this view, Hidalgo & Hausmann [30] argues that a country's export potential is influenced by a country's income level (namely, GDP): high-tech goods can be exported by high-income countries. It is clear that this point cannot be unconditionally and unequivocally accepted with regard to individual countries.

Melnyk [31] argues that the components of export potential include: the potential of internal resources (a function of the technical and technological base, staff qualifications, management methods, finance); the potential of the target foreign market; market access conditions, which include national (trade policy of the country, the system of support for export production) and external conditions (trade regime of the exporting country). Indeed, these factors influence the formation of export potential. However, Melnyk only points to the existence of functional dependence of export potential on these indicators, without its further formalization. Therefore, it is not possible to practically use the approach.

To forecast exports, Kireiev [32] proposes to use regression equations of supply and demand. Accordingly, the demand for national products of the country is determined on the basis of the sum of weighted by the correction factors of real-world GDP and the export price index. This equation is based on the assumption of the existence of global development cycles. In fact, countries are developing locally: around the "center countries" of production and export of goods are "satellite countries", which have similar economic indicators because of the close trade links between them.

Bogomazova [33] also provides a regression model for estimating export potential, describing the country's exports on the basis of three variables: the nominal exchange rate of the hryvnias against the US dollar, foreign direct investment inflows into Ukraine, and industrial and agricultural growth rates. In our opinion, such a model does not fully characterize the possibilities of forecasting Ukraine's exports, because regression models are quite difficult because the economic situation is changing very quickly.

In assessing the impact of regulatory authorities on the foreign trade of high-tech products in Ukraine, scientists note the possibility of using cause-effect relationships between indicators characterizing the market's business processes and government regulatory instruments that can be quantified [34, 35].

Thus, each of these methodological approaches to assessing the competitiveness of the country, taking into account the export potential of the economy has its own unique features, advantages, and analytical components.

In our opinion, the strength of the methodological approach is Jonson [15], Porter [16] is the use of four components in the technology competitiveness model – national orientation, socio-economic infrastructure, technological infrastructure, and productive potential, as well as the use of high-tech technology indicators to assess their competitiveness. In addition, the authors influence the export of technology (based on research and development, patents, etc.). At the same time, such research requires the processing of a large amount of statistical information, which is often difficult for ordinary researchers to access. In our view, a qualitative analysis based on comprehensive indicators is useful for a comprehensive and sufficiently simple assessment of a country's technological competitiveness.

Scientists and business analysts such as Kagermann [17], Ross [18], Schwab [19], investigated the influence of the factors of the new industrial revolution on the technological competitiveness of the country. At the same time, they came to the conclusion that today, in the context of insufficient statistics on the impact of specific breakthrough technologies on the country's economic development, the best quality indicators of the country's technological competitiveness remain integral indicators, primarily such as Global Competitiveness Index of World Economic Forum, the Global Innovation Index, IMD World Competitiveness Ranking and others.

Another group of scientists (América & Zamora-Torres [24]; Balcerzak [25]; Becker et al. [27]; Fagerberg [23]; Hausmann & Klinger [29]; Hidalgo & Hausmann [30]; Bogomazova [33]; Kireiev [32]; Koval et al. [35]; Melnik [31]; Sushchenko et al. [34]) investigated the impact of trade in technological goods on economic growth and conducted various assessments of the impact of a country's export potential on its technological competitiveness. An analysis of the results of these studies showed that indicators such as the ratio of high-tech exports to GDP of a country, the ratio of the number of employees involved in research and development to the employed population of the country, the ratio of research and development expenditure (R&D expenditure) to the country's GDP, relative (comparative) country advantages by product group and other categories are useful for a comprehensive assessment of a country's export potential. These indicators are often used to assess a country's export potential in a comprehensive manner and to identify the comparative advantages of its exports.

Thus, there is the problem of some combination of these methodological approaches in order to establish a comprehensive and relatively simple methodological approach to assessing a country's technological competitiveness (as in the case of Ukraine), taking into account the impact of the new industrial revolution.

3.2 IDENTIFICATION OF BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

Presently, in a highly globalized and competitive world, technological change and innovation are the basis of the long-term economic growth of any successful country. As a consequence, the development of economic policy-based countries, based on the development of the scientific, technological, and innovation environment, will contribute to their sustainable economic growth and leveling breaks in the innovative development. At the same time, in the conditions of competition's intensification in foreign and domestic markets for the leading countries of the world, the problem of advanced production technologies' introduction of the XXI century new industrial revolution is substantially aggravated [36].

Taking into account the signing of an association agreement between Ukraine and the EU countries in 2014, which provides cooperation in the innovation and scientific and technical sphere, the development and implementation of Ukraine's innovative potential through the intensification of innovative cooperation with the EU is an urgent direction of the foreign policy strategy.

At this stage of innovative development of socio-economic systems, the European Union is seen as the most successful example of regional economic integration. Today, despite a number of internal crisis phenomena, this integration group is one of the main geo-economic centers of influence in the system of international economic relations. Therefore, in our study the innovative development of the EU-27 countries and Ukraine as the innovative development of socio-economic systems was considered.

By 2030, world-renowned institutions and international industry associations are predicted to be able to launch a revolution in industrial production only by introducing, first and foremost, high-tech industries. The wave of the new industrial revolution will drive the rise of new digital industrial technologies known as Industry 4.0, based on industries such as nanomaterials, 3D printing, genetic engineering, molecular biotechnology, cloud computing, multidimensional modeling, the Internet of Things, and artificial intelligence [37, 38].

This revolution is also connected with the problem of leveling and improving the EU's economic performance. The dynamics of Europe's future development will depend on the quality of its scientific and technological innovations. In this context, EU Member States should develop economic policies to create a science, technology, and innovation environment that will promote sustained economic growth and leveling breaks in the innovative development. Considering the rather ambiguous state of development of Ukraine's high-tech sphere, the problem of assessing factors of formation of technological competitiveness of Ukraine in the face of new challenges for the state in the process of development of relations with the EU.

The root causes of internal fragmentation within the framework of the European integration project are quite multifaceted, and the economic heterogeneity of the EU member states and the unevenness of their development are the fundamental foundations for the formation of various blocs and general internal divergence.

However, the formation of internal alliances or various groups of states, distinguished by disproportions and unequal economic development, different rates of economic growth, a divergent vision of the existing geo-economic and geopolitical problems, to some extent an objective phenomenon in the course of the progressive development of the union, which included the formation, repeated expansion of borders and processes of deepening integration.

Determination of the level and state of development of innovations in Ukraine in the international context, in particular within the framework of integration processes, will be carried out in accordance with international ratings assessing the innovative potential, technological and innovative competitiveness. In this regards, it was studied and analyzed authoritative ratings in the field of determining the innovative potential of the economy of states, namely: the Global Competitiveness Index of World Economic Forum (GCI WEF); the IMD World Competitiveness Ranking (IMD WCR); the IMD World Digital Competitiveness Ranking (IMD WDCR) to assess the country's ability to develop and implement digital technologies; the Global Innovation Index (GII) to study the detailed indicators of innovation activities in the world.

The Global Innovation Index is produced jointly by Cornell University, INSEAD Business School and the World Intellectual Property Organization. In 2019, the Global Innovation Index covered 129 world economies based on 82 indicators, which are distributed in seven areas: institutions, human capital and research, infrastructure, market development, business development, knowledge and technology creation, creativity [39]. Therefore, the dynamics of this index for the EU countries and Ukraine since the signing of the association agreement (2014) was considered (**Table 3.1**).

According to the Global Innovation Index from 28 studied countries, Ukraine ranks 28th in 2014–2017, and 27th in 2018–2019. Also for the period of 2014–2019 there are significant breaks in innovation development among EU countries. The lowest rates were in countries such as Bulgaria, Greece, Croatia, Poland and Romania. The highest rates are in the UK, Sweden, Finland, the Netherlands, Denmark and Germany.

In general, the Global Innovation Index is formed of 7 sub-indices, that explains the reasons for the breaks in innovation development of countries. **Fig. 3.1** presents these sub-indices, and **Table 3.2** presents the data of the given sub-indices for the EU and Ukraine in 2019.

So, in terms of the quality of institutions, Ukraine is in the last 28th place, next to such countries as Bulgaria and Romania. But the leaders in this sub-index are Denmark, the Netherlands, Finland and Sweden. In terms of human capital and research, Ukraine ranks 24th ahead of Bulgaria, Croatia, Romania and Slovakia, and the leaders are Denmark, Germany, Austria, Finland and Sweden. Ukraine's infrastructure is in last place with a huge break over the EU countries, while in Denmark, Ireland, Sweden and the UK, the state of infrastructure is one of the strengths of the state of innovative development. According to the sub-index of market sophistication, Ukraine is on the penultimate place together with Romania and Slovenia, and the best indicator is in Britain and Denmark. In terms of business sophistication, Ukraine is in 25th place ahead of Greece, Romania, Croatia and Slovakia, and Sweden, Finland and the Netherlands took the first positions. Knowledge

and technology outputs is the most powerful sub-index for Ukraine, in which it ranks 18th, ahead of Bulgaria, Croatia, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia and Slovenia. The first positions are also have Sweden, the Netherlands, Ireland and Britain. In terms of creativity, Ukraine is ranked 24th ahead of Greece, Croatia, Romania and Poland, and the leaders are Luxembourg, Malta, the Netherlands and the UK.

Table 3.1 Dynamics of the Global Innovation Index of the EU countries and Ukraine in 2014–2019

Country	2014	2015	2016	2017	2018	2019
Belgium	51.7	50.9	52	49.9	50.5	50.2
Bulgaria	40.7	42.2	41.4	42.8	42.6	40.3
Czechia	50.2	51.3	49.4	51	48.7	49.4
Denmark	57.50	57.7	58.5	58.7	58.4	58.4
Germany	56.00	57.1	57.9	58.4	58	58.2
Estonia	51.5	52.8	51.7	50.9	50.5	50
Ireland	56.70	59.1	59	58.1	57.2	56.1
Greece	38.9	40.3	39.8	38.8	38.9	38.9
Spain	49.3	49.1	49.2	48.8	48.7	47.9
France	52.2	53.6	54	54.2	54.4	54.2
Croatia	40.7	41.7	38.3	39.8	40.7	37.8
Italy	45.7	46.4	47.2	47	46.3	46.3
Cyprus	45.8	43.5	46.3	46.8	47.8	48.3
Latvia	44.8	45.5	44.3	44.6	43.2	43.2
Lithuania	41	42.3	41.8	41.2	41.2	41.5
Luxembourg	56.90	59	57.1	56.4	54.5	53.5
Hungary	44.6	43	44.7	41.7	44.9	44.5
Malta	50.4	50.5	50.4	50.6	50.3	49
Netherlands	60.60	61.6	58.3	63.4	63.3	61.4
Austria	53.4	54.1	52.6	53.1	51.3	50.9
Poland	40.6	40.2	40.2	42	41.7	41.3
Portugal	45.6	46.6	46.4	46.1	45.7	44.6
Romania	38.1	38.2	37.9	39.2	37.6	36.8
Slovenia	47.2	48.5	46	45.8	46.9	45.3
Slovakia	41.9	43	41.7	43.4	42.9	42
Finland	60.70	60	59.9	58.5	59.6	59.8
Sweden	62.3	62.4	63.6	63.8	63.1	63.7
UK	62.4	62.4	61.9	60.9	60.1	61.3
Ukraine	36.3	36.5	35.7	37.6	38.5	37.4

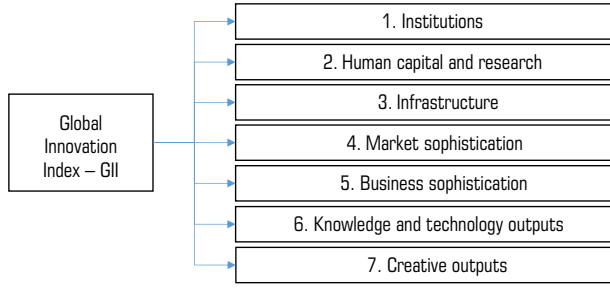

Fig. 3.1 Subindexes of the Global Innovation Index

Table 3.2 Data from the sub-indices of the Global Innovation Index of the EU and Ukraine in 2019

Country	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative outputs
Belgium	82.0	55.0	57.2	55.3	54.1	40.8	38.5
Bulgaria	68.3	30.6	53.7	47.5	40.3	31.4	33.8
Czechia	78.6	43.4	56.4	52.4	46.3	43.8	43.1
Denmark	91.7	63.1	65.8	66.9	59.1	46.4	48.6
Germany	86.4	63.2	62.0	58.6	56.1	52.7	49.6
Estonia	81.7	42.1	61.5	52.6	42.6	36.0	51.7
Ireland	85.5	48.4	66.3	54.6	55.8	56.9	43.3
Greece	67.2	49.5	51.7	50.3	32.4	25.1	30.1
Spain	78.1	47.0	63.1	59.5	38.7	37.2	39.7
France	83.2	55.8	62.3	62.9	53.3	45.0	45.0
Croatia	69.3	35.6	51.6	46.0	34.3	25.6	31.0
Italy	75.3	45.4	59.4	51.4	42.2	38.9	36.8
Cyprus	80.3	35.8	55.9	58.2	47.6	41.2	41.1
Latvia	77.2	36.9	50.5	54.4	37.4	27.5	42.8
Lithuania	76.0	36.3	51.7	50.9	38.0	24.4	40.3
Luxembourg	80.7	41.7	58.7	46.9	60.7	42.2	56.2
Hungary	71.6	41.0	52.7	45.7	40.8	42.8	34.6
Malta	75.2	36.6	61.1	45.2	54.9	31.9	55.0
Netherlands	90.9	52.4	61.8	58.2	63.7	61.8	53.2
Austria	86.0	60.2	61.4	52.8	53.8	36.7	41.4
Poland	73.6	41.2	53.8	47.9	38.4	30.9	32.4
Portugal	81.8	47.7	56.8	49.8	37.3	29.8	39.4
Romania	67.1	29.1	54.5	43.2	33.6	30.3	25.8
Slovenia	82.3	46.6	53.9	43.6	44.1	30.7	42.1
Slovakia	73.1	32.4	54.2	47.4	35.6	34.0	37.1
Finland	93.6	63.4	62.1	57.3	63.9	55.1	48.1
Sweden	90.1	62.1	69.1	62.1	68.8	61.8	51.9
UK	87.1	59.3	64.4	76.0	54.3	56.6	52.2
Ukraine	53.9	35.6	36.0	43.3	34.8	34.6	33.5

Thus, the quality of institutions is not Ukraine's strength as an innovator and is significantly behind all EU countries. Human capital is the driving force in development of innovation in Ukraine, but it requires increased attention from the public and private sectors, as the country may lose one of its strongest competitive advantages. It can be said that the state of infrastructure development remains at a frankly low level. Speaking about the level of market sophistication in Ukraine, it is advisable to note that Ukraine remained at the level of 2014 and ranks 27th among all the studied economies of the EU countries. Ukraine has improved the indicator of business sophistication. It can also be seen that Ukraine has the highest position among all other sub-indices in terms of knowledge and technology outputs, which shows that the country's scientific and educational potential, knowledge of the population are the biggest advantages of Ukraine, which currently ensure the country's competitiveness in innovation. In terms of creativity, Ukraine has also significantly improved its position in recent years.

While comparing the state of innovative development with other countries of the world according to the Global Innovation Index, it can be admitted that the breaks in the innovative development of Ukraine are the following: in 2014 it ranked 63rd among 143 countries of the world with an indicator of 36.26; 2015 – 64th place (36.45) among 141 countries; 2016 – fifty-sixth place (35.52) among 128 countries; 2017 – 50th place (37.62) among 127 countries; 2018 – 43rd place (38.52) among 126 countries; 2019 – 47th place (37.40) among 129 countries; 2020 – 45th place (36.32) among 131 countries of the world [5].

So, the world has entered an era of cardinal socio-economic changes caused by a new technological revolution, associated with a number of significant technological innovations. Currently, the real practice of the implementation of the Agreement during 2015–2020 found a very insignificant impact of European integration measures on the acceleration of technological progress in the Ukrainian economy, significantly lags behind in scientific and technological development from the leading countries of the world – as evidenced by international rankings and significant breaks in innovative development both among the EU countries and for Ukraine.

3.3 METHODS FOR LEVELING BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

For leveling breaks in the innovative development of socio-economic systems on the example of Ukraine and to accelerate European integration processes, it is necessary to develop an approach to determine the impact of selected factors on individual indicators of innovation development.

The study proposes a method for leveling breaks in the innovative development of the country, which includes three stages:

I. Qualitative analysis of four international integral indicators, namely:

– the Global Competitiveness Index of World Economic Forum (GCI WEF), including indicator of technological readiness (9th pillar: Technological readiness) and indicator of innovation (12th pillar: Innovation);

– the IMD World Competitiveness Ranking (IMD WCR), in particular indicator of infrastructure;

– the IMD World Digital Competitiveness Ranking (IMD WDCR) to assess the country's ability to develop and implement digital technologies;

– the Global Innovation Index (GII) to study the detailed indicators of innovation activities in the world.

II. Positioning the country in a European competitive environment through *cluster analysis*.

III. Modeling the relationship between indices and factors of innovative development based on *correlation and regression analysis*.

The correlation analysis is used to determine and study the relationship between the indicators studied and to establish the relative degree of dependence of the performance indicator on each factor.

The main purpose of multiple regression analysis is to consider the relationships between a dependent variable and several independent variables. It is necessary to analyze the relationship between the resulting variable and the many factors, and then to identify the factors that most influence the outcome. This analysis can predict the value of a finite variable depending on the values of certain factors.

The forecast linear equation that estimates the multiple regression model that will be used (3.1):

$$Y = a + b_1 \times X_1 + b_2 \times X_2 + b_3 \times X_3 + \ldots + b_n \times X_n, \quad (3.1)$$

Y is the dependent variable, what is being predicted or explained; X_1, X_2, X_3, X_n are the independent variables, that are explaining the variance in Y; 'a' is the constant or value of function with zero value of all factors; b_1, b_2, b_3, b_n are the regression coefficients.

R_2 will be used to describe the precision of the process model. If the value exceeds 0.7, the model is considered reliable.

Aiming to find out how Ukraine's innovative development has changed since the signing of the association agreement with the EU, Ukraine and the 27 EU countries were chosen as a model for the study.

The research period is 2011–2019, because 2011 (according to the world's leading experts) was the beginning of a period of economic recovery in the leading economies after the global financial crisis of 2008–2009. It was also in 2011 that they first began to speak of a new industrial revolution, the main factors of which were having a growing impact on breaks in the innovative development of the world's leading economies, particularly those of the European Union, and associated countries.

3.4 RESEARCH RESULT

The research result is the identification of the main ways to leveling breaks in the innovative development of Ukraine.

Positioning the country in a European competitive environment through cluster analysis on all 10 indicators of the European Innovation Scoreboard (EIS) for the EU-27 and Ukraine (**Table 3.3**).

The result of clustering is shown in **Fig. 3.2**, where 7 clusters with a threshold value of 310 were identified and presented in **Table 3.4** [40, 41].

Table 3.3 Source data for the cluster analysis on the main indicators of the European Union Innovation Scoreboard for EU and Ukraine

Country	Human resources	Attractive research systems	Innovation-friendly environment	Finance and support	Firm investments	Innovators	Linkages	Intellectual assets	Employment impacts	Sales impacts
Ukraine	53.40	17.27	169.63	11.30	45.13	20.18	37.55	20.90	86.86	35.15
Slovakia	94.30	56.38	87.32	28.29	82.73	37.25	63.03	39.85	140.54	114.23
Slovenia	127.30	100.95	143.03	36.57	134.66	61.36	116.25	81.94	105.27	67.73
Sweden	216.98	210.95	310.18	141.05	175.53	103.43	154.93	122.64	167.78	89.22
Romania	13.64	32.77	112.94	48.11	10.57	0.00	40.48	23.78	45.19	62.07
Portugal	105.07	135.20	227.24	96.22	124.46	156.33	64.92	70.80	96.15	55.42
Poland	75.36	36.65	211.02	46.81	95.84	14.31	40.68	65.84	106.15	55.67
Netherlands	175.53	220.98	280.54	139.01	98.20	112.24	159.42	105.23	138.59	93.71
Malta	88.73	87.58	233.14	106.98	105.75	53.20	17.10	128.61	187.23	59.02
Latvia	75.99	52.51	138.30	126.72	73.84	35.70	56.34	59.09	100.25	50.82
Luxembourg	177.95	236.20	236.20	122.67	81.91	126.84	90.16	141.04	189.20	84.75
Lithuania	119.47	54.29	187.53	97.67	101.13	98.82	108.96	52.43	64.72	53.17
Italy	61.45	111.14	121.18	65.21	94.88	116.85	69.05	96.18	87.01	80.36
Ireland	175.23	171.08	149.53	83.10	113.90	118.67	84.10	53.36	200.86	128.70
Hungary	51.48	66.76	144.47	53.39	106.56	30.39	60.65	44.50	150.19	84.68
Croatia	65.70	50.24	71.37	44.83	117.94	85.99	67.50	32.81	80.89	38.29
France	159.41	140.94	143.14	159.11	108.90	113.97	103.08	78.89	93.00	88.67
Finland	198.53	173.53	321.58	158.75	168.70	153.29	167.92	118.73	93.54	90.08
Spain	177.85	105.21	197.25	90.40	83.58	40.92	67.93	70.12	114.85	83.96
Greece	92.69	77.99	76.73	61.50	85.37	130.97	129.70	39.13	57.37	67.58
Estonia	140.54	121.60	137.96	104.89	123.33	95.05	133.79	112.74	79.11	66.43
Denmark	206.89	224.56	329.62	167.89	139.59	86.59	154.14	137.40	118.34	73.85
Germany	108.73	105.35	169.76	138.36	190.03	122.38	139.59	119.78	113.88	119.12
Czechia	84.42	83.72	121.55	66.78	121.71	86.72	92.67	51.69	148.78	94.68
Cyprus	118.76	145.25	140.13	86.90	101.07	73.55	61.41	98.03	75.62	98.49
Bulgaria	60.08	29.42	74.59	13.45	52.91	23.97	35.59	77.89	120.10	40.26
Belgium	133.53	190.72	158.14	131.08	158.96	133.63	168.53	81.73	95.46	103.90
Austria	143.26	167.85	130.65	109.55	127.20	135.09	187.75	126.30	75.42	83.94

Source: the study based on [5]

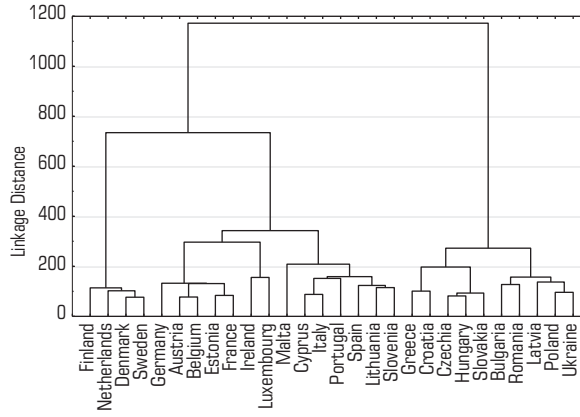

Fig. 3.2 Dendrogram of the EU countries and Ukraine according to EIS 2019 indicators
Source: own calculations based on [40]

Table 3.4 The composition of the selected clusters of the EU countries and Ukraine according to the indicators of the European innovation scoreboard (EIS) 2019

Cluster	Countries
Cluster 1	Finland, Netherlands, Denmark, Sweden
Cluster 2	Belgium, Germany, Austria, France, Estonia
Cluster 3	Ireland, Luxembourg
Cluster 4	Malta
Cluster 5	Cyprus, Italy, Portugal, Slovenia, Lithuania, Spain
Cluster 6	Croatia, Greece, Czech Republic, Hungary, Slovakia
Cluster 7	Ukraine, Romania, Poland, Bulgaria, Latvia

Source: own calculations based on [40]

Ukraine is a part of cluster 7 (**Fig. 3.3**) that is far behind the others. The most problematic indicators are "Attractive research system" and "Innovators". If the average EU is 136.6 and 95.9, then for the cluster 7, these indicators will be 33.7 and 18.8 respectively. Some advantages countries of cluster 7 have only in indicators of "Innovation-friendly environment" (141.3) and "Employment impacts" (91.7), reflecting general trends in Ukraine. Thus, the cluster analysis showed that Ukraine is now in a single cluster with countries, such as Bulgaria, Romania, Poland, and Latvia, which have not yet fully been able to adapt their economies to the level of technological and innovative competitiveness of the leading countries.

Among countries in cluster 7, Poland and Latvia have the most innovative development. Their strengths include "Innovation-friendly environment", "Employment impacts", "Firm investments", and "Human resources" indicators (**Table 3.3**). In Bulgaria, "Intellectual assets" (at the level of Belgium

and France) and "Employment impacts" (the highest level among the cluster, which is equal to the same indicator for countries such as Germany and Denmark) are among the greatest advantages of innovative development. Ukraine is the second-to-last cluster country. Romania has the lowest indicators among the EU-27 countries for the components of the "European Union Innovation Scoreboard" like "Human resources", "Attractive research systems", "Firm investments", "Innovators", "Intellectual assets", "Employment impacts". But the available results show that Ukraine has some strengths in the European competitive environment, such as innovation-friendly environment and labor.

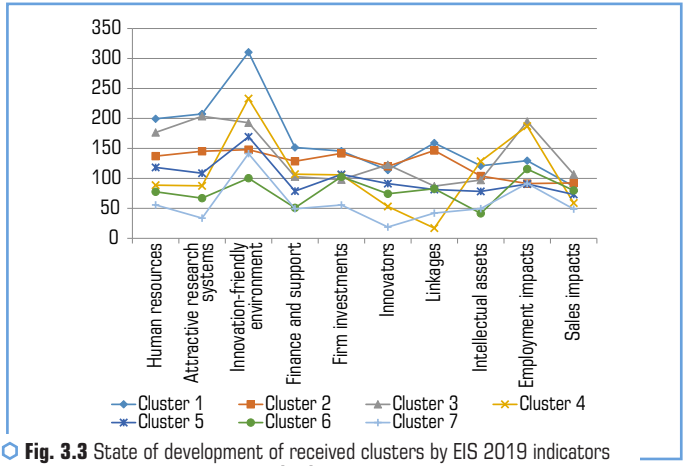

Fig. 3.3 State of development of received clusters by EIS 2019 indicators
Source: own calculations based on [40]

For deeper conclusions, further analysis was made of the state of infrastructure development (**Fig. 3.4**). Compared to other countries in the cluster, Ukraine has the lowest level of infrastructure development in the cluster. Poland and Bulgaria are leading on this indicator.

To assess the degree of influence of chosen factors on the indices that determine the breaks in the innovative development of Ukraine, it was used the method of correlation and regression analysis based on the main indicators of the GCI WEF (including Technological readiness and Innovation), the IMD WDCR, the GII and our own calculations.

The chosen factors (independent variables X1–X12) can be divided into the following categories, **Table 3.5**:

1. Conditions for creating educational and institutional capacity: expenditure on education (X1), the number of graduates in science and technology (X2), quality of research institutions (X3), the ratio of the number of employees involved in research and development to the employed population (X4).

2. Innovation financing: the ratio of R&D expenditure to the country's GDP (X5), FDI inflows (X6).

3. Innovative infrastructure: access to ICT (X7), state of cluster development (X8).

4. The economic effect of innovation: the ratio of exports of high-tech products to industrial exports (X9), the ICT services exports (X10), the number of PCT patents (X11), income from intellectual property use (X12).

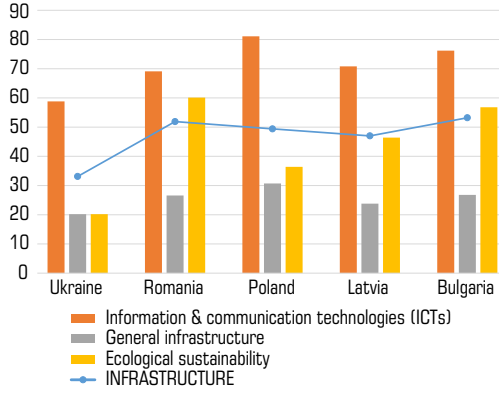

Fig. 3.4 State of development of Infrastructure in the countries of the seventh cluster by GII 2020 indicators
Source: the study based on [42]

Table 3.5 Source data for correlation between chosen factors and indices that determine the breaks in the innovative development of Ukraine

Year	Expenditure on education, % of GDP	Graduates in science and technology, %	Quality of scientific research institutions	Ratio of employees involved in R&D to the employed population, %	Ratio of R&D expenditures to GDP, %	FDI inflows (% of GDP)	ICT access	State of cluster development	Ratio of high-tech products export to industrial exports, %	ICT services exports, % of total exports of services	PCT patents applications, million pop.	Income from the intellectual property use, million $
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
2011	5.9	26.3	3.6	0.947	0.738	4.417	47.9	28.6	3.277	17.923	0.3	107
2012	5.9	26.3	3.7	0.877	0.754	4.651	48.6	35.4	4.737	19.34	2.1	124
2013	6.2	25.6	3.6	0.822	0.759	2.46	52.7	31.17	4.134	22.204	2.9	167
2014	6.7	25.6	3.8	0.792	0.649	0.634	61.6	33.3	4.129	30.482	3.2	118
2015	6.7	25.5	4.2	0.778	0.617	3.351	62.7	32.5	3.994	31.442	3.6	85
2016	6	25.5	4.2	0.627	0.700	3.689	64.8	32.5	3.295	31.756	3.9	73
2017	5.9	26.7	3.9	0.608	0.600	2.165	66	35.5	2.795	33.513	3.6	72
2018	5.9	26.7	3.9	0.600	0.600	2.6	66	35.5	2.900	31.3	3.7	74
2019	5	24.2	3.5	1.100	0.4	3.2	66.5	37.3	2	31.7	3.9	74

As dependent variables (Y1–Y5), the indices that reflect the competitiveness of Ukraine were selected, namely the GCI WEF (Y1) and its main indicators, such as "Technological readiness" (Y2) and "Innovation" (Y3); GII (Y4) and the IMD WDCR (Y5) (**Table 3.6**).

Table 3.6 Results of calculation of variables (Y1–Y5)

Year	Global Competitiveness Index	Technological readiness (GCI)	Innovation (GCI)	Global Innovation Index	World Digital Competitiveness Ranking
	Y1	Y2	Y3	Y4	Y5
2011	4.000	3.74	3.1	35.00	–
2012	4.140	3.6	3.2	36.10	–
2013	4.050	3.28	3.0	35.80	54
2014	4.140	3.5	3.2	36.30	50
2015	4.030	3.45	3.4	36.45	59
2016	4.000	3.58	3.4	35.72	59
2017	4.110	3.8	3.4	37.62	60
2018	4.010	3.84	3.4	43.00	58
2019	4.120	3.9	3.5	47.00	60

Source: own calculations based on [8–10]

Based on the Table of initial data for the indicated indicators in the period 2011–2019 years, a correlation analysis was carried out, the results of which are presented in **Table 3.7**.

The data given in **Table 3.7** show that the GCI WEF of Ukraine has basically a very weak link with such factors as the number of graduates in science and technology, expenditure on education, the quality of research institutions, the ratio of R&D expenditures to GDP, and FDI inflows. The GCI WEF is closely related to only one indicator of state of cluster development (0.594), and has little in common indicators such as ICT access, ICT services exports and education expenditure.

The link between technological development and the chosen factors is weak or moderate. There is a strong correlation between this index and expenditure on education (–0.729) and income from intellectual property use (–0.730), state of cluster development (0.516), the ratio of R&D expenditure to GDP (–0.624) and access to ICT (–0.371).

The link of innovation potential to the factors selected is mostly either strong, very weak or almost non-existent. Thus, indicators such as access to ICT (0.844), income from intellectual property use (–0.909), export of ICT services (0.802), number of PCT patents (0.703) and ratio of R&D expenditure to GDP have a significant link with Ukraine's innovation potential (–0,755).

The correlation between the GII and the factors shows that the link between them is mostly moderate or strong. The three main factors are the ratio of R&D expenditure to GDP (–0.879 –

a very close link), state of cluster development (–0.727) and the ratio of high-technology exports to industrial exports (–0.743).

Table 3.7 Correlation between chosen factors and indices that determine the breaks in the innovative development of Ukraine

Factors	Global Competitiveness Index	Technological readiness (GCI)	Innovation (GCI)	Global Innovation Index	World Digital Competitiveness Ranking
Expenditure on education, % of GDP	–0.12381	–0.729	–0.37023	–0.70557	–0.57762
Graduates in science and technology, %	–0.19581	0.0893	–0.30045	–0.41941	–0.01487
Quality of scientific research institutions	–0.40208	–0.203	0.477786	–0.30827	0.268272
Ratio of employees involved in R&D to the employed population, %	0.324322	0.096	–0.19326	0.288689	–0.05928
Ratio of R&D expenditures to GDP, %	–0.2739	–0.623	–0.75517	–0.87914	–0.47486
FDI inflows, % of GDP	–0.33551	0.165	0.033029	–0.10409	0.802082
ICT access	0.015384	0.371	0.843931	0.565446	0.604922
State of cluster development	0.593752	0.516	0.594049	0.726723	0.475249
Ratio of high-tech products export to industrial exports, %	0.146648	–0.789	–0.6702	–0.74305	–0.6957
ICT services exports, % of total exports of services	0.063871	0.270	0.80242	0.447864	0.514709
PCT patents applications, million pop.	0.146025	0.040	0.702985	0.470915	0.787447
Income from the intellectual property use, million $	0.172407	–0.730	–0.90995	–0.47957	–0.73414

Source: own calculations based on [43–45]

The IMD WDCR has the greatest connection with indicators such as FDI inflows (0.802), the number of PCT patents (0.787), and income from intellectual property use (–0.734).

To complete the study, a multiple regression analysis was conducted based on the factors the correlation with which the correlation was strongest.

On the basis of the multiple regression analysis of the modeling and prediction of changes in the values of the main indices that determine the global and technological competitiveness of Ukraine, it has been possible to establish the following.

The coefficient of determination is insignificant (R^2=0.5592), so the reliability of the model is very low and the results of regression analysis on this factor indicate that there is no link between the Global Competitiveness Index and the selected factors (**Table 3.8**).

Table 3.8 Source data for multiple regression analysis between the Global Competitiveness Index (GCI WEF) and selected factors

Year	Global Competitiveness Index	State of cluster development	FDI inflows (% of GDP)	Ratio of high-tech products export to industrial exports, %
	Y1	X1	X2	X3
2011	4.000	28.6	4.417	3.277
2012	4.140	35.4	4.651	4.737
2013	4.050	31.17	2.46	4.134
2014	4.140	33.3	0.634	4.129
2015	4.030	32.5	3.351	3.994
2016	4.000	32.5	3.689	3.295
2017	4.110	35.5	2.165	2.795
2018	4.010	35.5	2.6	2.900
2019	4.120	37.3	3.2	2.000
Results of multiple regression analysis between the Global Competitiveness Index (GCI WEF) and selected factors				
Multiple R			0.747846	
R^2			0.559273	
F			2.114964	
Significance F			0.216959	
Y			3.461275	
X1			0.015957	
X2			–0.01125	
X3			0.030031	

Source: own calculations based on [43]

$$Y = 2.5351 + 0.0707 \times X_2.$$

The increase in the number of graduates in science and technology by 1 % will increase the index of technological development (in the GCI WEF) at 0.0707; $R^2 = 0.752202$ (**Table 3.9**).

$$Y = 3.1108 + 0.0006 \times X_1 - 0.033 \times X_3.$$

Improving the quality of research institutions by 1 point will increase the index of innovation potential (in the GCI WEF) to 0.0006. Increasing the revenues from the use of intellectual property for $1 million will reduce the index of innovation potential by 0.033; $R^2 = 0.893797$ (**Table 3.10**).

Table 3.9 Source data for multiple regression analysis between Technological Readiness (composed of GCI WEF) and selected factors

Year	Technological readiness (GCI)	Ratio of high-tech products export to industrial exports, %	Graduates in science and technology, %	Income from the intellectual property use, million $
	Y2	X1	X2	X3
2011	3.74	3.277	26.3	107
2012	3.6	4.737	26.3	124
2013	3.28	4.134	25.6	167
2014	3.5	4.129	25.6	118
2015	3.45	3.994	25.5	85
2016	3.58	3.295	25.5	73
2017	3.8	2.795	26.7	72
2018	3.84	2.900	26.7	74
2019	3.9	2.000	24.2	74

Results of multiple regression analysis between Technological Readiness (composed of GCI WEF) and selected factors	
Multiple R	0.867296
R^2	0.752202
F	5.059245
Significance F	0.056462
Y	2.535193
X1	–0.1627
X2	0.070742
X3	–0.00166

Source: own calculations based on [43]

Table 3.10 Source data for multiple regression analysis between Innovation (GCI WEF) and selected factors

Year	Innovation (GCI)	Quality of scientific research institutions	ICT access	Income from the intellectual property use, million $
	Y3	X1	X2	X3
2011	3.1	3.6	47.9	107
2012	3.2	3.7	48.6	124
2013	3.0	3.6	52.7	167
2014	3.2	3.8	61.6	118
2015	3.4	4.2	62.7	85
2016	3.4	4.2	64.8	73
2017	3.4	3.9	66	72
2018	3.4	3.9	66	74
2019	3.5	3.5	66.5	74
Results of multiple regression analysis between Innovation (GCI WEF) and selected factors				
Multiple R			0.945408	
R^2			0.893797	
F			14.02652	
Significance F			0.007198	
Y			3.110847	
X1			0.000642	
X2			0.008395	
X3			–0.0033	

Source: own calculations based on [43, 44]

$$Y = 50.8041 + 0.4271 \times X_2.$$

Increasing the level of cluster development by 1 point will increase the GII by 0.4271; $R^2 = 0.924411$ (**Table 3.11**).

$$Y = 51.52405 + 2.106391 \times X_1 - 1.71027 \times X_2 + 1.651747 \times X_3.$$

An increase of 1 % in FDI inflows would result in an increase of 2,106391 points in the IMD WDCR. An increase of 1 % in exports of high-tech products to industrial exports would result in an increase of 1.71027 points in the IMD WDCR, and an increase in the number of PCT patents would result in an increase of 1.651747 points in the IMD WDCR; $R^2 = 0.840884$ (**Table 3.12**).

Table 3.11 Source data for multiple regression analysis between Global Innovation Index (GII) and selected factors

Year	Global Innovation Index	Ratio of R&D expenditures to GDP, %	State of cluster development	ICT services exports, % of total exports of services
	Y4	X1	X2	X3
2011	35.00	0.738	28.6	17.923
2012	36.10	0.754	35.4	19.34
2013	35.80	0.759	31.17	22.204
2014	36.30	0.649	33.3	30.482
2015	36.45	0.617	32.5	31.442
2016	35.72	0.700	32.5	31.756
2017	37.62	0.600	35.5	33.513
2018	43.00	0.600	35.5	31.3
2019	47.00	0.4	37.3	31.7
Results of multiple regression analysis between Global Innovation Index (GII) and selected factors				
Multiple R			0.924411	
R^2			0.854537	
F			9.790969	
Significance F			0.015561	
Y			50.80415	
X1			–32.7322	
X2			0.4271	
X3			–0.21111	

Source: own calculations based on [9]

Table 3.12 Source data for multiple regression analysis between the Digital Competitiveness Index (IMD WDCR) and selected factors

Year	World Digital Competitiveness Ranking	FDI inflows (% of GDP)	Ratio of high-tech products export to industrial exports, %	PCT patents applications/million pop.
	Y5	X1	X2	X3
2013	54	2.46	4.134	2.9
2014	50	0.634	4.129	3.2
2015	59	3.351	3.994	3.6
2016	59	3.689	3.295	3.9
2017	60	2.165	2.795	3.6
2018	58	2.6	2.900	3.7
2019	60	3.2	2	3.9
Results of multiple regression analysis between the Digital Competitiveness Index (IMD WDCR) and selected factors				
Multiple R			0.916997	
R^2			0.840884	
F			5.284739	
Significance F			0.102451	
Y			51.52405	
X1			2.106491	
X2			–1.71027	
X3			1.651747	

Source: own calculations based on [10]

Correlation analysis has showed the importance of taking into account the impact of chosen factors on the level of innovative development of Ukraine. The presented method can be applied in leveling breaks in the innovative development of Ukraine at the stage of activation of EU integration processes.

3.5 MANAGEMENT OF BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

Further process of Ukraine's integration into the EU economic space is a priority path of development. In order to achieve its most effective scenario, it is necessary to develop

a clear management of breaks in the innovative development of socio-economic systems on the example of Ukraine.

Weaknesses of Ukraine's innovative development are: the country's economy, which plays the role of a resource donor and takes a negligible part as a subcontractor in the scientific and technical sphere; lack of a unified and clear system of state support for entrepreneurship; low level of investment in research and development, especially in enterprises; rising unemployment; the innovative potential of regions to attract foreign capital is used too poorly; the development of science takes place separately from economic needs; low level of cooperation between the science sector and business, which is not yet strategic; the problem of fragmentation of entrepreneurship, which results in the complexity of major innovation projects; most businesses are focused on survival rather than the development and implementation of innovation strategies; the results of research activities are poorly confirmed by foreign publications and patents; low level of innovation culture of societies; educational programs in higher educational institutions are not sufficiently adapted to the needs of the labour market; a small share of business entities in international competitions and programs [46, 47].

Thus, the main goals of break management in the innovative development of Ukraine are to increase innovation activity and improve the results of innovation.

To achieve these goals, the management system should: be based on the ability to predict the consequences of the implementation of decisions and on this basis to adjust management actions taking into account the situation; be multivariate, nonlinear and situational, so that it is possible to compare management actions with trends in the socio-economic environment.

Given the priority role of industry in ensuring and regulating innovation development, the main directions of state policy of innovation development at the present stage should be: determining the main directions of innovation breakthrough based on a comprehensive analysis of global trends, technological forecasting and careful analysis of existing innovation potential; providing favourable conditions for technological modernization of the production base of enterprises, increasing innovation efficiency and investment attractiveness of production; adoption of the concept of partnership of the state, scientific community in achievement of parameters of the state branch programs and projects of formation of the internal market of consumption of food and expert potential of science-intensive production; creation of an effective infrastructure for the generation of scientific knowledge and the implementation of innovative processes aimed at forming a market for science-intensive products in accordance with consumer demand; increasing the role of regions in the development of innovation processes, methods of promoting innovation. Therefore, at the state level it is necessary to ensure the formation of regulatory framework and information and analytical support of the market, monitoring and forecasting of market conditions, strict control over product safety and implementation of European product quality standards. In modern conditions, the innovative development of production enterprises is possible only on the basis of an appropriate model, which should take into account the regional characteristics of production and opportunities for innovative development.

The formation of an innovative model of production development is a systemic problem and requires a comprehensive solution to a number of problems: gradual increase in funding for regional production science from all sources to promote the transformation of priority industries in the region in high-tech developments and effective investment policy; increasing the effectiveness of regional-branch science and creating a powerful package of competitive innovations (modern technical complexes adapted to the conditions of a particular region); formation of economic mechanisms to stimulate demand for innovative products, preferential lending of resources and credit support, preferential taxation of innovative projects; increasing the level of capitalization of intellectual property through the introduction of its objects into economic circulation and further use of the obtained results to finance research and development; creation of a flexible modern regional innovation infrastructure capable, together with the relevant national infrastructure, of providing a rapid transition from basic and applied research to the practical application of their results.

In addition, in the process of managing breaks in innovation development in Ukraine, it is necessary to create a clearly defined concept of further innovation development and economic security and focus on creating a favourable business environment, harmonizing the government system, reducing the class break, eradicating corruption and attracting new investment [48].

Due to this, the urgent task is a scientifically sound study of break management systems, its organizational structures, mechanisms that ensure the balance of the management system and meet modern market needs. Understanding the conceptual essence of management as a complex system will make it possible to solve problems of optimization of management processes, increase their efficiency.

Too large a list of objects related to the management of breaks in the innovative development of Ukraine, makes us think about the question, what unites all these objects, on what influences depends on their innovative development, what are the differences in their properties. Such parameters in terms of a systems approach are: structure, interaction with the environment, goals and objectives of management. Based on this, it is possible to select the following control objects:

1. Since the socio-economic system is based on human activities, the decomposition of the socio-economic system to lower levels of the system we get as one of the components – man, i.e. in management it is necessary to influence people, therefore, use appropriate approaches, principles and methods. Therefore, to build an innovative model of economic development requires special attention to the development of human capital as the foundation of society.

2. Since we are talking about management, the methods and approaches of general management theory can be used to manage breaks in the innovative development of the socio-economic system.

3. Improving the results of innovative development includes elements of the economy, so when managing breaks in the innovative development of socio-economic systems using methods used in economic fields of science. This management system should encourage the subjects of the national economy to innovate and invest in innovation in order to increase the supply of innovative products, technologies and knowledge.

4. The concept of innovative development and economic security, creating a favourable business environment, eradicating corruption and attracting new investment is a complex large system,

characterized by a large number and variety of its constituent elements. A large system is usually characterized by numerical management arrays, which should help diversify the organizational forms of the national economy, ensure cooperation of small, medium and large enterprises, support leading large enterprises and associations that can implement national innovation priorities, development of research and production cooperation, industrial and financial integration.

5. A complex system is characterized by the fact that the control object usually behaves anti-intuitively, there is no mathematical description of the operator of the control object, because it is non-stationary and can be difficult to identify. Usually, the patterns of behaviour of the system are determined by its structure and characteristics of the elements, as well as the conditions of operation.

Thus, attempts to determine the patterns of development of socio-economic systems, which can be described by mathematical models, have scientifically sound prerequisites. Currently, a fairly large number of economic laws of development and behaviour of socio-economic systems of different levels. Based on the system and process scientific approaches in [49] proposed a methodical approach to modelling the process of supporting transformational management decisions, based on a kind of management tools – a bank of methods and models that allows to prepare, make and maintain management decisions based on model building transformation in accordance with the situation at the facility.

Management of breaks in the innovative development of socio-economic systems is an organized management [50], which focuses on the rapid disclosure of obstacles to innovation and the formation of prerequisites for continuous monitoring and their timely overcoming to restore the viability of businesses on an innovative basis.

The process of managing breaks in innovation development involves: analysis of the state of the macro- and micro-environment and the choice of the best strategy for the socio-economic system; disclosure of economic measures, management actions to identify obstacles to innovative development, the formation of a system for monitoring the environment of economic entities to identify breaks; strategic controlling of innovation activity of social and economic systems; prompt assessment and analysis of the financial condition of economic entities in order to identify the possibility of curtailing the innovation process; policy development in the conditions of curtailment of the innovation process and removal of business entities from this state; constant accounting of innovation risk and development of measures to reduce it.

The classification of strategies of innovative development of economy, which includes diffusion of innovations, the state support of innovative forms, the local innovative environment, intersectoral scientific and technical clusters, commodity cloning, license copying, self-development, strategy of advanced development, strategy of sustainable development, strategy of local development is resulted in work [51] and their characteristics will allow using methods of break management in the innovative development of socio-economic systems to establish cooperation between all participants in the innovation process, which promote innovation at all stages of creating and bringing an innovative product to market and solve the problem of building an innovative economy with developed entrepreneurship, innovation and high productivity in the areas [52].

This will make it possible to address the issue of creating innovations in these areas, namely: to increase funding for research on a competitive basis, focusing on the transition of results obtained in basic research in the field of applied research and scientific and technical development, to finance which business is involved; to review the priority directions of development of science and technology in order to bring them closer to the directions identified in the developed countries of the world, on the basis of modern world technological trends; to create within the settlements places intended primarily for the development of intellectual, creative activity, innovation movement, development of creative industries (including the allocation of territories, the creation of appropriate infrastructure, providing information-analytical and methodological support for innovation culture); to create, with the involvement of world experts, trainers, mentors, the European Entrepreneurship Network (EEN), schools of exchange of experience and national resources for entrepreneurship and innovation training, including in-service training networks for both teachers and heads of higher education and research institutions; improve the quality of education by bringing it closer to the needs of the global market and the needs of professionals capable of creating, adapting and using technological innovations, supporting the implementation of disciplines in entrepreneurship, financial literacy and intellectual property protection.

Taking into account the data obtained at each stage of the study, the results of calculations and correlation-regression analysis, the following recommendations can be made for managing breaks in the country's innovative development in the framework of EU association and transformation: development of an effective and clear strategy increase financial support for innovation and modernization of Ukrainian industries in order to increase the competitiveness of Ukrainian goods in the markets of the countries under consideration and diversify mutual trade, increase R&D expenditures and research funding to increase Ukraine's innovative development and attractiveness for cooperation in this field, development and implementation of joint educational programs, research and technical projects, etc.

CONCLUSIONS

The analysis of world rankings has shown that innovative competitiveness of Ukraine is determined by comparative factor advantages in coverage of higher education, availability of scientific staff and quality of research institutions, but breaks in the innovative development are caused by low state support, lack of stability and problems in institutional development hamper the country's innovative potential.

Ukraine remains predominantly an importer in the global market of high-tech products, because its foreign trade in high-tech products is characterized by low share of these products in total exports of the country and a significant trade deficit. It has only small comparative advantages in the markets of foreign countries in such high-tech products, as aircrafts, space crafts and their parts.

The conducted cluster analysis indicates that Ukraine is now in the same cluster with the countries Bulgaria, Romania, Poland, and Latvia that have not yet fully adapted their economies to the level of innovative development of the leaders of the countries. The strengths of Ukraine in the European competitive environment include innovation-friendly environment and labor.

Thus, the modeling and forecasting of the development of the main indices, which determine breaks in the innovative development of Ukraine, showed and made possible the following authors' recommendations for leveling these breaks:

1. It is required to ensure an increase in the number of such graduates by creating and improving research centers at the universities.

2. It is required to diagnose operation quality of research institutions, develop strategies for their improvement and achieving adequate state funding for science. The country needs the development of intellectual property legislation and support for small and medium-sized enterprises, which are the driving force behind the country's innovation activity.

3. It is required to develop a program of innovative industrial clusters, which provide for a system of incentives for participants and related fringe benefits and improve the mechanisms of state financial support of cluster development.

4. Ukraine should improve its investment climate. The state support is required for the development of high-tech industries and increase in the volume of those types of production, which revealed comparative advantage. It is necessary to increase the funding of science and development (grants, patents, etc.).

In addition, for leveling breaks in the innovative development of Ukraine, it is also necessary to:

a) increase both foreign investment and state financing by improving the country's investment climate, increasing the availability of credit resources for high-tech enterprises and creating special lending programs;

b) a broad reform of governance and basic institutions, reduction of corruption, restoration of trust in the government, a reform of the judicial system, improvement of regulatory acts and other institutional improvements;

c) reforming the state and supporting small and medium enterprises, supporting technologies based on the formation and expansion of regional cluster programs or through "smart specialization";

d) implementation of technology exchange programs, production experience, integration of Ukraine into the world scientific and technological information space, first of all within the framework of the EU.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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