Innovative Component of Countries' Competitiveness Growth

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Abstract—**The features of the innovative development of countries with different types of national innovation systems are determined in the article. Based on the use of economical and mathematical modeling and statistical analysis tools the authors carried out the assessment of innovative development factors impact on ensuring the counties' economic growth. Connection between the level of innovation development and the level of competitiveness is identified. It is proposed to conduct the clustering of countries in the form of a matrix illustrated links between innovativeness and competitiveness. Strategic directions of the counties' innovation development in the context of their influence on the international competitiveness level are substantiated.**

Keywords—innovations, innovation development, competitiveness growth, competitiveness level

I. INTRODUCTION

In recent years, the exclusive majority of researchers consider innovations a key factor in economic growth. That is why many research papers are devoted to theoretical and empirical research on the role of innovation and their impact on the economic growth of countries and their level of international competitiveness and learning by doing [1, 2]. It is also obvious that in today's conditions of the world economy development, those national economies that are able to provide sustainable economic growth through the development, implementation and efficient use and transfer of innovations receive significant competitive advantages.

The Global Competitiveness Report 2018 presented by the World Economic Forum emphasizes that fostering innovation requires holistic strategies that most economies have yet to master. Innovation is especially critical as a driver of productivity growth and value creation in the Fourth Industrial Revolution (4IR). It is already at the core of the growth agenda of most advanced economies and a growing number of emerging economies. But governments are struggling to understand what makes a country innovative. The new GCI adopts a broad approach guided by three principles: first, a country's capacity to innovate depends on the quality of a vast and complex ecosystem; second, innovation is a process through which ideas become successful products; third, innovation happens everywhere, not just in a laboratory, and its outcomes take many forms, from products – goods and services – to businesses and organizational models [3].

In modern conditions the drivers of growth and competitiveness change. Countries that can adopt new ideas, methods or products, that are flexible and able to adapt to changes become more competitiveness. That is why innovations can accelerate growth and development for every economy.

II. RELATED WORK

Today, there is a significant increase not only in the practical implementation of innovative technologies and processes, but also in the theoretical understanding of these trends in scientific research. The scientific papers of R. Nelson, C. Freeman, J. A. Allen and others are devoted to the study of the nature of innovation processes and the factors of their economic motivation. Such researchers as L. Zakharkina, I. Myroshnychenko D. Smolennikov, S. Pokychko [4], P.P. Iglesias Sánchez, C.J. Maldonado, De Las Heras Pedrosa [5], A. Mikhaylova, A. Mikhaylov [6], E. Yakovleva, N. Azarova, E. Titova [7], consider innovations as the result of the transformation of ideas, research, development, new or improved scientific and technical, socio-economic, political and other decisions. In their mind they contribute to improving the population quality of life and the national security by harmonizing the economic interests of economic entities, consumers and society (needs of rationalization, environmental protection issues, lower unemployment, increase the tax base, increase in average household incomes, reducing their differentiation, the growth of intellectual potential of society, increasing life expectancy, improving the competitiveness of regions, countries, etc.).

Existing models of innovation development, peculiarities of the scientific, technical and innovation policy of the leading countries in the formation and development of their own national innovation systems are investigated in the scientific papers of V. Zitek, V. Klimova [8], E. Zaitseva, S. Stradinya [9], O. Karasev, A. Beloshitsky, S. Trostyansky, A. Krivtsova [10], M. Martínez-Pellitero, M. Buesa, J.Y. Heijs, T. Baumert [11]. Attempts to assess the impact of the innovation processes development on the countries economic development are conducted in the papers of R.E. Goldsmith, G.R. Foxall [12], K. Uppenberg [13], E. Roszko-Wójtowicz, J. Białek [14]. However, further researches are necessary to define and estimate the innovation factors that have a significant influence on the dynamics of economic and competitiveness growth of the countries.

III. RESULTS

One of the most complex indicators used in world practice for assessing the level of innovation development is the Global Innovation Index (GII) [15], which is based on

ranking of 126 countries, representing 90.8% of the world's population and 96.3% of global GDP, according to the results of their innovation development. According to the GII 2018 TOP20 of the most innovative economies is represented by highly developed countries of the world, such as Switzerland, the Netherlands, Sweden, Great Britain, Singapore, the USA, Finland, Denmark, Germany, Ireland, Israel, South Korea, Japan, Hong Kong, Luxembourg, France , Canada, Norway and Australia, as well as in 2018, China entered TOP20 (17th place). Hence, among the innovation leaders, 55% are European countries, 30% are Asian, 15% are North American countries and Australia.

The results of estimating the variation and uneven distribution of innovation potential in accordance with GII in the world are presented in Table 1 and allow to state: the innovative development of the countries in the world is relatively uniform in terms of GII (the coefficient of variation does not exceed 33%), but it is characterized by a tendency to increase the variation degree. 40% of countries in the world are characterized by a GII score higher than the average of 36.67 in 2018.

TABLE I. ESTIMATION OF VARIATION AND UNEVENNESS OF COUNTRIES INNOVATION DEVELOPMENT BY THE GII

	2013	2014	2015	2016	2017	2018
GII max	66.59	64.78	68.30	66.28	67.69	68.40
GII min	19.32	12.66	14.95	14.5	15.64	15.04
GII mean	37.41	36.90	37.01	36.73	37.12	36.67
Number of countries (GII above the mean)	59	60	61	51	52	50
Share of countries (GII above the mean), %	41.55	41.96	43.26	39.84	40.94	39.68
Standard deviation	11.06	11.25	11.65	12.02	11.97	12.08
Coefficient of variation, %	29.6	30.5	31.5	32.7	32.2	32.9
Range ratio	3.45	5.12	4.57	4.56	4.33	4.55
Decile ratio	2.23	2.26	2.31	2.41	2.34	2.37
First decile	24.97	24.52	24.17	23.11	23.61	23.09
Ninth decile	55.81	55.42	55.92	55.78	55.14	54.62

The degree of differentiation in the period 2013-2018 remains almost unchanged, the GII score of the most innovative country (Switzerland) is 4.55 times higher than the indicator the least developed (Yemen). 10% of the least developed countries have GII (less than 23.09), which is 37% less than the world average, 10% of the most innovative countries - GII (more than 54.62), which is 49% higher than the world average. In accordance with the decile ratio, the GII minimum score of 10% of the most innovative countries has exceeded the GII maximum score of 10% of the least innovative developed countries by 2.37 times, with a tendency to a slight increase in the degree of differentiation (by 6.3% in 2018 compared to 2013). In general, there is no significant differentiation of the GII in the statistical sample of 126 countries.

On the basis of the statistical grouping tools (grouping with equal intervals), the differentiation of the world countries regarding the innovative development level was carried out, the results of which are presented in Table 2.

Consequently, the least innovative developed, countries, which account for 46.8%, account for 33.9% of the world's innovation potential; countries of the 3rd group (Poland, Lithuania, Croatia, Greece, Ukraine, Chile, Turkey and others), which occupy 36.39%, are characterized by an average level of innovation development and provide 22.8% of the world's innovative potential; the most developed innovative countries (5-6 groups 18.3%) provide 28.2% of the world's innovation development. The 4th group of countries (Estonia, Belgium, Malta, Czech Republic, Italy, Portugal, OAU and others), with have a level of innovative development above the average, but not as high as in the TOP20 countries, provide 15% of the world's innovation potential.

TABLE II. RESULTS OF COUNTRIES GROUPING BY THEIR INNOVATION DEVELOPMENT LEVEL (GII 2018)

	Groups of countries according to their innovation development level (GII)	Number of countries	Mean of GII in groups	Share in number of countries, %	Share in innovation development level, %	Coefficient of localization (CL), %
1	The least innovative countries (GII 15,04-23,93)	17	21.42	13.5	7.9	58.4
2	Less innovative countries (GII 23,93-32,83)	42	28.63	33.3	26.0	78.1
3	Countries with average level of innovation development (GII 32,83-41,72)	29	36.39	23.0	22.8	99.2
4	Countries with level of innovation development above average (GII 41,72-50,61)	15	46.32	11.9	15.0	126.3
5	Higher innovative countries (GII 50,61-59,51)	16	54.37	12.7	18.8	148.3
6	The highest innovative countries (GII 59,51-68,40)	7	62.03	5.6	9.4	169.1
	Total	126	36.67	100.0	100.0	-

According to the calculated coefficients of localization, the world's innovative potential is concentrated mainly in countries of 4-5 groups (CL> 100%). At the same time, the calculation of the concentration coefficient that equals to 13.1% (high concentration at CC ≥ 40) indicates a relative insignificant concentration of the innovation development level and confirms the thesis about the relatively uniform nature of the countries innovative development based on the GII. Such a relative uniformity of innovation development is due to the nature of the GII indicator itself, which is a multi-dimensional assessment of the innovation activity results, which, in addition to ensuring the complex nature of the assessment, leads to the averaging of the integral level of innovation development.

The distinction of the innovation development features may be due to the differentiation of innovation development models. Based on national peculiarities and economic potential, in modern studies, four models of national innovation systems are singled out: the traditional or the "triple helix" model; Euro-Atlantic model; East-Asia model, alternative models.

Thus, the main differences in the countries' models of innovation development are related to the developing innovations possibility from the idea to its practical implementation and the availability of appropriate support and promotion infrastructure, the level of interaction between science (universities), the government and business, including in terms of innovation activity financial provision, the ability to independently generate ideas in certain segments or effectively borrow and implement technology.

In order to assess the influence of innovative factors on the dynamics of economic development (the rate of economic growth of the countries) taken into account in the GII, seven countries were selected based: the USA, which corresponds to the model of the triple spiral; Great Britain (large developed European country) and Switzerland (small developed), as those implementing the Euro-Atlantic model of innovation development; Singapore and China, which are leaders in the GII 2018 among the countries with the Asian model and characterized by the rapid pace of creating a knowledge economy. Among the countries with an alternative model of the innovation system, countries from different continents, namely, Turkey (the country of West Asia) and Chile (the country of South America), were identified as leaders of such a model with the GII rating of 2018.

In order to analyze the relationship between the system of indices of countries innovation development and the dynamics of their economic growth (GDP), a multiple correlation analysis was conducted. As a result of the analysis, the most significant innovation factors that most influenced the dynamics of the economic growth of selected countries in the framework of models of national innovation systems were determined (Table 3).

TABLE III. THE MOST SIGNIFICANT FACTORS INFLUENCING THE DYNAMICS OF COUNTRIES ECONOMIC GROWTH WITHIN THE FRAMEWORK OF THE NATIONAL INNOVATION SYSTEM

Model	Country	Innovation factors (correlation coefficient)
The model of «triple helix»	USA	ICT services imports, % total trade (0.71), GERD financed by business, % (0.64), Venture capital deals/bnPPP$ GDP (0.64)
Euro-Atlantic model	Great Britain	Researchers, FTE/mn pop. (0.92),Venture capital deals/bnPPP$ GDP (0.77), GERD financed by business, % (0.64)
	Switzerland	PCT patent applications/bn PPP$ GDP (0.78), GERD financed by abroad, % (-0.77), Researchers, FTE/mn pop. (0.77)
East-Asia model	Singapore	ICT services imports, % total trade (0.87), Patents by origin/bn PPP$ GDP (0.82), Intellectual property receipts, % total trade (0.61)
	China	ICT services exports, % total trade (-0.92), GERD financed by abroad, % (0.88), Patents by origin/bn PPP$ GDP (-0.87)
Alternative model	Turkey	ICT services exports, % total trade (0.81), High-tech exports less re-exports, % total trade (0.80), Patents by origin/bn PPP$ GDP (0.73)
	Chile	ICT services exports, % total trade (0.90), GERD financed by abroad, % (0.81), Patents by origin/bn PPP$ GDP (-0.71)

From the analysis, it's possible to draw the following conclusions regarding the functioning and development of modern NIS:

1) Studies of the traditional model demonstrate that the dynamics of economic growth in the United States is determined by the factors of innovative input, which indicates the large available resources and conditions for innovation. The moderate correlation with the GDP growth rate of factors such as R&D financed by private business and the value of venture capital transactions further demonstrate the features of this model, namely the large number of venture funds and the significant role of firms, not the state, in the financial provision and support of innovative ideas.

2) The analysis of the Euro-Atlantic model shows that the economic growth of such countries is also driven by the factors of innovation input, namely the number of researchers (direct very strong link), venture capital (direct strong), R&d financed by private business (direct moderate); patent applications (direct strong); R&D financed abroad (reverse strong link due to the fact that innovative developments financed outside national borders affect the acceleration of the dynamics of innovation growth of another country, not the investor country). One can see a strong similarity between the «triple helix» model and the Euro-Atlantic model of large European countries, as evidenced by the same innovative factors influencing the dynamics of economic growth. This also confirms the peculiarity of this type of system, namely, the presence of numerous innovation centers, venture funds, which just carry out financing, conclude patent and venture transactions and combine the rich human resources of researchers.

3) The East-Asian model show that factors influencing the dynamics of GDP growth are not only factors of innovative input, but also of output (patents by origin, exports of ICT services, proceeds from intellectual property). But at the same time, countries show completely different results of the analysis. Thus, in these conditions, the dynamics of China's growth are caused by the export of ICT services (the presence of a reverse strong link), the number of patents (strong reverse link) and R&D financed abroad (direct strong link). The reverse link of some indicators can only be explained by the slowdown in China's economic growth, as opposed to the growth of innovative indicators. In the case of Singapore, its growth is driven more by the factors of innovation results, namely the proceeds of intellectual property and patents of origin in value terms. The analysis confirms that the NISs of these countries are focused on technical innovations and the latest technologies, and not on the production of fundamental knowledge.

4) According to an Alternative model, it should be noted that the economic growth of these countries is also determined by innovative factors of input and output, which confirms the importance of scientific and creative results for the countries. Turkey and Chile are developing countries, which is why their own scientific results and the transition to an innovative model of development are very important for them. Thus, in these conditions, the dynamics of growth in Turkey is determined by the import of ICT services, which allows improving the quality of own developments (direct

strong link), export of high technologies (direct strong link) and patents by origin (direct strong link). In the case of Chile, its economic growth will be accompanied by an increase in patent applications (direct very strong link), intellectual property payments (direct strong link) and a decrease in R&D financed by firms abroad (reverse strong link). The growth of financing of foreign R&D will lead to a decrease in GDP, which once again confirms the importance of investment in their own ideas and developments.

Each of the models has its own characteristics, advantages and disadvantages, which are also confirmed by the results of the correlation analysis carried out. Thus, a certain similarity between the Euro-Atlantic model and the triple helix model is seen, which is expressed in the completeness of the innovation cycle, the role and place of the state in the regulation of innovation processes, the features of financial support for new technologies and methods of stimulating innovation activity. Also, drawing parallels between the Asian and alternative models, it can be noted that in some ways they are similar, but the advantage of the first is the most effective interaction of the main stages of the innovation process from the beginning of concept development to the organization of mass production, selection and rapid dissemination of innovative ideas.

An assessment of the relationship between the level of innovation development and the level of competitiveness of

the countries showed a close direct relationship between the GII and GCI indices (2018), which is estimated by the correlation coefficient, which is equal to 0.91 (Fig. 1).
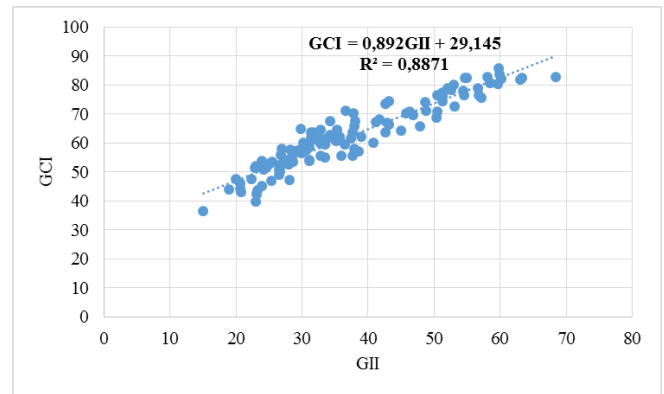

Fig. 1. Regression model illustrated connection between the level of innovation development and the level of competitiveness

Thus, the growth of the level of innovation development by 1% causes an increase in the level of competitiveness by 0.892% (based on a sample of 122 countries included in both ratings). Variation in the level of competitiveness is explained by 88.71% variation in the level of innovation development.

COMPETITIVENESS		Very low	Low	Below average	Above average	High	Very high
	Very high					Denmark, Germany, Korea, Japan, Hong Kong, France, Canada, Norway, Australia, New Zealand **(correlation 0.58)**	Switzerland, Netherlands, Sweden, United Kingdom, Singapore, USA, Finland **(correlation 0.10)**
	High			Chile, Qatar	Estonia, Spain, Belgium, Italy, Czech Republic, UAE, Slovenia, Portugal, Malaysia **(correlation 0.04)**	Ireland, Israel, Luxembourg, China, Austria, Iceland **(correlation 0.37)**	
	Above average		Oman, Peru, Bahrain, Indonesia Philippines, Kazakhstan, Mauritius **(correlation -0.25)**	Poland, Lithuania, India, Greece, Thailand, Turkey, Russian Federation, Romania, Costa Rica, Mexico, Kuwait, Saudi Arabia, Uruguay, Colombia, Brunei **(correlation 0.59)**	Malta, Cyprus Hungary, Latvia Slovakia, Bulgaria **(correlation 0.61)**		
	Below average	Algeria	Armenia, Panama, Morocco, Bosnia and Herzegovina, Egypt, Kenya, Jordan, Albania, Argentina, Jamaica, Sri Lanka, Macedonia, Azerbaijan, Dominican Rep., Paraguay, Lebanon, Botswana, Ecuador, Guatemala, Kyrgyzstan, **(correlation 0.59)**	Croatia, Ukraine, Viet Nam, Moldova, Tunisia Montenegro, Mongolia, Serbia, South Africa, Georgia, Brazil, Iran, **(correlation 0.15)**			
	Low	Cameroon, Bolivia, Bangladesh Nigeria, Zambia, Côte d'Ivoire **(correlation 0.23)**	Tanzania, Namibia, Cambodia, Rwanda, Senegal, Tajikistan, Uganda, El Salvador, Honduras, Ghana, Nepal, Pakistan **(correlation -0.21)**				
	Very low	Mali, Zimbabwe Malawi, Guinea, Mozambique Benin, Burkina Faso, Yemen **(correlation 0.54)**					
		Very low	Low	Below average	Above average	High	Very high
		INNOVATIVENESS					

Fig. 2. Countries groups according to connection between innovation development and competitiveness

In order to take into account the peculiarities of countries with different levels of innovative and competitive development, it is proposed to conduct the clustering of countries, presenting them in the form of a matrix that associates the parameters studied. The results are presented in Fig. 2.

Thus, moderate correlation was found among the groups of countries with a high level of innovation development and a very high level of competitiveness (10 countries, the second group of ten countries from TOP20), in a group of countries with a level of innovation and competitiveness above average levels (15 countries), in a group of countries with low level of innovation development and competitiveness below the average level (21 countries). According to the countries' systematization results of the, it can be offered the following options for their further development. For countries that have very low, low and below average competitiveness and innovation, it is appropriate to focus on finding other sources of competitiveness and engage in innovative development as high technology consumers. Also the focus of policies should be the achievement of macroeconomic stability and the establishment and improvement of the basic institutions underpinning the modern market economy. Korea, Singapore, and Taiwan are examples of economies that have made the transition to the innovation stage in a relatively short span of time; indeed, Taiwan has made the transition from an agricultural economy with low income per capita to a prosperous global industrial ICT powerhouse in less than 40 years, an impressive achievement [16].

For countries with a combination of competitiveness and innovation the above average, high and very high it is expedient to identify the segments in which they have the greatest advantages and strengthen their positions and have a more diversified export portfolio. The governments of these countries in the context of democratic institutions and processes are called upon to preserve the gains made over the previous decades in terms of macro management and institutional development.

IV. CONCLUSION

Consequently, active innovation development is an important benchmark for the country's economic development, caused by current global challenges. Countries, regardless of their development level and competitiveness level, are involved in innovation processes, as evidenced by the growth of their positions in the global innovation ranking and the relatively low variation of the GII scores. The most innovative countries, having their own national innovation systems, characterized by certain peculiarities of functioning, determine certain orientations of innovation dynamics, while other countries, mainly the Asian region countries, are setting relatively high rates of innovation development dynamics. The systematization of countries based on the assessment of the connection between innovation and competitive development is offered, that allows to determine the strategic development peculiarities, taking into account the innovation impact on the level of competitiveness. The results of study can be used in practice for differentiating vectors of innovation development and taking into account country's and regional features in ensuring sustainable economic

growth. Revealing the relations between the level of competitiveness on innovation development allows modeling the impact of innovations on competitive growth, can be taken into account in the future research aimed to assess and analyze the characteristics of the dependence between indicators of countries groups with different types of innovation development and their competitiveness growth.

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