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MODELING RATING OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT OF THE COUNTRIES

The subject of the article is rating assessment and development of recommendations on management of scientific and technological development of the countries. The purpose of the article is to develop an index that assesses the scientific and technological potential, the results of scientific and technological activities and the pace of changes in the scientific and technological development of different countries of the world. The following tasks are solved in the article: the model of rating estimation of scientific and technical development of the countries of the world is developed; the countries of the world are classified depending on a level of their scientific and technical development; recommendations on development of scientific and technical potential of the countries depending on the chosen groups are given. The following methods are used: indexing method, ranking and grouping. The following results were obtained: the calculations possible to identify three groups of countries according to the level of their scientific and technological development: leaders, potential leaders and “overtaking” countries. Main result of the project is to promote the development of the scientific and technological potential, to demonstrate the insignificant results of the scientific and technological activity, and to reduce the low level of development of new technologies. For each of the above groups of countries, recommendations have been made for raising the level of their scientific and technological development. Conclusions: the current stage of the world`s technological development creates new opportunities for the countries of the world to ensure their sustainable growth. Therefore, the creating and maintaining the potential of scientific and technological development, coupled with an adequate government policy of economic development, opens up tremendous opportunities for the countries to ensure global competitiveness. The study presented provides general recommendations for individual countries to improve the processes of managing scientific and technological potential of individual groups of countries. The obtained results can become the basis for the concept and strategy development of scientific and technological development of different countries of the world.

Keywords: science; scientific and technological development; countries of the world rating; simulation.

Introduction

At the moment, the economic growth of countries is largely dependent on the creation of new innovative technologies and industries based on cutting-edge advances in science and scientific knowledge. Scientific and technological development is one of the main priorities of state policy in many countries of the world, so the problem of assessing and determining the level of a country’s scientific and technological development in relation to that of other countries based on ratings by various indexes is of particular importance. In the conditions of globalization of the world economy, implementation of the strategy of sustainable development of the leading economies of the world, understanding of the role of science in a particular country in comparison with that in other countries can contribute to its more dynamic development and ensuring better grounded decisions in the strategic management of the scientific and technical sphere, substantiating reasons for its support and financing.

International ratings can serve as a tool for evaluating the government performance in various aspects of their activities as compared to that of other countries. In addition, international ratings influence the governments' consistent activity for the development of their countries. International ratings show the level of a country’s development and its effectiveness in various fields, such as: innovation, information technologies, national economy, the social sphere, defining the living standards, etc.

But, as a show of analysis, there is no index, which is the result of the development of science in the rest of the world. There are many indexes, which include the evaluation of the scientific development, such as the warehouse part of the foreign indexes, which characterize the scientific and technological development, the competitive ability of the region, the level of economic development, human resources, only. That is the development of the index, which is bi-imaging mill of scientific development in the situation of intensification of the scientific knowledge on the zoom of the social-economical medium and the problems of the development of science [1], and the development of recommendations for the management of the development of scientific and technological potential of the country is relevant.

Analysis of recent research and publications

The development of the region's scientific and technological level of the development of the science of the world, on the appendix, S. Anholt, A. Gani [2], M. Desai [4], M. Porter [5], M. Shahab [6] and others.

In scientific literature, technological changes have long been regarded as one of the main drivers of economic growth (Jones [7], Broughel & Thierer [8], Komkov [9]). A large number of scientists around the world have been engaged in analyzing the factors contributing to scientific and technological development at three different levels of analysis. Macro-level studies have been considered in the social, economic, and political aspects (Uzunidis & Boutillier [10], Cozzens [11]). On the mezzanine level, the influence of the distribution of state funding for research, educational attainment, and scientific training has been studied (Porter [5]). At the microlevel, the relationships between the indicators of scientific and technological progress and the level of the researchers’ qualification, as well as between the organization of the research process and the age of the researcher have been looked into (Wang & Li [12]). Most scientists consider the levels of...
education, research and development and the amount of education, research and development funding to be the main drivers of technological development. Human capital and its development are seen as a source of shaping the country's scientific and technological potential (Diebolt & Hippe [13], Kyzym [14]). The influence of the level of funding on the level of scientific and technical performance has also been proven (Checchi [15], Rosenbloom [16]). The number of registered patents and the number of publications in research journals (Korzhatykh [17], Weingart [18]) are viewed by many scientists as an important factor affecting scientific results. The outcomes of scientific and technological development are influenced by a demand for high-tech products and the scope of high-tech products exports (Siyanbola, Adeyeye, Olaopa [19]).

Thus, it is possible to reach a conclusion that the level of the scientific and technological development of the countries of the world is influenced by a number of factors. In the meantime, all the factors of the scientific and technological development of the economy and the visa were not conducted.

The purpose and objectives of the publication

The purpose of the article is to develop an index that assesses the scientific and technological potential, the results of scientific and technological activities and the pace of changes in the scientific and technological development of different countries of the world.

To achieve this goal, the following tasks were solved:
- to develop a model of rating assessment of scientific and technical development of countries of the world;
- to classify the countries of the world depending on their level of scientific and technological development;
- give recommendations on the development of scientific and technological potential of the world countries depending on the selected groups.

This will allow not only to rank and group the countries of the world by these parameters, but also to suggest recommendations for their further scientific and technological development, which is very important in the modern globalized world.

Materials and methods

The method for calculating the Scientific and Technological Development Index, which is proposed in this paper, is based on the determining its three main components (fig. 1): the sub-index of the potential of scientific and technological development, the sub-index of the results of scientific and technological development and the sub-index of scientific and technological growth.

Fig. 1. Model of calculating the index of scientific and technological development

Source: own modelling

The sub-index of the scientific and technological development potential characterizes potential opportunities in the formation of scientific resources through two components: education (opportunities for training highly qualified specialists) and science (opportunities for the development of scientific potential due to availability of highly qualified specialists and the funding of scientific research).
The sub-index of the scientific and technological activity results characterizes the results of scientific activity through the creation of a scientific product (patents, articles in scientific journals), the use of results of intellectual property and income from high-tech exports) characterizes the results of scientific activity through the creation of a scientific product (patents, publications in scientific journals), the use of the results of intellectual property and earnings from high-tech exports).

The sub-index of scientific and technological growth characterizes the dynamics of the scientific and technological potential growth and the results of scientific and technological activity.

In calculating The Science and Technology Growth Index (ISTD), only the hard data of 21 variables are used, based on the quantitative data available from the open World Bank database. The World Bank database provides data for 217 world economies. However, not all of the indicators that were singled out for the purpose of index calculation contain information on all the countries of the world included into the database. Also, for some indicators the data for after 2016 are missing. When calculating index indicators, the following assumption was made: if there are no data for more than 4 indicators across the country, then it is excluded from further ranking; if there are no data for less than 4 indicators - the calculation is adjusted depending on the number of indicators included in the calculating indices and sub-indices for the given country.

The Science and Technology Development Potential Index includes 10 indicators available from the World Bank database. Indicators F1.1 – F1.9 are directly indicators presented in the World Bank database. Indicator F1.10 (Research and Development expenditure per researcher, US $ / person) calculated on the basis of World Bank data as:

\[
F1.10 = \frac{x_1 \cdot x_2}{x_3 \cdot x_4}
\]

where \(x_1\) – is the Research and development expenditure (% of GDP), \(x_2\) – is the GDP (current US $), \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people).

The sub-index of the results of scientific and technological activity includes 10 indicators, whose characteristics and sources, regarding the calculation of the indicators, are given in table 1.

| Indicator | Calculations | Comments |
|-----------|--------------|----------|
| F2.1. GDP per researcher, US $ / person | \(F2.1 = \frac{x_1}{x_3 \cdot x_4}\) | \(x_1\) – is the GDP (current US $), \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |
| F2.2. High-technology exports (current US$), % | \(F2.2 = x_5\) | \(x_5\) – is the High-technology exports (current US $) |
| F2.3. High-tech exports per technician, US $ / person | \(F2.3 = \frac{x_6}{x_3 \cdot x_4}\) | \(x_6\) – is the High-technology exports (current US $), \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is 1 million people |
| F2.4. Fees for Intellectual Property Use, Researcher Revenue, US $ / person | \(F2.4 = \frac{x_8}{x_3 \cdot x_4}\) | \(x_8\) – is the Charges for the use of intellectual property, receipts (BoP, current US$), \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |
| F2.5. Intellectual Property Use Fees, Payments per Researcher, US $ / person | \(F2.5 = \frac{x_9}{x_3 \cdot x_4}\) | \(x_9\) – is the Charges for the use of intellectual property, payments (BoP, current US$), \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |
| F2.6. Ratio of Intellectual Property Use to Payments, unit | \(F2.6 = \frac{x_{10}}{x_3 \cdot x_4}\) | \(x_{10}\) – is the Charges for the use of intellectual property, receipts (BoP, current US$), \(x_3\) – is the Charges for the use of intellectual property, payments (BoP, current US$), \(x_4\) – is the Population (in millions of people) |
| F2.7. Patent applications from residents for one researcher, unit / person | \(F2.7 = \frac{x_{11}}{x_3 \cdot x_4}\) | \(x_{11}\) – is the Patent applications, residents, \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |
| F2.8. Non-resident patent applications for one researcher, per person | \(F2.8 = \frac{x_{12}}{x_3 \cdot x_4}\) | \(x_{12}\) – is the Patent applications, non-residents, \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |
| F2.9. Scientific and technical journal articles per researcher, unit / person | \(F2.9 = \frac{x_{13}}{x_3 \cdot x_4}\) | \(x_{13}\) – is the Scientific and technical journal articles, \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |
| F2.10. Trademark applications for one researcher, unit / person | \(F2.10 = \frac{x_{14}}{x_3 \cdot x_4}\) | \(x_{14}\) – is the Trademark applications, total \(x_3\) – is the Researchers in R&D (per million people), \(x_4\) – is the Population (in millions of people) |

Source: own compilation
The Science and Technology Growth Sub-index is calculated on the basis of World Bank data from 5 years as the geometric average of growth.

In order to correct the differences in the units of index indicators and ranges of variation, all the 30 variables are normalized in the range \([0, 1]\) with higher scores that represent better results.

Data normalization and scaling is performed with regard to the minimum and maximum values for each variable in the index indicators. For variables in which higher values indicate higher results, the following rationing formula was applied:

\[
I_{\text{indicator}} = \frac{x_f - x_{\min}}{x_{\max} - x_{\min}},
\]

(2)

where \(I_{\text{indicator}}\) – is the index of the indicator calculated for the individual index indicators, \(x_f\) is the actual value of the individual indicator, \(x_{\min}\) is the minimum value of the indicator observed in the countries surveyed, \(x_{\max}\) – is the maximum value of the indicator observed in the countries surveyed.

Sub-indices of the potential of scientific and technological development (STP), results of scientific and technological activity (STA) and scientific and technological growth (STG) are calculated as the arithmetic mean of the obtained values of the individual indicators that characterize them.

If it is not possible to calculate individual indicators for some countries, these countries are removed from the ranking, provided that such indicators are more than 3 out of 10 for each sub-index.

The Science and Technology Growth Index (ISTD) is the geometric mean of these three sub-indices:

\[
\text{ISTD} = \sqrt[3]{\text{STP} \times \text{STA} \times \text{STG}},
\]

(3)

where STP is the sub-index of scientific and technological potential; STA – the sub-index of scientific and technological activities; STG – the sub-index of scientific and technological growth.

On the basis of the proposed method, the index of scientific and technological development for different countries of the world was calculated and their rating established.

### Results of the studies and their discussion

In accordance with the proposed method, the sub-indices of scientific and technological potential, scientific and technological results and scientific and technological growth, as well as the index of the scientific development of the countries of the world were calculated.

First, 217 countries, represented in the World Bank database [20], were considered. As a result of collecting data on the previously identified indicators and their analysis, 72 countries were selected for which the information was most complete. The remaining countries were not included in the ranking because of the lack of practical data that would allow the proposed model to be used to calculate indicators, sub-indices and the overall index. Further, each indicator was normalized, which made it possible to calculate the corresponding sub-indices, according to the formulas above.

The calculation of the Science and Technology Potential Sub-index (STP) allowed ranking 72 countries of the world according to their scientific and technological potential, which was assessed by their educational potential from the point of view of possibilities of training their personnel, including top-level personnel, as well as their scientific potential, which reflects the number of researchers and technicians engaged in the economy of the country and the scale of financing.

The ranking of the countries of the world on the basis of the calculated sub-index of scientific and technological potential is given in table 2.

### Table 2. Ranking the countries of the world by the sub-index of scientific and technological potential

| Position | Country          | Evaluation | Position | Country          | Evaluation | Position | Country          | Evaluation |
|----------|------------------|------------|----------|------------------|------------|----------|------------------|------------|
| 1        | Sweden           | 0.742      | 25       | Spain            | 0.383      | 49       | Bulgaria         | 0.235      |
| 2        | The USA          | 0.637      | 26       | The Czech Republic | 0.380     | 50       | Serbia           | 0.233      |
| 3        | Denmark          | 0.615      | 27       | Lithuania        | 0.358      | 51       | Tunisia          | 0.222      |
| 4        | Sweden           | 0.591      | 28       | Italy            | 0.350      | 52       | Columbia         | 0.218      |
| 5        | Singapore        | 0.572      | 29       | Poland           | 0.342      | 53       | Uzbekistan       | 0.212      |
| 6        | Republic of Korea | 0.570     | 30       | Portugal         | 0.330      | 54       | Chile            | 0.211      |
| 7        | Israel           | 0.567      | 31       | Cyprus           | 0.323      | 55       | Madagascar       | 0.208      |
| 8        | Luxemburg        | 0.561      | 32       | Georgia          | 0.319      | 56       | Moldova          | 0.207      |
| 9        | Norway           | 0.557      | 33       | Lithuania        | 0.318      | 57       | Argentina        | 0.207      |
| 10       | Finland          | 0.550      | 34       | Hong Kong, China | 0.302      | 58       | Mexico           | 0.199      |
| 11       | Germany          | 0.543      | 35       | The Republic of Slovenia | 0.289 | 59       | Malaysia         | 0.194      |
| 12       | The United Arab Emirates | 0.538 | 36       | Greece           | 0.284      | 60       | India            | 0.187      |
| 13       | Japan            | 0.537      | 37       | Hungary          | 0.283      | 61       | Romania          | 0.179      |
| 14       | Australia        | 0.529      | 38       | Costa Rica       | 0.279      | 62       | Montenegro       | 0.157      |
| 15       | Belgium          | 0.523      | 39       | The Russian Federation | 0.279 | 63       | Uruguay          | 0.148      |
According to the data calculated on the sub-index of the country's scientific and technological potential, the countries were divided into 3 subgroups, namely: leaders (STP> 0.5), potential leaders (STP 0.49-0.2), and "overtaking" countries (STP <0.2).

Leaders are countries with a high scientific and technological potential, they have an advanced system of training of highly qualified personnel, the governments of those countries allocate considerable funds for financing their educational and scientific activities. Those countries have a high scientific and technological potential to develop and implement the results of their own scientific and technological activity.

Potential leaders are countries with a sufficient scientific and technological potential, they realize the importance of training highly qualified personnel, the governments of these countries allocate funding for educational and scientific activities, but not enough to make them leaders in scientific and technological development, for training highly qualified personnel is not a major priority for the country's development. These countries have a sufficient scientific and technological potential to develop and implement their own scientific and technological output, but they need increased funding to build and strengthen their scientific and technological potential.

"Overtaking" countries are countries with a low scientific and technological potential, they have an underdeveloped system of training highly qualified personnel, the governments of these countries do not allocate sufficient funds to finance their educational and scientific activities, and higher education is not well-developed.

Such countries do not have sufficient scientific and technological capacity to develop and implement the results of their scientific and technological activity and their governments need to pay more attention to financing and training highly qualified personnel.

According to the ranking and grouping of the countries of the world, Ukraine is ranked 47th out of 72 countries. Ukraine has been classified as a country with a sufficient scientific and technological potential for development, whose government is not paying attention to the system of training highly qualified personnel, but does not allocate funding for its development sufficient for the country to become a leader in scientific and technological development.

Calculation of the Sub-Index of Scientific and Technological Activities (STR) allowed to rank 72 countries in accordance with the scientific and technological results obtained, which were evaluated by the results of the scientific and technological activity of their researchers on the basis of calculating the number of applications for patents by residents and non-residents of the country, applications for trademarks, the number of articles in scientific and technical journals, the revenues and payments gained from the use of intellectual property per researcher, as well as the share of high-tech export in the structure of the products trade calculated per one technician. The ranking of the countries of the world on the basis of the calculated sub-index of the results of scientific and technological activities is given in table 3.

| Position | Country          | Assessment | Position | Country          | Assessment | Position | Country          | Assessment |
|----------|------------------|------------|----------|------------------|------------|----------|------------------|------------|
| 1        | The USA          | 0.286      | 25       | Chile            | 0.102      | 49       | Montenegro       | 0.061      |
| 2        | Singapore        | 0.278      | 26       | Italy            | 0.098      | 50       | Spain            | 0.060      |
| 3        | Luxemburg        | 0.257      | 27       | Belgium          | 0.097      | 51       | Greece           | 0.060      |
| 4        | Ireland          | 0.230      | 28       | Hungary          | 0.094      | 52       | Poland           | 0.058      |
| 5        | Switzerland      | 0.213      | 29       | Bosnia and Herzegovina | 0.093 | 53       | India            | 0.057      |
| 6        | China            | 0.190      | 30       | Uruguay          | 0.089      | 54       | Lithuania        | 0.056      |
| 7        | Malta            | 0.187      | 31       | Australia        | 0.088      | 55       | Estonia          | 0.052      |
| 8        | Panama           | 0.182      | 32       | Israel           | 0.086      | 56       | Venezuela        | 0.049      |
| 9        | Finland          | 0.167      | 33       | New Zealand      | 0.083      | 57       | Turkey           | 0.049      |
| 10       | Japan            | 0.164      | 34       | Cyprus           | 0.081      | 58       | Ecuador          | 0.045      |
| 11       | Republic of Korea | 0.155      | 35       | Costa Rica       | 0.080      | 59       | The Russian Federation | 0.041 |
| 12       | The Netherlands  | 0.154      | 36       | Kazakhstan       | 0.080      | 60       | Portugal         | 0.040      |
According to the data calculated for the sub-index of scientific and technological activity, the countries ranked were divided into 3 subgroups, namely: leaders (STA> 0.1), potential leaders (STA 0.09-0.05), and "overtaking" countries (STA<0.05).

Leaders are countries with significant scientific and technological results, are characterized by a high share of high-tech products exports, significant scientific results, active in publication and patent registration activities, and have high revenues from intellectual property.

Potential leaders are countries with a medium-sized scientific and technological output, these countries have a small share of high-tech exports, not very significant scientific results manifested in publication and patent registration activity, and also have higher payments than benefits from intellectual property.

"Overtaking" countries are those with low scientific and technological results, these countries have a low share of high-tech products exports, insignificant scientific results, manifested in terms of publications and patent registration activity, and also have to pay a lot for intellectual property.

Ukraine has been placed with the countries with low scientific and technological results, a low share of high-tech products exports, insignificant scientific results per researcher, both in terms of publications and patent activity, and with high intellectual property payments.

The calculation of the Science and Technology Growth Sub-Index (STG) has allowed to rank 72 countries according to the dynamics of their scientific and technological results and growth of their scientific and technological potential.

This sub-index estimates the country’s growth rate in the areas such as the results of the scientific and technological activity of researchers based on an estimate of the growth rate of their both residents and non-residents applications for patents and for trademarks, the number of articles published in scientific and technical journals, revenues from the use of intellectual property per researcher, and a growing rate of high-tech exports in food trade. Also included in the assessment, are an increase in the PhD degrees obtained in economics and the funding of higher education, research and development. The ranking of the countries of the world on the basis of the calculated sub-index of scientific and technological growth is shown in table 4.

### Table 4. Ranking countries by the sub-index of scientific and technological growth

| Position | Country         | Assessment | Position | Country       | Assessment | Position | Country       | Assessment |
|----------|----------------|------------|----------|---------------|------------|----------|---------------|------------|
| 1        | China          | 0.604      | 25       | Georgia       | 0.460      | 49       | Israel        | 0.423      |
| 2        | The United States | 0.545     | 26       | The Czech Republic | 0.458     | 50       | Canada        | 0.422      |
| 3        | Slovakia       | 0.542      | 27       | Turkey        | 0.457      | 51       | Austria       | 0.421      |
| 4        | Lithuania      | 0.539      | 28       | The Netherlands | 0.452     | 52       | Estonia       | 0.420      |
| 5        | Hong Kong, China | 0.529     | 29       | France        | 0.451      | 53       | Columbia      | 0.414      |
| 6        | Spain          | 0.514      | 30       | New Zealand   | 0.447      | 54       | Republic of Korea | 0.413 |
| 7        | Denmark        | 0.509      | 31       | Latvia        | 0.447      | 55       | Greece        | 0.410      |
| 8        | Luxemboug      | 0.505      | 32       | Finland       | 0.447      | 56       | Philippines   | 0.409      |
| 9        | Costa Rica     | 0.502      | 33       | Morocco       | 0.446      | 57       | Malaysia      | 0.403      |
| 10       | Portugal       | 0.499      | 34       | Chile         | 0.445      | 58       | Croatia       | 0.398      |
| 11       | Cyprus         | 0.491      | 35       | Guatemala     | 0.444      | 59       | Japan         | 0.395      |
| 12       | Bulgaria       | 0.490      | 36       | Malta         | 0.444      | 60       | Pakistan      | 0.393      |
According to the data calculated on the sub-index of scientific and technological growth, the countries were divided into 3 subgroups, namely: leaders (STG > 0.5), potential leaders (STG 0.49-0.4), and "overtaking" countries (STG < 0.4).

Leaders are countries with high growth rates in increasing scientific and technological potential and results of scientific and technological activity. These countries may have a medium or low scientific and technological potential or scientific and technological output, but they are growing at a fairly rapid pace, which is promising for the future.

Potential leaders are countries with average growth rates of scientific and technological potential and scientific and technological activity. These countries may have a high or average scientific and technological potential or scientific and technological output, their average rates of growth, however, may be fraught in the future with slowing down the country’s scientific development, as well as the development of the economy as a whole.

These countries may have a high or average scientific and technological potential or the results of scientific and technological activity, but the low growth is fraught with the risk of losing the status of a scientifically developed and innovative country. These may be "old" economies that use their scientific potential but do not increase it at a high rate; or they may be countries that do not conduct their scientific or technological activities on a regular basis, or such activities may not be among the priorities in the country’s development. According to the ranking and grouping of the countries of the world, Ukraine ranked 47th out of 72 countries that were rated. Ukraine was classified as a country with a low growth rate of its scientific and technological potential and low results of scientific and technological activity. This reflects the current situation in the country, in which the number of researchers in recent years has been decreasing, with the results of their scientific activities and the share of high-tech exports of food production decreasing, too.

Also, the general index of scientific and technological development was calculated on the basis of the sub-indices calculated previously. The results of the ranking of the countries of the world in accordance with the calculated index of scientific and technological development are given in table 5.

### Table 5. Rating countries by the Index of scientific and technological development (ISTD)

| Position | Country               | ISTD  | Position | Country             | ISTD  | Position | Country  | ISTD  |
|----------|-----------------------|-------|----------|---------------------|-------|----------|----------|-------|
| 1        | The USA               | 0.463 | 25       | New Zealand         | 0.248 | 49       | Romania  | 0.183 |
| 2        | Singapore             | 0.425 | 26       | Italy               | 0.246 | 50       | Uruguay  | 0.180 |
| 3        | Switzerland           | 0.419 | 27       | Columbia            | 0.240 | 51       | Turkey   | 0.177 |
| 4        | Luxembourg            | 0.418 | 28       | Cyprus              | 0.234 | 52       | The Russian Federation | 0.171 |
| 5        | Finland               | 0.345 | 29       | The Czech Republic  | 0.233 | 53       | India    | 0.170 |
| 6        | Ireland               | 0.339 | 30       | Hong Kong, China    | 0.231 | 54       | Salvador | 0.166 |
| 7        | The republic of Korea | 0.332 | 31       | Spain               | 0.228 | 55       | Bulgaria | 0.161 |
| 8        | The Netherlands       | 0.329 | 32       | Hungary             | 0.226 | 56       | Venezuela| 0.158 |
| 9        | Japan                 | 0.327 | 33       | Costa Rica          | 0.224 | 57       | Ecuador  | 0.155 |
| 10       | Denmark               | 0.322 | 34       | Lithuania           | 0.221 | 58       | Montenegro | 0.154 |

Source: own compilation
The advantages of the proposed index consist in a possibility of evaluating the prospects of scientific and technological development for each of the countries of the world on the basis of a unified source of data provided by the World Bank, in an even distribution of indicators (each sub-index includes 10 indicators), and in dividing the countries into groups in accordance with the values obtained for each sub-index, which makes it possible to suggest recommendations to each country included in the rating for developing its scientific and technological potential.

Conclusions and prospects for further development

The current stage of the world’s technological development creates new opportunities for the countries of the world to ensure their sustainable growth. Therefore, the creating and maintaining the potential of scientific and technological development, coupled with an adequate government policy of economic development, opens up tremendous opportunities for the countries of the world to ensure global competitiveness.

In accordance with the purpose of the research, the article proposes a methodology for calculating an index that evaluates the scientific and technological potential, the results of scientific and technical activities and the rate of change in scientific and technological development of different countries around the world. In order to achieve this goal, a model for rating the scientific and technological development of the world’s countries was developed, which, unlike the existing models, takes into account only quantitative indicators taken from a reliable source (the World Bank), takes into account the scale of the economies of the countries being evaluated in accordance with their scientific potential (all the resulting indicators are given to the number of performers of the relevant scientific and technical works), takes into account the rate of change in scientific and technological development of the world’s countries (it makes it possible to estimate the rate of change in scientific and technological development of the countries).

The presented method has made it possible not only to determine the place of the countries under assessment in the world scientific and technological development, but also to give recommendations on the development of scientific and technological potential of the countries of

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**Table 5.**

| Rank | Country      | ISTD  | Group | Country       | ISTD  | Group |
|------|--------------|-------|-------|---------------|-------|-------|
| 11   | Sweden       | 0.322 | 35    | Malaysia      | 0.220 | 59    | Ukraine | 0.153 |
| 12   | China        | 0.317 | 36    | Mexico        | 0.219 | 60    | Argentina | 0.146 |
| 13   | The United Kingdom | 0.308 | 37    | Slovak        | 0.214 | 61    | Kazakhstan | 0.145 |
| 14   | Germany      | 0.305 | 38    | Poland        | 0.212 | 62    | Moldova | 0.145 |
| 15   | Norway       | 0.302 | 39    | Chile         | 0.212 | 63    | Georgia | 0.144 |
| 16   | France       | 0.283 | 40    | Latvia        | 0.210 | 64    | Serbia | 0.144 |
| 17   | Belgium      | 0.281 | 41    | Estonia       | 0.204 | 65    | Madagascar | 0.143 |
| 18   | Malta        | 0.277 | 42    | Brazil        | 0.198 | 66    | Guatemala | 0.138 |
| 19   | Israel       | 0.275 | 43    | The Philippines | 0.197 | 67    | Bosnia and Herzegovina | 0.127 |
| 20   | Panama       | 0.262 | 44    | United Arab Emirates | 0.191 | 68    | South Africa | 0.124 |
| 21   | Australia    | 0.259 | 45    | Croatia       | 0.191 | 69    | Morocco | 0.099 |
| 22   | Austria      | 0.258 | 46    | Greece        | 0.191 | 70    | Egypt, Arab Republic | 0.094 |
| 23   | Canada       | 0.254 | 47    | Tunisia       | 0.188 | 71    | Uzbekistan | 0.093 |
| 24   | Slovenia     | 0.253 | 48    | Portugal      | 0.187 | 72    | Pakistan | 0.081 |

Source: own compilation

According to the data calculated on the R&D index, the countries were divided into 3 subgroups, namely: leaders (ISTD > 0.25), potential leaders (ISTD 0.249-0.2), and "overtaking" countries (ISTD <0.2).

Leaders in the scientific and technological development are countries that are at the forefront of independent research and implementation of technological innovations, demonstrate significant achievements in the formation and development of the country’s scientific and technological potential, have significant scientific and technological achievements and provide for high growth rates of the scientific and technological potential and its results.

Potential leaders of scientific and technological development are countries that invest in the development of their scientific and technological potential, use new technologies, achieve significant scientific and technological results, but their growth rate is lower than that of the leaders.

The countries that are overtaking the others in terms of scientific and technological development are countries that do not sufficiently invest in the development of their scientific and technological potential, show modest results of their scientific and technological activity, have low rates of growth of their scientific and technological potential and insignificant results of their scientific and technological activity.

According to the general index of scientific and technological development, Ukraine ranks 59th out of 72 countries of the world.

The presented method has made it possible not only to determine the place of the countries under assessment in the world scientific and technological development, but also to give recommendations on the development of scientific and technological potential of the countries of
the world depending on their belonging to groups of countries.

Potential leaders of scientific and technological development should work on developing their own scientific potential, attract additional financial resources to fund the training of highly qualified specialists in the promising sectors of the economy, finance scientific and technological research projects, promote the development of the national innovation system, reduce dependence on technologies borrowed from the developed countries of the world, promote the scientific and technological development of industries that are capable of expanding the export of high-tech products.

"Overtaking" countries should increase funding for training specialists and improving their educational systems, develop ways of disseminating new technologies, promote their own scientific development, solve concrete problems by introducing innovative technologies, and studying the experience of the developed countries in order to build their own scientific and technological potential.

The study presented in the article provides general recommendations for individual countries to improve the processes of managing scientific and technological potential of individual groups of countries. The obtained results can become the basis for the concept and strategy development of scientific and technological development of different countries of the world.

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МОДЕЛИРОВАНИЕ РЕЙТИНГА НАУЧНО-ТЕХНОЛОГИЧЕСКОГО РАЗВИТИЯ СТРАН

Предметом статьи является рейтинговая оценка и разработка рекомендаций по управлению научно-техническим развитием стран. Цель исследования – разработать методологию расчета индекса научно-технического развития и ранжировать страны мира. В статье решены следующие задачи: разработана модель рейтинговой оценки научно-технического развития стран мира; классифицированы страны мира в зависимости от уровня их научно-технического развития; даны рекомендации по развитию научно-технического потенциала стран в зависимости от выбранных групп. Применяются следующие методы: индексный метод, ранжирование и группировка. Получены следующие результаты: приведенные расчеты позволили определить три группы стран в соответствии с уровнем их научно-технического развития: лидеры, потенциальные лидеры и страны "догоняющие". Основным результатом проекта является содействие развитию научно-технического потенциала, демонстрация результатов научно-технической деятельности и улучшение уровня развития новых технологий. Для каждой из перечисленных групп стран были даны рекомендации по развитию науки и технологий.

Выводы: современный этап мирового технологического развития создает новые возможности для стран по обеспечению их устойчивого роста. Поэтому создание и поддержка потенциала научно-технического уровня в сочетании с адекватной государственной политики экономического развития открывает перед странами огромные возможности для обеспечения глобальной конкурентоспособности. В представленном исследовании даны общие рекомендации для отдельных стран по совершенствованию процессов управления научно-техническим потенциалом групп стран. Полученные результаты могут стать основой для разработки концепции и стратегии научно-технического развития стран мира.

Ключевые слова: наука; научно-техническое развитие; страны мирового рейтинга; моделирование.