INNOVATION DEVELOPMENT OF RUSSIA AND OTHER COUNTRIES OF THE BRICS

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Abstract: *Significant changes take place in the world. Four countries out of five BRICS ones (China, Russia, Brazil and India) are already in top ten countries of the world economy. The objective of this article is to characterize the place of BRICS countries in the world innovation development ratings and in the world industry in comparison with other world economy leaders.*

Several world ratings have been chosen for the analysis of BRICS countries' position in world innovation economy. They indicate the readiness to "knowledge economy". The rank of the countries in such ratings is made according to several indicators, which characterize the implementation level of information and communication technologies.The analysis shows the representativeness of the world ratings chosen for the analysis ("Networked Readiness Index", "ICT Development Index", "Global Competitiveness Index", "Global Innovation Index", "Bloomberg Innovation Index" etc.).

Calculations revealed high correlation between the world countries' indexes in the innovation ratings and between separate indicators of their economic development (GDP, expenses for research, gross value added of high-tech production, ICT production per capita).

Comparison of BRICS countries' position in innovation ratings against the leading countries has shown that China is on the higher position in comparison with the other BRICS countries. But not all BRICS countries have high positions in innovation ratings. It is shown that in case of creation of technologies it is necessary for BRICS countries not only to have a solid basis for maintenance and development of scientific and technological potential but also to join efforts in ICT creation and distribution to use all existing opportunities.

Analysis of the manufacturing industry data (including high-technology) revealed strengthening of BRICS positions in the world industry. It is especially notable comparing accumulated figures of BRICS countries with NAFTA and EU data in dynamics.

Key words: *BRICS, Research & Development, innovation economy.*

JEL codes: *O11, O14, O19.*

1. Introduction: The importance of the discussed issue

BRICS are very different countries. Three of them are in Eurasia (Russia, China and India). The political structure significantly differs in BRICS countries. Cultures of their multi-ethnic population are not the same. They are also uneven in terms of demography, including the level of human development. Two of the countries with population of more than a billion can be highlighted – China and India. Their territories and natural resources can hardly be compared. However, the resource potential of each country is very significant by the world scale as well.

Nevertheless, among the key elements combining BRICS countries the following ones can be outlined: substantial current growth rates, large size of the economy, vast human capital (population, labor and intellectual resources), unquestioned economic leadership in each of their geographic regions and the possibility to influence

the world economy significantly in the next 20-30 years. The last one is the most important one. All the BRICS countries are being actively modernized and transformed. They now take the leadership in their regions (Russia – on the post-Soviet territory, China – in Eastern Asia, India – in South Asia, Brazil – in South America, South African Republic – in Africa). But they are turning from regional leaders into global players. Combination of basic parameters of economic development of BRICS countries confirms the importance of this consolidation, which remains open for other countries to join.

In other words, the further course of the world history will depend on the development of these countries. Therefore, the subject of the research is topical as there is a need to study the processes that take place in BRICS from different prospective (Riccardo, 2016; Gray, 2016; Kahn, 2015).

Information society is being formed on the planet. But it should not be forgotten that the countries develop unevenly, as well as in the use of ICT. The so-called "digital gap" takes place. Achievements in science form technological progress. The processes are dynamic in almost all spheres. Interpenetration and synergy effect can be noted. A global network structure is being formed. In fact, society and all kind of areas of activities are currently intrinsic to interconnectivity and global scope (Rodionova et al., 2010; ITU, 2017).

The use and implementation of achievements in science, knowledge-based sectors of the economy, the expansion of the global technology market – all of these are the basics for dynamic economic development for the countries. It is also a factor of strength centers formation of modern society. The results of scientific research are nowadays being implemented especially in knowledge-based branches. Defining demand on R&D and applied research, they formally promote further development of fundamental study. In other words, information innovation is necessary today for all branches of economy.

The current article is in line with a series of articles on the declared subject, where it is outlined that the forming innovation systems of the BRICS countries, where the government takes an active part, play a major role in the creation of new technologies, creative solutions and innovation products at present (Kovalev, 2015). At the same time during the discussion on BRICS two opposite opinions have been clearly formed. According to first – the creation and development of relations in BRICS countries signifies that the West is losing its global influence on world politics and economy (Lo and Hiscock, 2014). Adherents to the second approach think that BRICS have a few real achievements. And there is also third party that considers BRICS to be a threat to the West.

In this article we consider BRICS countries' position in innovations. The authors of the article earlier characterized the position of Russia in the world innovation economy. For example, Russian position was compared against the Commonwealth of Independent States (CIS, in which Russia is a leader by all indicators). Russian position is also compared with the countries of the Central and Eastern Europe (Rodionova, 2013), as well as with the world leading countries.

Let us outline that the world ratings, taken by us for the analysis, are very informative. Nevertheless, it should be noted that the experts of the UN and the World Bank consider various aspects of innovation development. An alternative basis for the evaluation is used in some studies (that differs from the method used in the innovation development ratings analyzed by us). It forms an influence chain that studies the mechanisms by means of which access to ICT and its' significant use are able to enhance "information opportunities" of the countries. It is marked that all of this eventually would lead to the improvement of human and social potential. The importance of ICT policy and digital economy for the structural changes, equality and social integration has been raised in many articles of the national and foreign authors.

It was also stated that China has entered a group of countries with middle income, as it had increased its' capital over labour ratio and due to its' ability to quickly assimilate technologies in a wide range of activities (Castillo, 2013). The aim and novelty of the present study is not simply to evaluate the BRICS countries' position in world ratings but to show that the development and application of scientific achievements and new information technologies and communications are the most important factors of industrial development, meaning also economic development of this group of countries in today's global world. At the same time, it is important to understand what BRICS countries have to initiate in order to maintain in the group of world economy leaders.

2. Methodology and Data

First of all it is appropriate to present a picture of today's world "scientific landscape" and to identify BRICS countries' position according to characteristics of the forming innovation society (in the first place according to the expenses for scientific research and development).

Next stage is to analyze BRICS countries' position in several world ratings ("ICT Development Index", "Global Innovation Index", etc.). It would be shown that all of them with a high degree of reliability characterize features and the level of ICT implementation in countries of the world, as a significant number of indicators are analyzed in each of such ratings. Evaluation of validity of world ratings chosen for the analysis would be carried out by means of correlation coefficient calculation and detecting dependence between positions in

abovementioned ratings (by integrated indicators of indexes of all world countries) and separate indicators of their economic development. These calculations will show rate of interdependency of these indicators.

Evaluation of BRICS countries' position in rating tables against the positions of world economy leaders would confirm BRICS's role in world innovation development. Studying the positions achieved in world industrial production by BRICS countries comparative to the world leaders would enable to evaluate their role in world economy.

Materials of international organizations and research articles have been used for the study as well as World Bank reports, UNIDO reviews and reports etc. The US National Science Foundation (NSF) materials were used (NSF, 2018) to study the world countries' positions in production in various branches of manufacturing industry. The theoretical background of the present study is based upon numerous studies of national and foreign authors dedicated to the analysis of problems and trends of world development as well as personal scientific research of the author.

3. Results and Discussion

Inequality in social-economic development of the world countries has led to polarization of scientific research and development (R&D) in the world.

The data analysis indicates that contrasts are still remaining between developed and developing countries of the world. The gap is significant. Scientific research and development expenses in developed countries are 2-3 times higher than in developing countries. And the number of scientific studies in developed countries is several times higher, as well as the amount of scientific publications per 1 mln citizens. But rapid growth of R&D indicators can be seen in China, India, Mexico, Brazil etc.

Share of R&D expenses in world GDP structure is estimated to be nearly 2% (due to the indicators of economically developed countries). At the same time it's worth paying attention to high concentration of R&D expenses in world "scientific landscape". Three main zones have emerged: North America, Europe and Eastern Asia. But changes are already seen in the alignment of forces. For example, we are certain that the three-dimensional space of scientific research (USA – EU – Japan) is turning into a four-dimensional (USA – EU – China – Japan). It happened due to the China's rapid increase in R&D expenses. This exact fact is determines China taking the leading position in world economy and in world industry (not only the number of its human resources as previously thought). This has affected the quantity and quality of Chinese export of high-tech production (China is currently a world leader in this area).

Our calculations confirm leadership of North America and Europe by many indicators of innovation development. But it is important to note the significant changes that occurred in the Asian region countries in this sphere, namely due to Japan, China, India and "new industrialization countries" (Republic of Korea, Singapore etc.). Expenses for scientific research are increasing in the world, in regions and in countries. Meanwhile Asia's role has grown to 44% (2016) of the world total. China's share has increased very substantially up to 20% of the world total. Role of Japan decreased a little (to 10%) but it is still a considerable share. Value of India has risen (to 3%) (UNESCO, 2015). Total share of R&D expenses of BRICS countries (27%) is increasing along with growth of their GDP (especially in China).

For many years the USA have been leading in R&D expenses (26% of world expenses). But it is important that China has already taken the second place in the table of ranks. R&D expenses' share in GDP of China has tripled – from 0.7% to 2.1% within period 2002-2016. It's worth reminding that China has already taken the first place in the world by the size of GDP per Purchasing Power Parity ($23.12 trln, in 2017), outperforming USA ($19.36 trln) (CIA, 2018). Nevertheless, data shows that China and other BRICS countries are still far behind the leaders in R&D expenses per capita (USA – $1430, Japan – $1260, China – $240, India – $90 approximately) (UNESCO, 2015).

According to Eurostat in 2015 China is leading with a considerable breakaway in the amount of high-tech export ($554.3 bln), ahead of Germany ($185.6 bln) and USA ($154.4 bln). At the same time the share of high-tech export in total export of manufactured produce exceeds 25%, as well as in the Republic of Korea (for comparison: 19% in USA and 17% in Germany). It is worth mentioning that China and the Republic of Korea are among those countries which provided import substitution industrialization macroeconomic policy. According to Aregbeshola (2017) it is proved that the strategic importance of ISI macroeconomic policy is a possible catalyst to catapult an economy out of import dependency towards industrialization that could ultimately help to build export capacity. In this research it is shown that there is the short and long run relationships between growth and ISI measurable indicators.

3.1. Correlation coefficients calculation

More important factors nowadays are peculiarities of innovation development, factors of knowledge and latest technologies generation and application, innovation infrastructure. Generally all these indicators which necessary

for existence in the frames of new development paradigm «Industry 4.0», that is not only widely being discussed but is already applied in advances countries.

Many complex international indexes characterize the level of knowledge-based economy development. They use different criteria to evaluate differences in the application rate of innovations and information technologies in countries of the world. There are many criteria and indicators in each of their ratings. All of them more or less reflect the peculiarities of scientific and technical progress and ICT influence on the economic development of countries. We have calculated correlation coefficients between pairs of indicators to estimate representativeness of ratings used for ranging countries of the world.

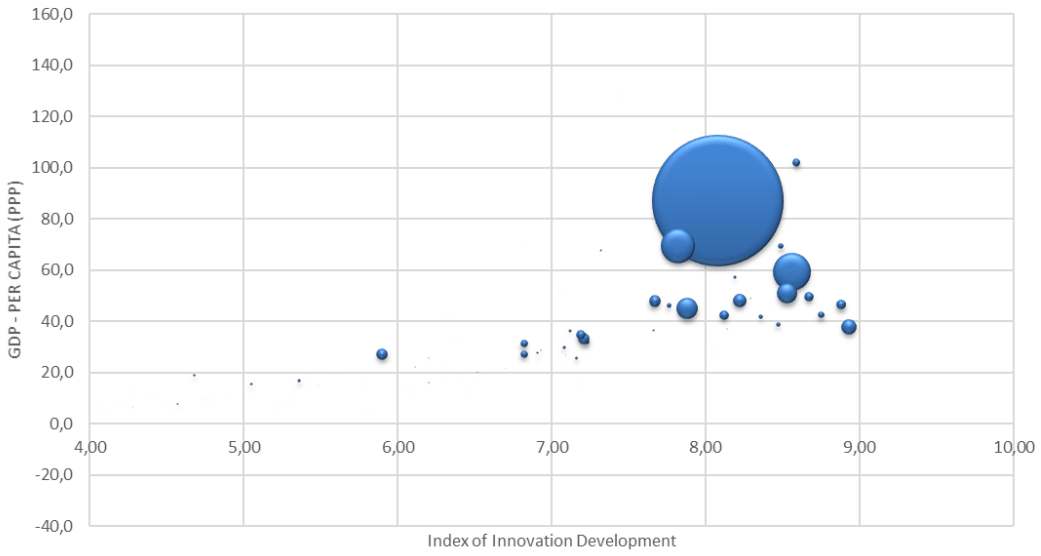
Firstly, based on the correlation coefficients calculations, direct correlation has been identified between indicators (ranks) of the countries of the world in rating tables of various indexes (The Networked Readiness Index, The ICT Development Index, The Global Competitiveness Index, The Global Innovation Index, etc.) each with each (significant figure: 0.8–0.86 approximately). It signifies that all of them highly interchangeable and can be applied for the analysis situations with innovation development of the countries. In other words, the evaluation criteria which used in Indexes sufficiently reflect special features of economic and innovation development.

Secondly, calculations of correlation coefficients that were made also showed strong direct dependence between the world countries' indicators in each rating table of any index and several economic indicators of those countries as well. GDP per capita has been chosen first as a criterion of economic development level (correlation coefficient – 0.77). Then index values in rating tables were compared with the volume of high-technology production in countries per capita (value added of high-tech manufacturing industries per capita). And the last calculation of correlation coefficient reflected countries' positions in rating tables in connection with expenses for R&D per capita (R&D expenditure per capita).

High dependence revealed by us (correlation within the range from 0.7 to 0.9) proves the following. As has already been outlined all analyzed Integrated Indexes reflect the actual particular features of innovation development in countries and their differences. It is noted that not all countries of the world would be able to come to the development of network economy but only those countries with highest level of socio-economic development. At the same time nowadays only those countries that have put knowledge and ICT at the service of economy would be able to become leaders in high-tech production per capita. Besides they are occupying leading positions in world economy and strive to maintain those positions (Rodionova, 2013). The countries with higher level of innovation development and ICT implementation also achieve greatest results in increasing welfare of their population (it is also shown by their indicators of GDP per capita). Nevertheless, the synergy effect is possible only when certain threshold of ICT implementation is reached. But it would not be possible to achieve such positive effect in countries with poor and uneducated population.

A direct strong correlation between GDP per capita and the index of innovative development (0.77) is clearly visible in the diagram (figure 1). The diagram also shows that, the volume of exports of high-tech products per capita (circle size) is also directly proportional to two above-mentioned indicators. Thus, it can be concluded that more innovative economies have higher welfare indicators.

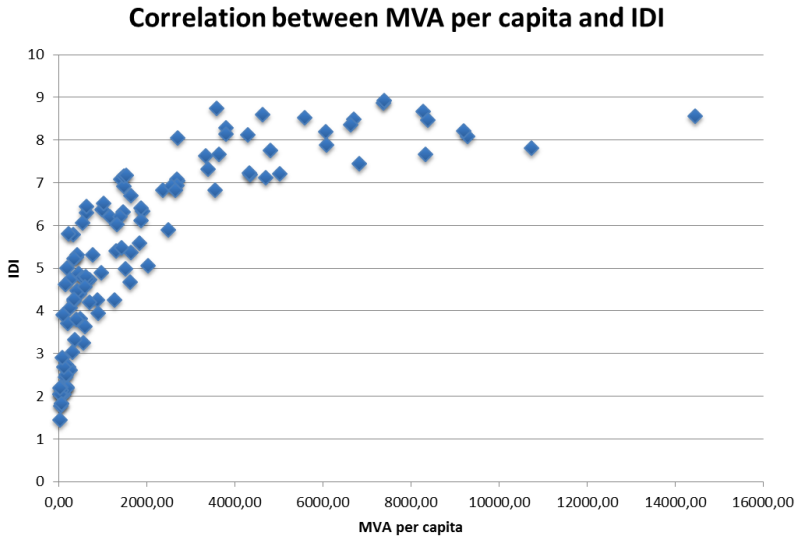
Fig. 1 Correlation between Index of Innovation Development (X-line), GDP per capita (Y-line) and High-Tech Export per capita (circle size)



Source: Calculated by the authors.

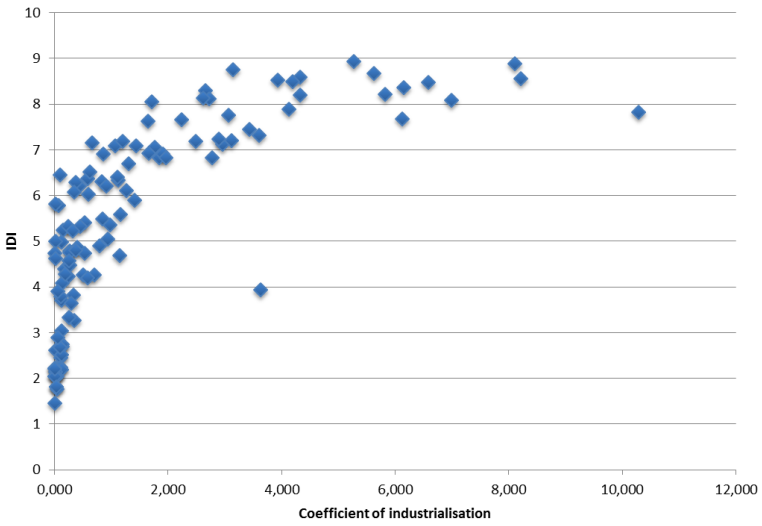
It is noted that there is a strong direct correlation between, on the one hand, the index of innovation development and, on the other hand, the value added of manufacturing industries per capita (0.76) (figure 2) and the coefficient of industrialization (0.72) (figure 3). It indicates that innovative development is one of the key factors of industrialization and competitiveness in the modern world.

Fig. 2 Correlation between the index of innovation development and the value added of manufacturing industries per capita



Source: Calculated by the authors.

Fig. 3 Correlation between the index of innovation development and the coefficient of industrialization



Source: Calculated by the authors.

3.2. Russia and other BRICS countries in world innovation ratings

The current progress in the field of the Internet, big data analysis, digital intelligence forms innovations and fundamentally transforms economic activity, public administration and society – ultimately contributing to the improvement of people's lives. The level of ICT development today is one of the most important indicators of the economic and social well-being of countries. Therefore, it is important to analyze the positions of the countries in world rankings that characterize the achievements of the countries in terms of the development of innovation and information and communication technologies (ICT).

The Global Innovation Index – GII. From the Global Innovation Index 2017, devoted to measuring the innovation performance of 127 economies and the theme 'Innovation Feeding the World', six messages emerge.

Many of these messages are concerned with innovation as a driver of growth generally. One is concerned specifically with the role of innovation as a way to address the growing need for advances in agriculture and food value chains (WIPO, 2017). They cover a wide range of indicators thus offering a vast amount of data for the analysis of global trends of innovation development. Following can be traced in rating table for 2017: China – 22nd place, Russia – 45th, South Africa – 57th, India – 60th, Brazil – 69th. The leaders of this rating are Switzerland, Sweden, Netherlands, USA, United Kingdom, Denmark, Singapore, Finland, Germany and Ireland.

***The ICT Development Index*.** This combined indicator is calculated using the methodology of the International Telecommunication Union, the specialized UN unit that defines the world standards in the field of ICT (ITU, 2017). The index was developed in 2007 on the basis of 11 indicators assessing the level of ICT development in countries. The Integral index converts these indicators into a single criterion that can be used as a tool for conducting comparative analysis at the global, regional and national levels. The indicators reflect access to ICTs, features of ICT use, including as a practical knowledge of these technologies by the population.

For example, the number of mobile broadband connections has increased in the world from 0.8 bln in 2010 to approximately 3.5 bln in 2015 (ITU, 2017). The number of Internet users is rapidly increasing and reached about 40% of total population. However, developing countries are still behind the developed countries in access to information and communication technologies (ICT), and least developed countries are in most difficult situation. So "digital gap" remains. Disparities in ICT availability are recorded not only inside the countries but also between them, especially between rural and urban areas. Considerable digital gap also remains in many countries between men and women. Inequality in income is widely common and leads to such disparities.

However, there has been progress in the growth of ICT in the least developed countries. Currently, more than half of households in the world have access to the Internet, although the growth rate has decreased and is less than 5 percent per year. There is also significant progress in overcoming the digital gender gap in various regions.

The leading positions in this rating are occupied by the Island, Republic of Korea, Switzerland, Denmark, United Kingdom, Japan is on 10th place, USA – 16th. In 2017 Russia takes 45th place, Brazil - 66th, China – 80th place, South Africa – 92nd, India – 134th (among 176 countries) (ITU, 2017). In other words, positions of the BRICS countries in this innovation rating are also not so high.

The Networked Readiness Index (NRI). This index evaluates digital infrastructure quality and the ability to use ICT for ensuring economic growth, promoting innovations and improving the welfare of population (WEF, 2016). Networked Readiness Index is measured on a scale from 1 (worst results) to 7 (best results) basing on aggregation of data: existence of network infrastructure in the country, preparedness to use it in civil society, in business sector and in governmental structures. The actual level of ICT application is also measured in the countries with a number of indicators.

The index components reflect key factors that influence information technology development. But a detailed analysis of the countries' positions in the ratings with separate components of the index is more important.

For example, the report notes that Russia's promotion in the rating is constrained due to a weak and deteriorating regulatory framework (indicator "Political Environment and Regulation", 88th place). Russia's position is also weak by such indicators as "Legislative efficiency" (81st place), "Judicial system" (81st place), "Intellectual property protection" (123rd place), etc.

Leaders of this rating are Singapore, Finland, Sweden, Norway, USA Netherlands, Switzerland, United Kingdom and Japan (among 139 countries). It is important to outline that in 2016 Russia followed with 41st place, China was on 59th place, South Africa – on 65th, Brazil – 72nd and India – 91st.

Bloomberg Innovation Index. The 2018 ranking process began with more than 200 economies. Each was scored on a 0-100 scale based on seven equally weighted categories (R&D intensity, manufacturing value added, productivity, high tech density, tertiary effectiveness, researcher concentration, patent activity). Nations that did not report data for at least six categories were eliminated, trimming the list to 80. Bloomberg released the top 50 and category scores within this cohort (Jamrisko and Lu, 2018).

According to the rating of innovative economies of the Bloomberg Innovation Index in 2018, the top five leaders included South Korea, Sweden, Singapore, Germany and Switzerland. At the same time in 2017-2018 Russia rose from 25th to 26th place (however, it dropped from 12th place in comparison with 2016), China rose from 21st to 19th place, South Africa was on 48th place, entered the TOP-50 leaders. In 2017, Brazil was on 46th place, but in 2018 dropped out of the TOP-50.

China's relatively good position is due to high patent activity (6th place in the world), high tech density (4th place in the world) and R&D intensity (16th place in the world). According to Crescenzi and Rodriguez-Pose (2017) and Crescenzi and Jaax (2016), a striking feature of patent intensity is China and India's heavy investment in innovation 'inputs'—increasing literacy rates and higher education enrolment, raising production of

engineering graduates and increasing expenditure on R&D – have been translated into rapidly rising patenting rates. Moreover, China's patents took off. In 2000-2007 patent intensity in China rose fourfold up to 4.4 patents per million inhabitants. China moved up the two spots to the 19th, buoyed by its high proportion of new science and engineering graduates in the labor force and increasing number of patents by innovators such as Huawei Technologies Co. (Jamrisko and Lu, 2018).

The fall of Russia in 2016-2018 was largely due to the sanctions against Russia and had a negative impact on its positions by the indicators that characterize the development of science, but it continues to hold high positions in terms of the tertiary effectiveness (3rd place in 2017, 5th place in 2018).

South Africa and Brazil ranked 30-50th position by the same indicators (R&D intensity, manufacturing value added, productivity, high tech density, tertiary effectiveness, researcher concentration).

***Competitiveness Index of global economy*.** The Global Competitiveness Index can be considered as the total or complex index. For the years 2015-2016 it was calculated for 137 countries of the world (WEF, 2018). It evaluates countries' rates according to criteria that not only reflects the basic development conditions but also measures factors of economy development efficiency and factors of innovation implementation in the countries of the world using 113 variables. All of them in combination give a detailed description of competitiveness level of world countries in global economy. Switzerland, USA, Singapore, Netherlands, Germany, Hong Kong, Sweden, United Kingdom, Japan, Finland etc. – are as usual in the group of leaders. However, worth pointing that China in this rating also is ahead of other BRICS countries (27th place). In 2010-2011 Russia was on 63rd place while now – in rating for 2017-2018 it already holds 38th place. At the same place, India has taken 40th position, South Africa – 61st, Brazil – 80th.

Therefore, the analysis of international ratings of innovation development revealed that leading positions are occupied by highly developed countries. At the same time positions of BRICS countries are not very high but they improve each year. China is improving especially fast. Pace of innovation development and progress in ICT implementation in world countries contribute to the improvement of their position in world economy.

Countries-leaders and leading economic groups are constantly strengthen their influence on control of world high-tech production market. The undertaken comparative analysis showed an increase of BRICS countries' share in world industry comparing to NAFTA and EU indicators. For example, total industrial output of manufacturing industry of the BRICS countries in 2016 amounted to one third of world value (at constant 2010 prices in US$). It exceeds total output of NAFTA countries (19%) and countries of the EU (18%) (UNIDO, 2017). Although in 1999 the total amount of BRICS countries was only 10%, while the share of NAFTA countries was almost 32% and EU countries – almost 28% (in current US dollars) (NSF, 2018). As for the total indicators of BRICS countries in high-technology productions - they have mainly increased due to China indicators, notably increase took place in all studied sectors of economy (value added of pharmaceuticals industry – 22%, computer equipment – 37%, communication – 40%, semi-conductors – 31%, production of high-precision and medical equipment – 14.5%, value added of aircraft and spacecraft – 6%, 2016). Share of BRICS of world value added of all HT manufacturing industries is 26%, 2016 (only share of China – 23.5%). For comparison: NAFTA – 32.6%, EU – 16.3%). Although in 2001 the share of BRICS was 8.7%, NAFTA - 41%, the total share of EU countries – 18% (NSF, 2018).

In other words, the BRICS countries' increase of importance in world industry is obvious. It is important to outline that BRICS countries' growth rate in science and technology and in ICT sectors considerably exceed growth rates in developed countries. However, we should remember that countries of the BRICS go completely different paths towards "knowledge economy".

4. Conclusions

No doubt ICT penetration into all branches of economy and all aspects of human activity is a key factor to scientific and technological as well as economic progress in the context of globalization.

Development of informational technologies in BRICS countries is still behind the ICT implementation in developed countries, which results in low ranks of these countries in world ratings. Nevertheless, analysis of manufacturing industry output data (including high-technology products) showed that the positions of BRICS countries in global economy are strengthening.

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