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The influence of intellectual capital and innovations on the economic development of the world and national economy

Abstract

We consider in the study that the existing economic model will inevitably be replaced by a new effective model of creative and competitive economic development. Technological innovations have caused the rapid growth of the world economy. As the result, production costs have been reduced and the profits of corporations in many sectors of the world economy have increased. Innovation is a factor of rise in Kondratiev cycles. Innovations give an impetus to increase the value added of a country's economy. The article asserts that intellectual capital is the basis and is becoming an increasingly important component of national and world development.

The article has investigated in which way innovation activities affect real GDP and has suggested the answer to the question on what stage of the Kondratiev cycles the world economy is. Innovation as an object of intellectual capital is introduced in the form of patents and other intellectual property.

We have analyzed the relevant trends for 2004-2020. The research has determined that by 2030, a significant increase in the number of patent applications is expected. The article has examined the dependence of the world real GDP on the number of filed patent applications in the world by constructing trend lines. It has been found that the largest approximation with a coefficient of determination greater than 0.92 is a polynomial trend line, in which the dynamic growth with a small number of patent applications is inhibited by a sharp increase in their number.

The research has defined that the phases of the cyber revolution correlate with Kondratiev waves. The modern phase is characterized by the rapid generation and dissemination of innovations. The article has examined the filing of patent applications in the top 20 countries around the world, among which the leading positions are occupied by China, the USA, and Japan.

By constructing trend lines, the research has analyzed the dependence of Ukraine's real GDP on the number of innovations and has shown that there is no such clear dependence. This indicates the raw material orientation of the Ukrainian economy. The article states that it is extremely important for Ukraine to make the transition from the triad model (with state-monopoly capitalism) to the national economic model, which corresponds to the approaches of the people's capitalism.

Keywords: Innovation; Patent; Trend; Countries of the World; Intellectual Capital; Kondratiev Waves (Cycles)

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Вплив інтелектуального капіталу й інновацій на економічний розвиток світової та національної економіки

Анотація. У статті проаналізовано інноваційну діяльність у країнах світу й формування інтелектуального капіталу. Представлено прогноз зростання кількості заявок на патенти у світі до 2030 року. Доведено, що залежність світового реального ВВП від цього показника має поліноміальний характер другого порядку. Визначено причини уповільнення зростання світового реального ВВП із різким зростанням кількості заявок на патенти. Співставлено аналогічну залежність для України. Залежність реального ВВП України від кількості патентів і ліцензій проявляється слабо, що пов'язано з сировинною спрямованістю економіки держави. Визначено рекомендації щодо розвитку економічної системи України. Досліджено взаємозв'язок хвиль Кондрат'єва та сучасного інноваційного розвитку

Ключові слова: інновація; патент; тренд; країни світу; інтелектуальний капітал; хвилі Кондрат'єва.

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Влияние интеллектуального капитала и инноваций на экономическое развитие мировой и национальной экономики

Аннотация. В статье проанализирована инновационная деятельность в странах мира и формирование интеллектуального капитала. Представлены прогноз роста количества заявок на патенты в мире до 2030 года. Доказано, что зависимость мирового реального ВВП от этого показателя имеет полиномиальный характер второго порядка. Определены причины замедления роста мирового ВВП в соответствии с резким ростом числа заявок на патенты. Составлена аналогичная зависимость для Украины. Зависимость реального ВВП Украины от количества заявок на патенты Украины проявляется слабо, что связано с сырьевой направленностью экономики государства. Определены рекомендации по развитию экономической системы Украины. Исследована взаимосвязь волн Кондратьева и современного инновационного развития.

Ключевые слова: инновация; патент; тренд; страны мира; интеллектуальный капитал; волны Кондратьева.

1. Introduction

Technological innovations and open trade have significantly changed world production. The conversion of raw materials into parts and components, the assembly of finished products and their delivery to the final consumer involve supply chains that cover a large number of economies around the world.

Due to the scientific and technological progress, a wide range of consumer goods has become more affordable. The economic growth in the world continues, which promotes the integration of developing countries into the world economy, creating opportunities for economic development and poverty reduction. Intellectual capital, especially in the form of technology, design and branding, completely permeates the global economy. The degree of implementation of the latest innovative solutions influences the amount of money that consumers pay for the product and defines companies that operate successfully in the market. The decision-making on cooperation and further organization of global value chains is based on the location of

various industries, business objectives, the history of partnerships, and forms of intellectual capital management.

The use of intellectual capital has accelerated the structural transformation of the economy and production relations. The increase in the influence of intellectual capital on production leads to the fact that some employees lose their jobs, while others, showing skill, receive high rewards. Modern technologies continue to transform production, and it will inevitably lead to further improvement of technological products and changes in the structure of production. For instance, advances in 3D printing, robotics, and automated manufacturing may well lead certain companies to move production tasks closer to the final consumer. In addition, at present, there is a trend of rapid growth of developing economies and shifts in the geography of global value chains.

2. Brief Literature Review

To determine the directions of scientific progress, countries must have a theoretical and economic justification for these processes. A well-known Ukrainian scientist Oleg Soskin (2014) developed and proposed for Ukraine the theory of people's capitalism. According to his research, the world economy consists of countries belonging to different civilizations, different levels of social and economic development, with different strategic goals and involved in the implementation of different national economic models. This particular fact significantly complicates the definition of the model of a single world economy. Soskin demonstrated the economic model as a holistic system of interaction of different economic interests, forces, priorities and goals, the direction of progress towards its effective formation, structuring and evolution. He also developed mechanisms to implement this model in such a way that the existing economic model will inevitably be replaced by a new effective model of creative and competitive economic development. According to the author, only a rapid and drastic transformation of the economic system towards this model will allow developing of a prosperous, successful, economically independent Ukraine (Soskin, 2014).

The problems of intellectual capital formation and innovative development of the economy, which we study in this research, are covered in the scientific works of many scientists. Granada & Mejia (2020) showed how innovations affect employment depending on professionalism, gender, and employment rate. Glód (2018) studied the role of transformation of innovation management methods in the production of medical equipment using a set of statistical methods. Wojciech Karmeni, De La Villarmois & Mansouri (2017) analyzed the impact of control over innovation in the functioning of the franchise scheme. Heij, Volberda, Van den Bosch & Hollen (2019) proved that introduction of innovations in the management of the enterprise is much more profitable than the use of scientific research on the production site. According to Vzdorova (2014), the concept of intellectual capital should be treated with scientifically defined caution. The author substantiated the threat of a gap between the scientific community and the requirements of an average person. She states that such a gap can occur if information technology is used by people not to generate knowledge, but to achieve everyday goals in their everyday life.

Lazyrin (2015) introduces the term «neo-industrialization» as a separate process aimed not only at changes in the economy, but mainly at radical changes in human thinking, which, in turn, affects the economy. He emphasizes that technology has now become more accessible to a modern individual. He also argues that the technological cycles described by Kondratiev will accelerate and the gaps between them will decrease. Praid & Korotayev (2008) analyzed the importance of the development of new technologies to address a number of global issues, such as the acute demographic situation in developing countries, environmental problems, overpopulation and total poverty, the integration of human activities and computer devices.

The development of innovation in the national economy is reflected in the increase in the objects of intellectual property. Both foreign and Ukrainian scientists have paid a lot of attention to this topic. Cao et al. (2020) identified the link between environmental regulation with the help of the innovative technologies and economic growth in a given region. Pearse & Peterlin (2019) explained how a creative entrepreneur can start and manage a business that includes a social responsibility component in the business model. Vovchenko et al. (2016) proved the need for innovation in the functioning of the global economy as a way to solve the problem of resource scarcity on the planet. Having suggested an algorithm for the development of the global economy, they proved the inevitability of overcoming many global problems through innovation.

Geldres-Weiss, Monreal-Perez & Tornavoi-Carvalho (2018) proposed an index of exports of innovative products, which provides accurate information that helps businesses to raise export-oriented production of innovative products. Senent-Bailach & Rey-Marti (2017) identified and developed the concept of social innovation, factors of innovation processes in social life. Hlavacek (2017) presented a new regional innovation program based on sectoral restructuring. Agostini, Galati & Gastaldi (2019) showed how digitalization affects innovation processes in the economy and society.

Moreira et al. (2017) presented a study of the impact arising from the interpretation of the concept of the inventive step on the potential of innovation in the field of electricity supply. Kolesnikov, Epifanova & Usenko (2016) identified the following features of state regulation of innovation in the global economy: the increase in the speed of innovation, intensifying of the export of innovations, regulation of the economy via the regulation of innovation, the dominance of indirect methods of regulating innovation by the state in the enterprise.

Farre-Mensa, Hegde & Ljungqvist (2019) proved that as a result of patent implementation in the startup, patent holders get an increase in employment by 55%, and sales growth by 80% in the next 5 years. Product quality also increases. Trautrimis, MacCarthy & Okade (2017) suggested an analysis of patent activity in the US automotive industry, examining the product categories with the most patented inventions and the most active suppliers who invented new products. Silva, Santos & Carvas (2020) conducted a quantitative and qualitative analysis of innovative aspects of the economic sector concerning software.

However, the works of these scientists have not fully identified the impact of intellectual capital on macroeconomic indicators of development of countries, including Ukraine. Therefore, this article pays much attention to these aspects.

3. Purpose

The purpose of the research is to study the implementation of innovations in the world and in Ukraine, to identify the share of each country in the total number of patent applications and their distribution among residents and nonresidents, to determine the impact of innovation on macroeconomic indicators (namely, real GDP), to compare world trends with the trend of Ukraine, on the basis of which to suggest recommendations for further development of the economic system of Ukraine.

4. Results

The growing need for sophisticated and specialized knowledge and technological interaction at both national and international levels has led to the parallel existence of two phenomena: geographical concentration and prevalence of the process of creating innovations. On the one hand, manufacturers sought to find and create innovations, which could allow achieving high quality at a lower cost. On the other hand, market forces, saving policy concerning the scale and the need for greater interdisciplinary interaction create the conditions for achieving geographical proximity.

Intellectual capital is becoming an increasingly important component of national and world development. Modern science studies the problem of human improvement and radical increasing of life expectancy, which is in the sphere of interest of transhumanists. In this context, a variety of areas of research are considered and discussed: from the already well-developed organ transplantation studies to brain prosthetics, which science is just approaching, from the use of artificial organs to the development of medical nanorobots. In particular, great attention is paid to the so-called NBIC-Convergence - the mutual strengthening of nanotechnology, biotechnology, information technology and cognitive science.

Since the 1980s-1990s, the creation of new scientific and technical knowledge has increasingly required interaction between institutions and organizations, state or private, national or multinational, regardless of their location. Gradually, China, India, Eastern Europe and other middle-income countries have become important targets for foreign direct investment (FDI) oriented to research and development (R&D) as sources of new knowledge. The deepening of globalization processes has brought these countries closer to the intellectual component of economic development of the world. These countries are being integrated into the global system of intellectual property protection.

Intellectual property rights concerning innovation are similar to any other property rights. They allow authors or owners of patents, trademarks or copyrighted works to benefit from their own works or investment in its creation. These rights are enshrined in Article 27 of the Universal Declaration of Human Rights, which recognizes the right of everyone to the protection of the

moral and material interests resulting from scientific, literary or artistic works of which an individual is the author.

The importance of intellectual property was first noted in the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886). The World Intellectual Property Organization performs the administrative functions concerning both conventions.

An efficient and equitable intellectual property system can assist all countries in realizing the potential of intellectual property as a catalyst for economic development and social and cultural well-being. At the same time, this system sets new rules and formalizes competition in the innovation market. The intellectual property system helps to strike a balance between the interests of innovators and the interests of the state, ensuring the creation of conditions for the development of creativity and innovation for the benefit of all people.

The innovative activity of the countries of the world is reflected, in the first place, in the number of patents that were applied for in the world for a certain year. Using Excel, let us forecast the number of submitted patent applications by 2030. The forecast is performed using linear regression. The forecast is based on the known data on the number of applications in 2004-2020 (Figure 1).

As it is seen from Figure 1, the number of patent applications is steadily increasing over the years. Only in 2009, there was a decrease from 1,930,000 applications to 1,855,900 applications due to the global economic crisis in 2008-2009. The growth rate varies from 9.3% in 2012 to the negative one -3.8% in 2009. The forecast line shows a steady increase in the number of patent applications per year. Moreover, in 2020 there will be an increase to 3,477,163 applications per year. In 2030, this figure will increase almost one and a half time compared to 2018 and will make 4,751,877 applications. This indicates a remarkable rise in innovation in the world.

According to J. Schumpeter, innovation is a factor in the rise of Kondratiev cycles. Innovations create an impetus to increase the value added of a country's economy. That is, they serve the development of the economy in general. At the peak of the Kondratiev cycle, innovations reach their maturity and then they no longer have space for development. Then, there is a need for institutional change, which leads to crises and as a result to the recession, followed by a new rise. There is a need to explore how innovation activities affect real GDP in order to find out on what stage of the Kondratiev cycle the world economy is.

Let us find out how this indicator affects the world's real GDP. To achieve this goal, we will consider a regression model of both linear and nonlinear nature for the accuracy of the calculation results. Since the nonlinear regression model of several variables will be very difficult to calculate and will not focus on the relationship between the number of filed patents and GDP, which most fully characterizes intellectual capital, it would be more appropriate to consider these trends as a regression dependence on one variable. The world real GDP has the following dynamics (Figure 2).

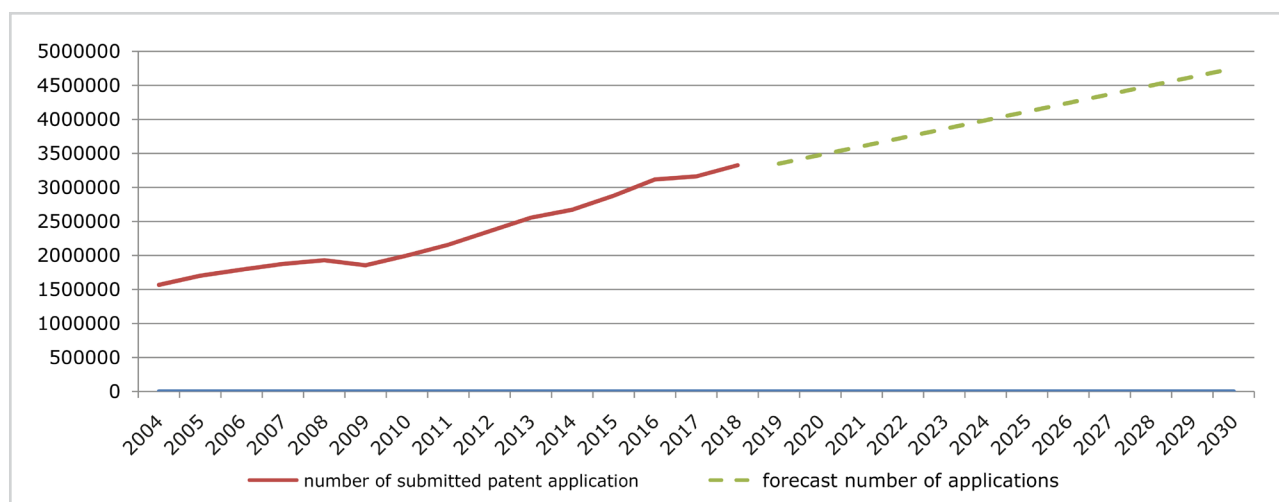


Figure 1:
The forecast of the number of submitted patent applications by 2030
 Source: Developed by the authors based on the WIPO IP Facts and Figures (2020)

Based on the statistical materials of the World Intellectual Property Organization, let us build a trend line of world GDP dependence on the number of patent applications in the form of a linear function (Figure 3).

The coefficient of determination has an acceptable value of 0.8398. That is, we can note the proportional dependence of the world economy on the active patent activity in the countries of the world. Let us construct a logarithmic, exponential, polynomial trend line of the second order.

The best approximation can be received when constructing a polynomial trend line of the second order with a coefficient of determination of 0.8826 (Figure 4). The coefficient of determination shows the share of variation of the performance trait (real GDP) under the influence of the factor trait (the number of filed patent applications). It is related to the quadratic correlation coefficient. In

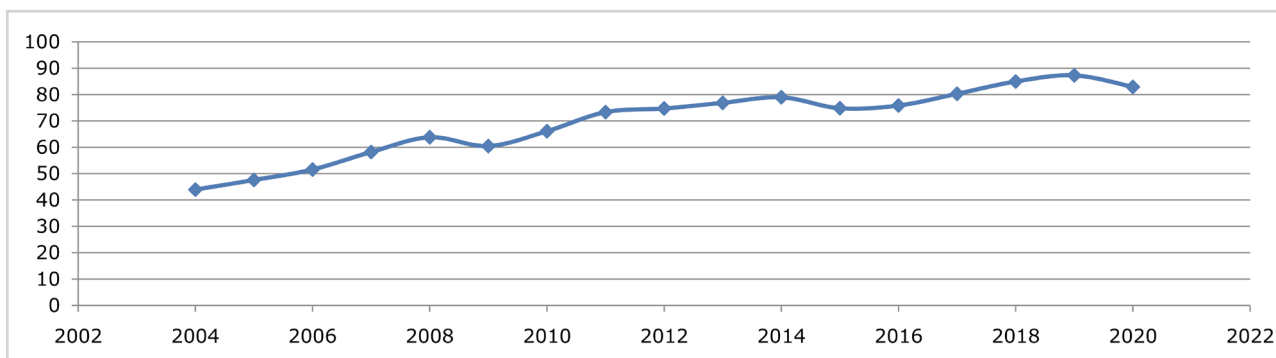


Figure 2:
Dynamics of world real GDP in 2004-2020 (trillions of dollars)
 Source: Developed by the authors using data of the IMF website (2020)

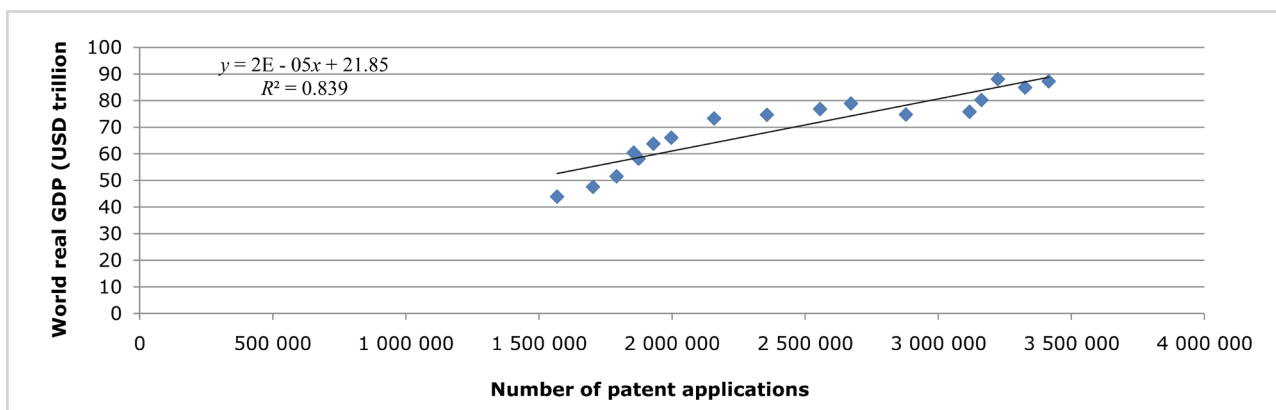


Figure 3:
Linear trend of the dependence of world real GDP on the number of patent applications (2004-2020)
 Source: Developed by the authors using data from WIPO IP Facts and Figures (2020)

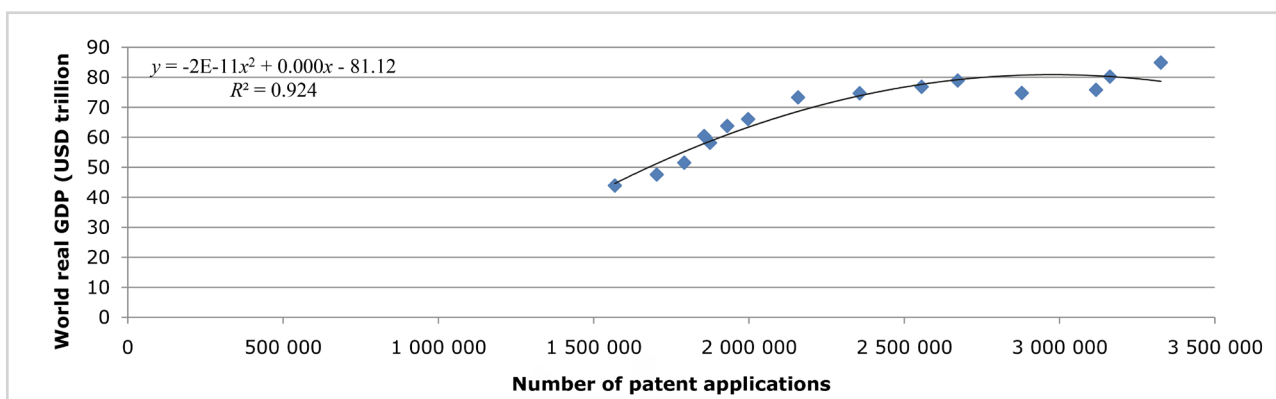


Figure 4:
Polynomial trend line of the second order of dependence of world real GDP on the number of patent applications (2004-2020)
 Source: Developed by the authors using data from WIPO IP Facts and Figures (2020)

the absence of a connection, the empirical coefficient of determination is zero, and in the case of a functional connection, it is one. In our case, there is a precise functional connection. The graph shows that the world GDP is growing with the growing number of patent applications, however, the more applications are filed, the slower the growth of world GDP is. This means that qualitative changes in the use of inventions are needed, not just quantitative ones. An example of this is the increase in the number of implementations of inventions in new areas of technology.

The manifestation of this dependence can be explained by the fact that the countries of the world are approaching the peak of the Kondratiev wave, which can be interpreted as a phase of the development of industrial and the first periods of scientific and cybernetic principles of production. Thus, the world economy is now in the middle, modernization phase of the cyber revolution, which will last until about 2030. Moreover, it should be noted that the phases of the cyber revolution correlate with Kondratiev waves. The current phase is characterized by the rapid generation and dissemination of innovations (L. Grinin & A. Grinin, 2015) such as:

- artificial intelligence and machine learning;
- the emergence of intelligent applications;
- the appearance of the Internet of things;
- virtual and augmented reality;
- use of digital twins;
- introduction of blockchain technology;
- wide use of of messengers.

The research has proved the need for institutional changes on the way to a new Kondratiev cycle, which corresponds to the introduction of new products, new processes, new markets, new resources, and new organizations. Thus, innovations are transformed into organizational innovations. They form the infrastructure of the innovative economy and generate institutional changes.

The structure of the innovative economy is constantly changing. Recent events in the world have led and will lead to a significant increase in investment in the pharmaceutical industry. In addition to traditional innovative industries (aircraft and rocketry, nuclear energy, electronics, communications), such industries as biotechnology, nanotechnology, chemistry and new materials, and information technology are also gaining momentum. Thus, countries of the world need to select new projects for investment, based on available intellectual capital and opportunities for its rapid generation in the selected areas of innovation.

Let us analyze which countries are the most progressive in this direction of development. The China National Intellectual Property Administration received 1.4 million patent applications in 2019. The US Patent and Trademark Office (USPTO) was the second with 621,453 applications. They are followed by the Japan Patent Office (JPO) with 307,969 applications. The Korean Intellectual Property Office (KIPO) had 218,975 applications and the European Patent Office (EPO) - 174,397 applications. Together, the top five offices accounted for 84.7% of the total number of applications in the world in 2019, which is 10.8 percentage points higher than their total share in 2008. China's share of total patent applications increased from 10.8% in 2008 in 2019, while in the other four countries this figure decreased over the same period (Creative economy, 2020).

The composition and rating of the top 10 offices has remained relatively stable since 2008. The composition of the top 10 offices has remained unchanged, except that in some years Australia was among the top 10 offices, while in other years it lost its place in the list to Brazil. In addition, China moved up from the third place in 2008 and took the first place in 2011. It has been the ranking leader for the last eight years. [Table 1](#) presents patent applications received by the top 20 offices, divided into the number filed by residents and non-residents. Offices on intellectual property (IP) of China (90.4%), Germany (68.7%), Japan (80.9%), the Republic of Korea (77.4%) and the Russian Federation (65.7%) received the majority of applications from resident applicants. In contrast, Australia (90.8%), Canada (88%) and India (67.5%) reported a high share of non-resident submissions (Creative economy, 2019).

The number of innovations introduced in the world grows with the number of submitted patent applications.

Let us examine whether the relationship between Ukraine's GDP and the number of patent applications filed in Ukraine follows the same patterns, and compare this pattern with a similar trend of a neighboring country, Russian Federation. As a result of the study, we have chosen the dependence with the highest value of the coefficient of determination, which in this case most closely approximates the function of the dependence of real GDP on the number of filed patent

Table 1:
Submission of the patent applications in Top-20 countries

#	Country	Residents	Non-residents	Total number of applications	Share of non-residents (%)
1	China	1 393 815	148 187	1 542 002	9.6
2	USA	285 095	312 046	597 141	52.3
3	Japan	253 630	59 937	313 567	19.1
4	Republic of Korea	162 561	47 431	209 992	22.6
5	EU	81 565	92 832	174 397	53.2
6	Germany	46 617	21 281	67 898	31.3
7	India	16 289	33 766	50 055	67.5
8	Russian Federation	24 926	13 031	37 957	34.3
9	Canada	4 349	31 812	36 161	88.0
10	Australia	2 757	27 200	29 957	90.8
11	Brazil	4 980	19 877	24 857	80.0
12	UK	12 865	8 076	20 941	38.6
13	Mexico	1 555	14 869	16 424	90.5
14	France	14 303	1 919	16 222	11.8
15	Hong Kong	314	15 672	15 986	98.0
16	Iran	11 908	915	12 823	7.1
17	Singapore	1 575	10 270	11 845	86.7
18	Italy	8 921	900	9 821	9.2
19	Indonesia	1 407	8 347	9 754	85.6
20	Thailand	904	7 245	8 149	88.9

Source: Creative economy (2019)

applications, namely the power function (Figure 5). In this case, $R^2 = 0.6269$, which indicates an improper approximation. The visual appearance of the graphs also shows this. Thus, it can be said that it is not possible to build a clear relationship between the number of innovations and the real GDP of Ukraine, i.e. the relationship is relatively weak. This may indicate the raw material direction of the Ukrainian economy. At present, the Ukrainian economic system is experiencing difficult times, which may worsen due to the threat of disruption of the Kondratiev cycle. It is well known that the Kondratiev cycle is characterized by a sinusoid: rise, peak, decline, crisis, and rise. The singularity of the end of the sixth technological mode will have to turn these processes in a completely different direction - the exact opposite, disrupting the normal course of events - rise, crisis, decline, peak, rise, thus creating the reversibility of Kondratiev cycles and other related economic cycles (Lazyrin, 2015).

In Russia, there is a second order polynomial dependence with R^2 , which has a less acceptable value, namely 0.4591 (Figure 6). Thus, in Russia there is a weak impact of innovation on the growth of welfare in the country, which is similar to Ukraine.

Thus, Ukraine has to take a course for greater innovation in the country. According to the scientific provisions of Oleg Soskin's monograph (2014), this can be achieved if Ukraine adheres to the concept of the people's capitalism model, which can be implemented in Ukraine using the research conducted by this scientist.

It is extremely important for Ukraine to make the transition from the model of state-monopoly capitalism to the economic model of market relations, which corresponds to the approaches of

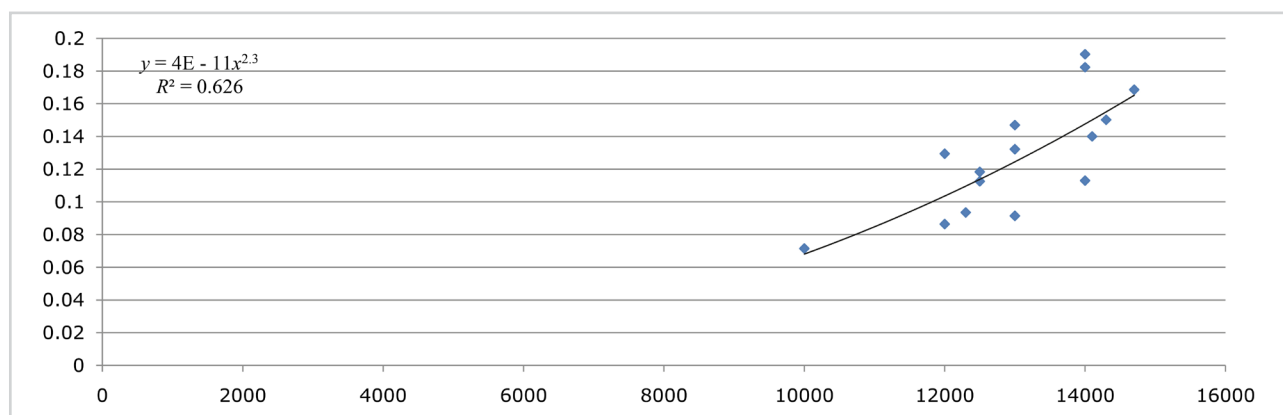


Figure 5:
Dependence of Ukraine's real GDP (USD trillion) on the number of patent applications (2004-2019)
Source: Developed by the authors using the data from the Ukrpatent (Ukrainian Intellectual Property Institute) annual report (2007, 2019) and State Statistics Service of Ukraine (2020)

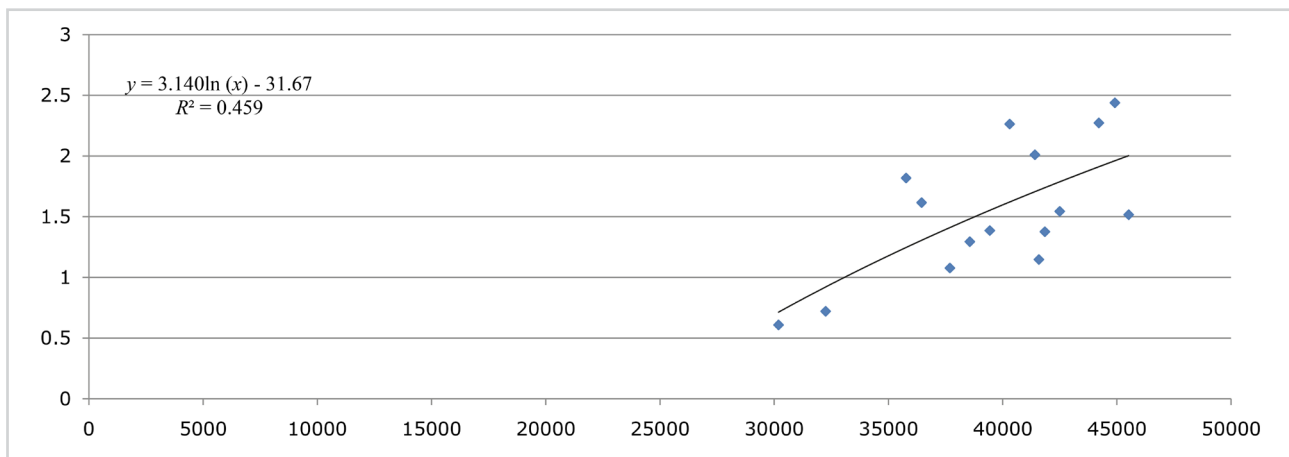


Figure 6:

Dependence of Russia's real GDP (USD trillion) on the number of patent applications (2004-2020)
 Source: Developed by the authors using data from Rospatent (Federal Service for Intellectual Property) annual report (2007, 2016, 2019, 2020)

people's capitalism model. The spread of various forms of social and economic cooperation in the spheres of production, trade, development of family private business, raising the role of the middle class will allow quick structuring and developing of an effective economic model in Ukraine.

5. Conclusions

The development of intellectual capital forms a new innovation environment. Innovations are introduced in various spheres of economic activity. Generation of innovations leads to investment in the development of economies around the world. Innovations are reflected at the national and global levels. Thus, with the introduction of innovations, countries may become less dependent on the negative effects of international corporations from other, more developed countries. The research has examined the dynamics of the number of patent applications and has constructed a forecast, which has revealed a steady increase in this indicator in the near future. The research has also determined the dependence of world GDP on the number of patent applications that shows a slowdown in GDP growth with a sharp increase in this indicator, which is due to a number of reasons, namely the inefficient use of innovation in certain industries. The research has also shown that Ukraine's GDP has a weak relation with the development of innovations in the country, which is a consequence of the raw material orientation of the state economy and other factors of influence, mainly political in nature. It is also shown that the GDP of Ukraine and Russia has a weak link with the development of innovation in these countries, which is a consequence of the raw material orientation of the economies of states and other factors of influence, mainly political in nature.

Further, the authors intend to identify the main directions of restructuring of Ukraine's economy in accordance with the global trend to increase the innovative development based on the available intellectual capital in the country. In the end, the authors would like to thank Prof. Oleg Soskin for the thorough recommendations provided during the preparation of this scientific article.

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