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Empirical analysis of determining the influence of the level of innovative development on the economy of world countries

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Abstract. This study analyzes the relationship between the Global Innovation Index (GII) and GDP per capita for the countries of the world, developed in cooperation with the International Business School (INSEAD), Cornell University (Cornell University) and the International Intellectual Property Organization (WIPO). This relationship was determined using correlation-regression analysis. According to the results of the analysis, the average level of the GII index in the appropriate groups of countries according to their incomes increased with the increase in GDP per capita. This fact proves that innovation is an important factor in the economic development of countries and policymakers should pay more attention on research and development to achieve innovatitive development.

1 Introduction

By the 21st century, not only the economies of developed countries, but also most developing countries, especially China, India, Russia, and Brazil, have shown that they accept the idea that "innovation is a driving force for economic growth and is essential for maintaining the viability of enterprises" [1]. The primary task of developing the country's economy at a stable pace is the structural modernization of the economy, support and stimulation of innovative activities, and the formation of an innovative economy.

In the conditions of the transition to an innovative economy, the dynamics of economic development and the level of population well-being, national security, and the possibility of equal integration into the world economy are mainly determined by the introduction of modern innovative technologies into economic sectors, social and other fields, with the wide application of the country's scientific and technical achievements.It is not difficult to better understand that innovation is now happening not only in high-tech companies and technology industries, but in all sectors of the economy [2].

Today, the rapid development of all spheres of society and state life in the countries of the world requires the implementation of reforms based on modern innovative ideas,

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developments and technologies that ensure rapid and qualitative progress towards economic and social progress. Of course, calculation, evaluation and analysis of new innovative data and indicators generated in the process of implementation of these reforms, making or taking appropriate decisions based on them is the main aspect of the issue.

1.1 Literature review

One of the drawbacks of innovation indices is that they cannot accurately reflect or account for area-based innovative development because the majority of them concentrate on the national level. As a result, these indicators might not be able to inspire novel concepts that are more pertinent in particular fields than they are on a global scale [3]. Anbumozhi et al. [4] analyzed building innovative, inclusive and resilient global value chains during COVID-19 and stated that Innovative, Inclusive, and Resilient Value Chains are a type of comprehensive planning that aims to improve their ability to adapt in order to anticipate unforeseen events, respond to disturbances, and recover from them. Chuanglin et al. [5] studied the impact of innovation on sustainable development in cities of Chine and concluded that inventive cities play a crucial role in building an inventive nation, creating new types of urban development, and promoting urban sustainable development. They not only serve as a foundation for innovation activities. Grevtsev [6] carried out research on Estimation of a Country’s Economic Development on the Basis of the Global Competitiveness Index. By investigating the competitiveness of macroeconomic objects at different hierarchical levels he analysis of a country’s competitiveness is presented on the basis of the global competitive index and offered an integral indicator of a branch of industry’s competitiveness potential according to seven main factors that permit numerical estimation. For the being time through increased energy efficiency and effective use of energy at both the macro and micro levels, innovation has emerged as a crucial component in attaining sustainable growth [7].

Theoretical and practical aspects of systems for evaluating the level of innovative development of the countries of the world were studied in the works of foreign economists I. Bil, K. Falkovskii, A. Kovalskii [8], T. Kaliari, T. Chiarini [9] and similar scientists. Their scientific research showed that new knowledge, human capital resources, business environment factors are important elements of the country's national innovation system, and as a result of the statistical analysis of these factors, integrated indicators were formed, and calculation of the country's innovative development level using the "diagram surface" method was reflected.

T.S. Kolmykova, S.G. Emelyanov, E.A. Merzlyakova [10], N.I. Komkov [11], E.V. Popov, D.M. Kochetkov [12] and studied in the scientific works of others. In assessing the innovative potential of the country, they first analyzed the innovative activity of the regions, and in this regard, this calculation studied from the point of view of creating and using innovations. Based on the available statistical indicators in the fields of innovation and technology, science and education, and information and communication technologies, normalization and formation of innovation creation and innovation use indices of the regions using the "Min-Max" method, analysis of the innovation development index of the regions using the Sturgess formula, in the future In order to justify the use of specific tools in the process of developing the scientific and technological development strategy of the regions and countries and carrying out the innovation policy, attention is paid to issues such as identifying the strengths and weaknesses of the regions in terms of innovative development based on the indices formed and analyzed.

The analysis of determining the impact of the level of innovative development on the economy of the countries of the world is influenced by a significant number of factors, among which one can distinguish the level of development of digital technologies [19], the introduction of artificial intelligence [20-22], bioprint technologies [23], protection of various data [24], neurotechnologies [25], robotics technologies [26], identification technologies [27], grant support for business [28], measures to increase competitiveness [29], socio-economic development regions [30, 31], innovative technologies [32], digitalization of the economy [33], decision-making systems [34], technological development [35], intellectual capital development [36], investment attractiveness [37], management efficiency [38], resource allocation [39], business behavior [40], and forecasting of business processes [41].

2 Materials and methods

Correlation analysis is based on determining correlation coefficients and evaluating their importance and reliability. If the links are linear, then the correlation coefficient can be used to estimate the link density:

$$r = \frac{\overline{x \cdot y} - \overline{x} \cdot \overline{y}}{\sigma_x \cdot \sigma_y},$$

In this place, σ_x and σ_y respectively x and y the mean squared deviations of the variables, and they are calculated using the following formulas:

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2}{n}}, \quad \sigma_y = \sqrt{\frac{\sum_{i=1}^{n}\left(y_i - \overline{y}\right)^2}{n}}$$

Also, the following modified formulas for calculating the correlation coefficient can be used:

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{n \cdot \sigma_x \cdot \sigma_y} \quad \text{or} \quad r = \frac{n\sum_{i=1}^{n} xy - \sum_{i=1}^{n} x \sum_{i=1}^{n} y}{\sqrt{\left[n\sum_{i=1}^{n} x^2 - \left(\sum_{i=1}^{n} x\right)^2\right] \cdot \left[n\sum_{i=1}^{n} y^2 - \left(\sum_{i=1}^{n} y\right)^2\right]}}.$$

The coefficient of determination is equal to the square of the correlation coefficient. The correlation coefficient (r) ranges from -1 to +1. If there is no relationship between the factors, then there is a positive relationship - there is an inverse relationship, there is a functional relationship.

The degree of bond density is usually interpreted as follows. If

Until $0{,}2$ – weak link;

$0{,}2 \div 0{,}4$ – binding that is weaker than the average density;

$0{,}4 \div 0{,}6$ – average binding;

$0{,}6 \div 0{,}8$ – tighter than average binding;

$0{,}8 \div 0{,}99$ – close connection.

Regression analysis makes it possible to assess the effectiveness of the characteristics that affect the resulting characteristic with sufficient accuracy in practice. With the help of regression analysis, it is possible to estimate the prediction values of socio-economic processes for future periods and determine their probability limits.

In regression and correlation analysis, the regression equation of the relationship is determined and it is estimated with a certain probability (confidence level), and then an economic-statistical analysis is performed. Often, several functions are suitable to represent the correlation pattern at the same time, so it is better to finally justify the choice of functions to represent the pattern of correlation on an alternative basis. Usually, the following functions are used in the study of connections between socio-economic processes [13]:

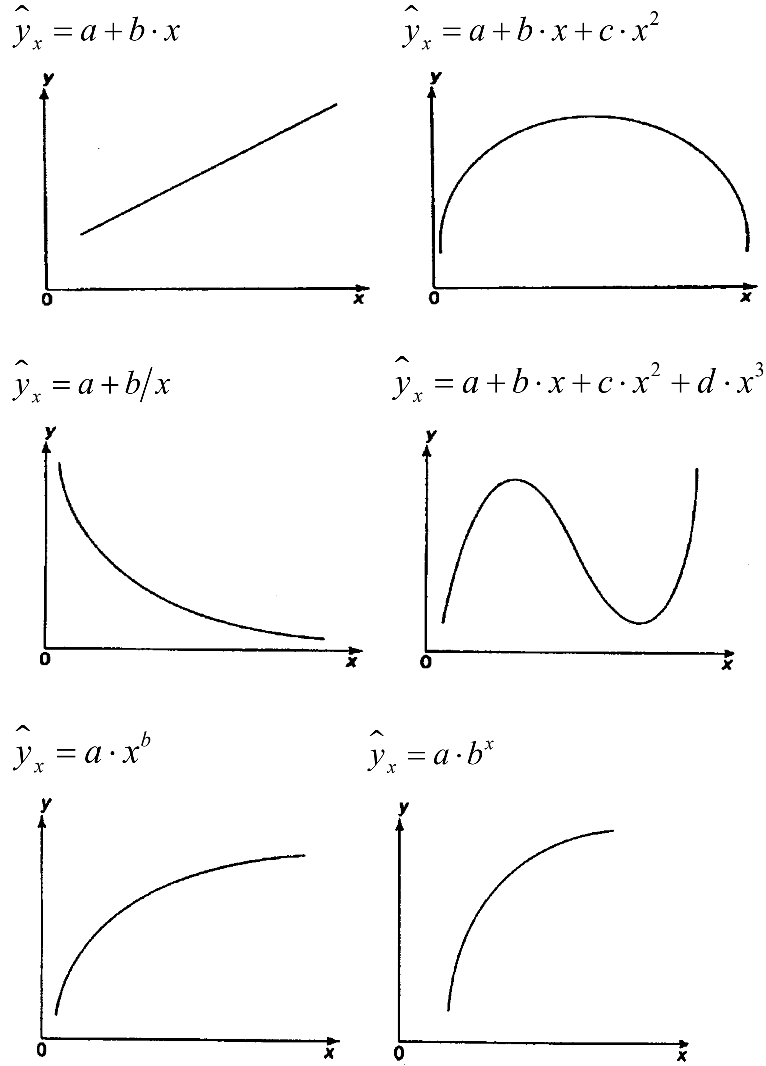

Fig 1. Functions and their graphs representing the relationship between independent and dependent variables.

The linear form of regression is the simplest form in terms of understanding, interpretation and calculation techniques.

A linear pair regression equation generally looks like this:

$\hat{y}_x = a + b \cdot x$ or $y = a + b \cdot x + \varepsilon$

here

a, b - model parameters;

ε - random variable.

The content of the parameters of the linear pair regression model:

a - free coefficient of the regression equation. It has no economic meaning, and the factor is the sign, if $x = 0$, y displays the value of the resulting character.

b - regression coefficient if the variable (factor sign) is changed by one measurement unit, y the resulting symbol indicates how many units of measurement the average changes.

ε - is a normally distributed random variable. Constant dispersion residual, y change is not depended on x change. Because there are other factors involved that are not considered in this model.

estimation of model parameters a and b is carried out by the method of least squares (Least Squares). The essence of (OLS) is that, y is calculated according to the regression equation of the actual (true) values of the resulting characterIt is found that the sum of the squared deviations from the (theoretical) values of $\hat{y}_x$ will be the smallest, i.e.:

$$\sum_{i=1}^{n}\left(y_i - \hat{y}_{x_i}\right)^2 = \sum_{i=1}^{n}\varepsilon_i^2 \rightarrow \min$$

It can be seen in thus graph:

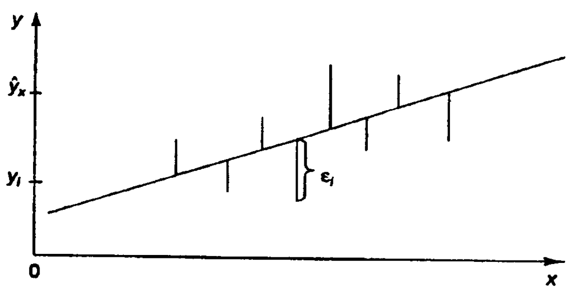

Fig 2. Regression line and least variance residuals [14].

To find the parameters of a linear pairwise regression equation by the method of least squares of S a and b we find the first-order derivative of , then the system of normal equations will have the following form **[15]**:

$$S(a,\ b) = \sum\left(y - a - b \cdot x\right)^2$$

$$\begin{cases} \dfrac{\partial S}{\partial a} = -2\sum\left(y - a - b \cdot x\right) = 0; \\ \dfrac{\partial S}{\partial b} = -2\sum x\left(y - a - b \cdot x\right) = 0. \end{cases}$$

$$\begin{cases} a \cdot n \quad + b \cdot \sum x \ = \sum y; \\ a \cdot \sum x + b \cdot \sum x^2 = \sum x \cdot y. \end{cases} \tag{1}$$

(1) The system of equations is solved with respect to a and b. As a result of solving the system of equations, ready-made formulas for finding the values of parameters a and b are derived:

(2) $b = \frac{\mathrm{cov}(x, y)}{\sigma_x^2}$, $a = \overline{y} - b \cdot \overline{x}$

here $\mathrm{cov}(x, y) = \overline{y \cdot x} - \overline{y} \cdot \overline{x}$ – x and y covariance of sign, $\sigma_x^2 = \overline{x^2} - \overline{x}^2$ – x variance of the sign.

3 Results

Global innovation index (GII) is widely used as a system for evaluating the level of innovative development of countries in world practice. This is because the GII covers the economies of nearly 130 countries, accounting for 91.8% of the world's population and 96.8% of the world's GDP [8].

GII is an indicator developed in cooperation with the International Business School (INSEAD), Cornell University and the International Intellectual Property Organization (WIPO).

GII is based on two group indices. The first group "Innovation Input Sub-Index" consists of indicators representing the innovative activity of the national economy, which includes five indicators. These are the following:

- institutional environment;
- human capital and research;
- infrastructure;
- market development;
- business development.

The second group "Innovation Output Sub-Index" consists of indicators that express the results of innovative activity of the economy, and it includes two indicators. These are the following:

- production of knowledge and technologies;
- creative product.

Thus, the GII general indicator is created as the average of two group indices (Innovation Input Sub-Index and Innovation Output Sub-Index).

According to the analysis of the GII rating indicators for the years 2016-2019, it was observed that developed countries were in the top ten, while Switzerland was clearly in the lead during the analyzed period. It is known that the country of Switzerland is leading in this ranking for nine years in a row (Table 1).

Table 1. According to the Global Innovation Index (GII) rating in 2016-2019. Top 10 countries

	2019 y.*		2018 y.**		2017 y.***		2016 y.****	
Rating	**Countries**	**Index (0-100)**	**Countries**	**Index (0-100)**	**Countries**	**Index (0-100)**	**Countries**	**Index (0-100)**
1	Switzerland	67,24	Switzerland	68,40	Switzerland	67,69	Switzerland	66,28
2	Sweden	63,65	The Netherlands	63,32	Sweden	63,82	Sweden	63,57
3	USA	61,73	Sweden	63,08	The Netherlands	63,36	Great Britain	61,93
4	The Netherlands	61,44	Great Britain	60,13	USA	61,40	USA	61,40
5	Great Britain	61,30	Singapore	59,83	Great Britain	60,89	Finland	59,90
6	Finland	59,83	USA	59,81	Denmark	58,70	Singapore	59,16

7	Denmark	58,44	Finland	59,63	Singapore	58,69	Ireland	59,03
8	Singapore	58,37	Denmark	58,39	Finland	58,49	Denmark	58,45
9	Germany	58,19	Germany	58,03	Germany	58,39	The Netherlands	58,29
10	Israel	57,43	Ireland	57,19	Ireland	58,13	Germany	57,94

Source: ** The Global Innovation Index 2019: Creating Healthy Lives-The Future of Medical Innovation // Switzerland.*
*** The Global Innovation Index 2018: Energizing the World with Innovation // Switzerland.*
**** The Global Innovation Index 2017: Innovation Feeding the World // Switzerland.*
***** The Global Innovation Index 2016: Winning with Global Innovation // Switzerland.*

The country of Sweden occupied the second place for three years and the third place only for one year. The USA ranked third in 2019, improving its position in previous years.

The GII ranking sees the Netherlands in the top three for the past three years, the UK every year and Singapore in the top five for the first time in 2018. In the rating of the country of Finland, there was a decrease in 2017 and an increase in the last two years. Denmark and Germany have kept their positions in the ranking stable. The country of Ireland was ranked in the top 10 for the first three years, and by 2019 it had taken 12th place. And for the first time in 2019, the country of Israel finished the ranking in the top ten.

During the analyzed years, according to the results of the research carried out by specialists in the calculation of the index, the high GII in Switzerland, Sweden, the USA, the Netherlands and Great Britain was determined to be related to the level of innovative infrastructure, the development of the business environment, creative products, and the level of production of knowledge and technologies. It can also be seen that Finland and Singapore have high levels of institutional environment, human capital and research, market and business development. Denmark, Germany, human capital and research, Ireland, innovative infrastructure, and Israel, compared to the top twenty-five countries of the GII, recorded a high rate of market and business development. Singapore, Switzerland, USA, Sweden, Denmark, Great Britain, Finland, Canada, South Korea are also ranked according to the "Innovation Implementation Index", and according to the "Innovation Results Index" Switzerland, Netherlands, Sweden, Great Britain, China, USA, The countries of Finland, Israel, Germany and Ireland are leading (Table 2). If we pay attention, Canada, South Korea, China and Ireland according to the "Innovation Index" are the countries that did not enter the top ten of the GII. These countries scored high on the index of the first group included in the GII, but ranked lower on the index of the second group. For example, Canada ranks ninth, South Korea tenth, Ireland twentieth, China twenty-sixth according to the "Innovation Index", and twenty-second, thirteenth, tenth and fifth according to the "Innovation Results Index".

Table 2. Ranking of the leading countries according to two group indices included in the GII, 2019.

Countries	**Innovation Input Sub-Index**						**Innovation Output Sub-Index**		
	Institutional environment	**human capital and research**	**infrastructure**	**market development**	**business development**	**Index (0-100)**	**production of knowledge and technologies**	**creative product**	**Index (0-100)**
Switzerland	89.1	61.9	68.2	68.4	67.5	**71.02**	70.3	56.6	**63.45**
Sweden	90.1	62.1	69.1	62.1	68.8	**70.43**	61.8	51.9	**56.87**
USA	89.7	55.7	59.2	87.0	62.7	**70.85**	59.7	45.5	**52.61**
The Netherlands	90.9	52.4	61.8	58.2	63.7	**65.40**	61.8	53.2	**57.49**
Great Britain	87.1	59.3	64.4	76.0	54.3	**68.22**	56.6	52.2	**54.38**

Finland	93.6	63.4	62.1	57.3	63.9	**68.04**	55.1	48.1	**51.62**
Denmark	91.7	63.1	65.8	66.9	59.1	**69.33**	46.4	48.6	**47.55**
Singapore	94.9	63.0	65.4	73.6	63.9	**72.15**	50.9	38.3	**44.59**
Germany	86.4	63.2	62.0	58.6	56.1	**65.28**	52.7	49.6	**51.10**
Israel	77.9	54.5	56.1	61.4	66.5	**63.28**	56.9	46.3	**51.59**

Source: *The Global Innovation Index 2019: Creating Healthy Lives-The Future of Medical Innovation // Switzerland* [16].

In order to assess the importance of the above-mentioned factors in the GII indicator and to determine the level of influence in the countries that are part of the GII top ten, we will analyze the influence levels of the two groups of indexes and indicators that are part of the GII indicator on the GII indicator using pair correlation coefficients.

According to the results of the analysis, there is a very high positive correlation with the GII indicator and the indices of the two groups included in it, the correlation coefficient between the GII indicator and the "Innovation Implementation Index" is 0.96, and the correlation coefficient between the GII indicator and the "Innovation Results Index" is equal to 0.97 . Also, the correlation between the GII indicator and the existing seven indicators is very high (0.84, 0.90, 0.81, 0.80, 0.82, and 0.93, 0.94, respectively) (Table 3).

According to the table below, a high positive correlation can be seen between the "Innovation Implementation Index" and the indicators of institutional environment, human capital and research, infrastructure, market development, and business development, and these correlation coefficients are 0.82, 0.86, 0.83, 0.80, 0.78, respectively. equal to 0.85.

The correlation coefficients between the "Innovation Implementation Index" and the production of knowledge and technologies, creative product indicators are 0.63 and 0.65, respectively.

Table 3. Pairwise correlation coefficients between the GII indicator and its two groups of indices and indicators

	Global Innovation Index	**Innovation Input Sub-Index**	**Innovation Output Sub-Index**	**Institutional environment**	**Human capital and research**	**Infrastructure**	**Market development**	**Business development**	**Production of knowledge and technologies**	**Creative product**
Global Innovation Index	1									
Innovation Input Sub-Index	0.96	1								
Innovation Output Sub-Index	0.97	0.82	1							
Institutional environment	0.84	0.86	0.67	1						
Human capital and research	0.90	0.83	0.66	0.62	1					
Infrastructure	0.81	0.80	0.65	0.67	0.64	1				
Market development	0.80	0.78	0.60	0.55	0.57	0.52	1			
Business development	0.82	0.85	0.72	0.69	0.68	0.65	0.58	1		
Production of knowledge and technologies	0.93	0.63	0.90	0.61	0.72	0.63	0.55	0.75	1	
Creative product	0.94	0.65	0.92	0.70	0.69	0.70	0.57	0.71	0.74	1

Source: Authors' development based on the date of https://www.globalinnovationindex.org/analysis-indicator [17].

"Innovative results index" has a high positive correlation with the indicator of production of knowledge and technologies equal to 0.90, and with the indicator of creative products equal to 0.92. It also shows a high positive correlation between the "Innovative Results Index" and the indicators of institutional environment, human capital and research, infrastructure, market development, and business development.

In addition, it can be seen that the institutional environment, human capital and research, infrastructure, market development, business development, production of knowledge and technologies, indicators of creative products have a medium and medium to strong positive correlation with each other. Based on the results of the above analysis, the change of the GII index in the GII top ten countries is almost the same as the "Innovation Implementation Index" and "Innovation Results Index", human capital and research, knowledge and technology production, and creative product indicators are at a higher level compared to the other four indicators. influenced, that is, human capital and its research activities, new knowledge and technologies, as well as the production of creative products in the above countries are highly developed.

4 Discussion

It can be seen that the GII represents the development of science in the countries, the level of use of the innovative potential in the countries. This makes it possible to analyze the place of innovative potential in the national economy.

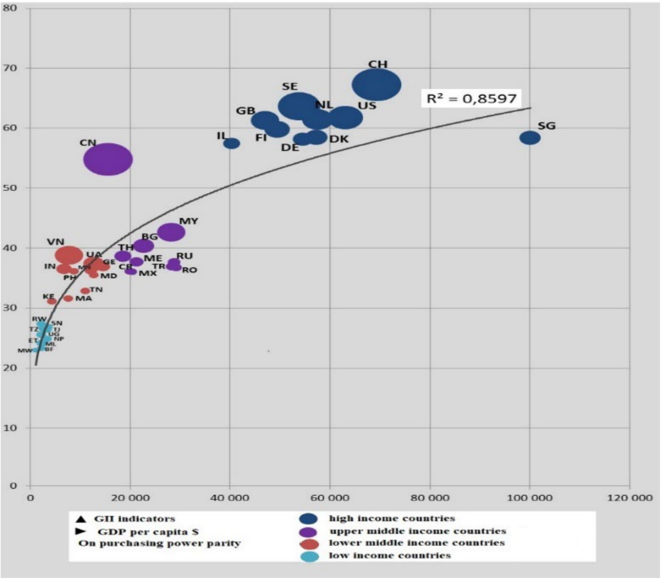

Fig. 3*. Correlation between GII indicator and GDP per capita, (pair correlation-regression analysis result)

Source: Authors' development based on the date of https://data.worldbank.org/ and https://www.globalinnovationindex.org/analysis-indicator

*Note: The names of the countries in the picture are abbreviated according to the ISO 3166-2 standard of the International Organization for Standardization (ISO), and the full names of the countries are given below:
BG (Bulgaria), BF (Burkina-Faso), CN (China), CR (Costa-Rica), DK (Denmark), ET (Ethiopia), FI (Finland), GE (Georgia), DE (Germany), IN (India), IL (Israel), KE (Kenya), MW (Malawi), MY (Malaysia), ML (Mali), MX (Mexico), MN (Mongolia), ME (Montenegro), MA (Morocco), NP (Nepal), NL (Netherlands), PH (Philippines), MD (Republic of Moldova), RO (Romania), RU (Russian Federation), RW (Rwanda), SN (Senegal), SG (Singapore), SE (Sweden) , CH (Switzerland), TJ (Tajikistan), TH (Thailand), TN (Tunisia), TR (Turkey), UG (Uganda), UA (Ukraine), GB (Great Britain), TZ (United Republic of Tanzania), US (USA), VN (Vietnam).

At the same time, the double correlation-regression analysis shows that there is a high level of correlation between the innovative potential and the level of economic development (Figure 1). In order to perform the following double correlation-regression analysis, forty countries are selected from the GII countries of 2019 and divided into four equal groups based on the World Bank's classification of world economies by income. Also, the qualifications in each group are the leading countries of their group according to the above classification. In the countries in the picture, the trend line representing the relationship between the GII index and GDP per capita is expressed in the form of a level function given by the coefficient of determination (R^2=0.8597). According to the results of the analysis, the average level of the GII indicator for the first group, that is, the group of high-income countries, was 60.76. This group includes Switzerland, Sweden, the United States, the Netherlands, and the United Kingdom, which have an above-average level of GII. The average level of the GII index for the second group is 39.77, and China, Malaysia, and Bulgaria have a much higher index in this group. The average level of the GII indicator for the third group is equal to 35.34, and the countries of Vietnam, Ukraine, Georgia, India, Mongolia, the Philippines and Moldova in this group have made an indicator slightly higher than the average level of the GII. Also, the average level of the GII indicator for the group of low-income countries, i.e. the fourth group, was 25.22, indicating that the countries of Rwanda, Senegal, Tanzania, Tajikistan and Uganda recorded a higher result than this indicator.

Based on the results of the above analysis, it can be seen that the average level of the GII indicator increases according to the income groups of countries with the increase in GDP per capita. This, on the one hand, is related to the fact that R&D requires large investments, and on the other hand, it justifies that innovation is an important factor of economic growth. A comparative analysis of the world economy shows that the leadership in the field of innovation is directly related to the expenses allocated to REDW. In particular, in 2019, the US accounted for 25.2%, China 22.5%, Japan 8%, Germany 5.4%, India 4% and South Korea 3.8% [9] of global REDW spending. The analysis of the composition of REDW expenses shows that the USA and China are the leaders in terms of the absolute amount of funds spent in this area (Table 4).

From the data in the table, it can be seen that the funds spent on REDW are increasing from year to year in leading countries and around the world. Also, the funds spent on REDW are 1.7% of the GDP per year on average worldwide, 2.3% for leading countries, and 0.95% for other countries.

There is a sharp difference between the Organization for Economic Cooperation and Development (OECD) countries and other countries in terms of expenditure per capita, which summarizes the development of national innovation activity. In particular, in 2018, in the countries of the USA, Germany, South Korea, and Japan, this indicator was equal to 1700 US dollars on average, and in the countries of China and Russia it was on average 310 US dollars [10].

Table 4. The world's leading countries in terms of OECD spending

	Countries	OECD spending in % of GDP				OECD expenditure, bln. US dollars. (Purchasing power parity on)			
		2019	**2018**	**2017**	**2016**	**2019**	**2018**	**2017**	**2016**
1	USA	2,84	2,84	2,83	2,81	596,58	565,76	537,59	512,46
2	China	1,98	1,97	1,96	1,94	532,80	499,63	444,82	400,99
3	Japan	3,50	3,50	3,50	3,55	190,65	189,51	185,53	172,32
4	Germany	2,84	2,84	2,84	2,88	128,32	126,55	114,84	112,50
5	India	0,86	0,85	0,84	0,85	95,79	89,23	76,91	72,85
6	South Korea	4,35	4,32	4,30	4,26	90,27	89,47	85,43	80,89
7	France	2,25	2,25	2,25	2,24	69,08	68,33	62,13	60,06
8	Russia	1,50	1,52	1,52	1,50	61,43	61,58	57,81	55,32

9	Great Britain	1,73	1,72	1,73	1,75	53,17	52,03	49,16	47,73
10	Brazil	1,16	1,17	1,18	1,20	39,40	39,38	37,14	37,04
Other countries		**0,97**	**0,97**	**0,92**	**0,95**	**513,30**	**507,38**	**451,17**	**436,64**
Around the world		**1,72**	**1,71**	**1,67**	**1,72**	**2 370,79**	**2 288,85**	**2 102,53**	**1 988,80**

Source: Authors' development based on the date of https://www.rdworldonline.com/ [18].

Also, the leading countries in R&D expenditures are also leading in the number of people engaged in scientific research. For example, in 2018, the number of academic staff per thousand employed people was 15.3 in South Korea, 10.9 in France, 9.9 in Japan, 9.7 in Germany, 9.4 in Great Britain, 9.3 in the United States, 5.6 in Russia, and 2.4 in China. did In addition, the government, business, higher education and private non-profit sectors are very active in the financing and absorption of REDW costs in the above countries. For example, in 2018, in countries such as the USA, Japan, Germany, and South Korea, the financing of REDW expenses was on average 71% from the business sector, 21.5% from the government, and 3.6% from the higher education and private non-profit sector. , 76.6% by the business sector in China - 29.5% in Russia, 20.2% by the government in China - 67.0% in Russia, and 1.1% by the higher education and private non-profit sector in Russia. According to statistics of 2018, the utilization rate of funds spent on OCED by sector is average in South Korea, Japan, USA, Germany, business sector - 75.3%, higher education - 12.6%, government - 10.5%, private non-profit sector - 2.3%, in the countries of China and Russia, this figure is 77.4% - 55.6%, higher education 7.4% - 9.7%, government 15.2% - 34.4%, respectively. In Russia, the private non-commercial sector accounted for 0.3% [11].

5 Conclusion

In general, the countries that are advanced in the field of innovation have achieved the creation of organic connections of innovation systems, that is, investments in human capital and development of innovation infrastructure serve to stimulate high-level creative activity.

The innovative development trends of the above countries of the world as well as the results of this research allowed us to develop the following generalized scientific conclusions and practical recommendations:

- by the 21st century, scientific and technical progress has become a decisive economic resource for sustainable socio-economic development compared to other factors of production. Advances in science and technology have provided countries with a great competitive advantage in the global economy;
- in the conditions of today's innovative development, ensuring the sustainable socio-economic development of the countries of the world requires implementation on the basis of modern innovative ideas, developments and science and technology;
- the growth of the stock of knowledge in the economy of the world countries has a positive effect on the GDP, and the growth of the GDP leads to an increase in the consumption of resources used for the formation of new knowledge;
- based on the results of our analysis, it can be seen that the average level of the GII (Global Innovation Index) indicator increases according to the income groups of countries with the increase in GDP per capita. On the one hand, this is due to the fact that R&D requires a large amount of investment, and on the other hand, it justifies that innovation is an important factor in the country's sustainable socio-economic development;
- it is necessary to further improve the innovative infrastructure to ensure the competitiveness of research results, including the transformation of practical developments into market products in order to increase the share of capitalized results;
- encourage the allocation of budget funds for research and development (R&D) in order to increase the reproduction of basic knowledge and improve the quality of "human capital";

- use public-private partnership mechanism in the field of innovation - the process of practical development and improvement of innovation infrastructure should be carried out with the participation of the state, and technological modernization should be carried out with the help of more business.

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