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The research of global innovation capital: a review and analytical comparison¹

Abstract. In the article, the global innovation activity in terms of 11 industries based on the data of the official international rating of Clarivate Analytics was researched. The rating was compiled by patent data analysing and quoting by four main criteria: volume, success, globalisation, and influence. The analysis of leading world companies actively introducing innovative products into such industries and sectors of the economy as aerospace and defense, automotive, chemicals and cosmetics, household goods, institution and government research, manufacturing and medical, oil, gas and energy, pharmaceuticals, software, as well as telecommunication, was presented. Among them, are: Bridgestone, Canon, Fujifilm, Honda Motor (Japan), Huawei (China), LG Electronics and Samsung Electronics (South Korea); Safran, Arkem and Alstom in France; BASF, Fraunhofer and Bayer in Germany, and TE Connectivity, Novartis and Roche in Switzerland. A brief description of the activity of the world companies introducing innovations and leading continuous work in the field of innovative developments and innovation activity in the section of each branch of economy was highlighted.

Keywords: Innovations; Derwent World Patents Index; Companies - Innovators; Innovative Activity; Thomson Innovation; Clarivate Analytics

JEL Classification: O31

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Дослідження глобального інноваційного капіталу: огляд й аналітичне порівняння

Анотація. У статті досліджено глобальну інноваційну активність у розрізі 11 галузей промисловості і секторів діяльності на підставі даних компанії «Кларівейт Аналітикс» (Clarivate Analytics), а саме: авіація та оборона, автомобілебудування, хімічна та косметична промисловість, електрообладнання, побутова техніка, медичне обладнання, нафтогазова промисловість й енергетика, фармацевтика, програмне забезпечення, телекомунікації, сектор науки і досліджень. Проведено аналіз провідних світових компаній, які активно впроваджують інновації та ведуть безперервну роботу в галузі інноваційних розробок та інноваційної діяльності в зазначених секторах. Географічний розподіл за кількістю інноваційно активних компаній рейтингу має такий вигляд: США – 39%, Японія – 34%, Франція – 10%, Німеччина – 4%, Південна Корея – 3%, Швейцарія – 3%, Голландія – 2%, інші представлені країни (Швеція, Ірландія, Фінляндія, Китай і Тайвань) – по 1% кожна.

Ключові слова: інновації; індекс цитування Derwent World Patents Index; інноваційні компанії; Thomson Innovation; інноваційна активність.

¹ Note of the Editor: Information in the research is relevant due to the Top 100 Global Innovators report of 2016 by Clarivate Analytics. You may also see a report published for 2017: <https://clarivate.com/stateofinnovation>

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Исследование глобального инновационного капитала: обзор и аналитическое сравнение

Аннотация. В статье проведено исследование глобальной инновационной активности в разрезе 11 отраслей промышленности на основе данных официального международного рейтинга компании Clarivate Analytics. Представлен анализ ведущих мировых компаний, активно внедряющих инновации и ведущих непрерывную работу в сфере инновационных разработок и инновационной деятельности в разрезе каждой отраслевой принадлежности.

Ключевые слова: инновации; Derwent World Patents Index; компании – инноваторы; Thomson Innovation; инновационная активность.

1. Introduction

Innovations have a global dimension and are at the core of the world economy. A study of global performance in the area of patent registration helps us understand what issues raise interest, what companies are leading and what regions are particularly active. Based on data provided by Clarivate Analytics, we review the world's leading companies that are currently active in innovation processes in terms of the industries where they operate and show trends in the area of innovation.

2. Brief Literature Review

Issues related to global performance in the area of innovation activity, innovation management and intellectual property have already been studied by distinguished scholars such as A. Bellucci [1], J. Brochner [2], J. Tidd [3], J. Frishammar [4], J. Rodriguez and M. Gomez [5], and others.

Among recent publications, it would be worth singling out works by authors such as L. Fedulova [6] who reveals the state of and trends in science and technology cooperation between Ukraine and the Russian Federation, and gives a comparative analysis of the level of innovative development of the EU member states and Ukraine; V. Plotnikova [7] who examined the importance of skilled personnel in managing national innovation systems using the example of the Russian industry; N. Kurmanova and D. Aibosynova who analyse statistical indicators of Kazakhstan's innovative development as compared to technologically advanced countries.

3. Purpose

The purpose of the article is to conduct a study on the global innovation activity by industry sectors and to review the world's leading companies that are currently active in innovation processes.

4. Results

In 2016, Clarivate Analytics published its *Top 100 Global Innovators* report which honours 100 companies that are active in innovation processes. The ranking is based on data related to the global innovation index by four main categories: capacity, success, global and influence. Let us examine each criterion more closely.

Capacity. The study focuses on companies with 100 or more innovation patents from the most recent 5 (innovations neither specified earlier nor referred to in Derwent World Patents Index). If a company complies with the criterion, it is further evaluated by the remaining criteria.

Success. The success metric measures the ratio of innovations described in published applications (those patents which are filed and publicly published by the patent office but not yet granted) to inventions protected with granted patents over the most recent five years.

Global. Protecting an invention in major world markets is an indication of the significant value a company places on its innovations and intellectual property. The number of fundamental inventions that have quadrilateral patents in their patent families, according to the Quadrilateral Patent Index by Clarivate Analytics, is calculated to create a ratio that shows which companies place a high value on their portfolios in major world markets.

Influence. This metric can be determined by looking at how often it is subsequently cited by other companies in their inventions. Through the Derwent Patent Citation Index database, citations to each organisation's patents are counted over the most recent five years, excluding self citations.

Such an analysis, and as a result the obtained ranking, was made possible by using tools created by Clarivate Analytics, such as the Derwent World Patents Index and the Thomson Innovation and Derwent Patent Citation Index. Although the overall methodology of the study is focused on patents, the article gives a view of scientific research on which the studied innovations are based, with information received from Web of Science, an online scientific citation indexing service. As regards data on pharmaceutical companies, the relevant information was vetted and verified basing on the results of clinical tests presented by companies, which are available at Cortellis associated with Clarivate Analytics.

It is important to note that the world companies leading in different sectors of the economy that are currently active in innovation processes in terms of the industries where they operate and which are included in the ranking spent USD 227 billion or more on research and development in 2015. It is applied knowledge that generates the continuous flow of innovation in the economy which meets the changing needs and which often creates the needs. And is man who generates innovations, which is why the pole of human capital is considerably growing in the innovative economy. Human capital is a strategic asset conditioning the country's ability to be competitive under the innovative economy. It is characterised by its ability to engage in innovation processes, to adapt to changes in the external and internal environments, to assess effects of globalisation, etc.

Given the rapid pace of development and commercialisation of innovations, elaboration of analytical solutions, which would allow for the protection and commercialisation of new ideas, as well as the acquisition of up-to-date information relevant to existing analogues of products and the volatile situation in the world market of innovative products, is of growing importance for many companies. Whereas earlier the company Thomson Reuters dealt with the issues involving intellectual property and science, bringing closer together all the tools at disposal of Clarivate Analytics has allowed the company's subscribers worldwide to access to constantly updated information on scientific and academic research work, patent analysis, standards, pharmaceutical and biotechnology developments and brand protection. Today, Clarivate Analytics is an independent company with over 4,000 staff members, working in more than 100 countries and running well-known brands which, among others, include Web of Science, Cortellis, Derwent Innovation, Derwent World Patents Index, CompuMark, MarkMonitor and Techstreet. Table 1 presents top global innovators in terms of industries.

Analysing the data shown in Table 1, we should notice that each of the companies presented in the table has its particular specialisation, closely cooperates with different research bodies or has research units engaged in innovative developments and their further commercialisation.

Tab. 1: 2016 top global innovators in terms of 11 industry sectors

Company	Country	Company profile
Aerospace & Defense		
Boeing	USA	Boeing is one of the world's largest manufacturers of commercial jets and military aircraft, as well as satellites, rotorcrafts, electronic and defense systems, and launch vehicles; the largest lead contractor of the US military-industrial complex by annual order volume. The corporation consists of two major business units, which are Boeing Commercial Airplanes (commercial aviation) and Boeing Integrated Defense Systems (defense and aerospace products and services). Innovative products include: jets with improved security and safety, provided with network capabilities enabling flights with regard to analytical data; technologies that ensure easy navigation and routing for aircraft; paperless technology on the flight deck [9; 10].
Automotive		
Aisin Seiki	Japan	Aisin is a Japanese company that primarily manufactures and sells auto parts for automotive companies such as Toyota, Audi, BMW, Nissan, Suzuki, Volvo and others. Other products include lifestyle and wellness related products such as gas heat pump products, sewing machines, medical equipment, etc. [11].
Chemicals & Cosmetics		
3M Company	USA	3M Company is a multinational conglomerate corporation producing more than 50,000 products for the medical market and various industries, including the automobile industry, the oil and gas industry, the mining industry, etc. (e.g. adhesives, abrasives, etc.) [12].
Hardware & Electronics		
Advanced Micro Devices	USA	Advanced Micro Devices is a semiconductor design innovator and the second largest manufacturer of processing units based on the x86 architecture, with a market share of 16.9% in 2014. It is also one of the largest manufacturers of graphics processors and chipsets for motherboards and flash memory. Hewlett-Packard, Dell, Acer and others are the company's strategic partners. Its main competitors are Intel (production of processing units and chipsets) and Nvidia (production of graphics processors) [13].
Household Goods		
General Electric	USA	General Electric is a diversified company with businesses across many industries. Its wide range of products includes locomotives, power units (in particular nuclear reactors), gas turbines, aircraft engines, etc. [14].
Institution & Government Research		
CNRS, The French National Center for Scientific Research	France	The French National Center for Scientific Research is the largest government-funded research organization under the administrative authority of France's Ministry of Research, dealing with basic and applied research at the national level [15].
Manufacturing & Medical		
Becton Dickinson	USA	Becton Dickinson is an international medical technology company which manufactures and sells a broad range of medical supplies, devices, laboratory equipment and diagnostic products, including medical supplies, antibodies and reagents. It focuses on ways to improve drug delivery, infectious disease and cancer surveillance, as well as support for drug development [16].
Oil, Gas & Energy		
Alstom	France	Alstom is a large French machine-building company and one of the world leaders, along with Siemens и Bombardier, in the production of energy equipment and rail transport. High-speed trains of the fourth generation represent the latest developments by Alstom in the area of rail transportation. In 2016, the company introduced Coradia iLint, the world's first hydrogen-powered passenger train [17].
Pharmaceuticals		
Abbott Laboratories	USA	Abbott Laboratories is an international company aimed at improving people's living by developing new products and technologies in healthcare. A broad range of advanced solutions in the field of diagnosis, medical devices, children and health food, as well as on the medicine market, enables the company to be successful in more than 150 countries [18].
Software		
Amazon	USA	Amazon is an American electronic commerce company and the largest Internet-based retailer focused on selling mass consumption products. Filing of a patent application for storage and delivery of goods with the use of airships and unmanned aircraft on 5 April 2016 is one of the company's latest achievements [19; 20].
Telecommunications		
Apple	USA	Apple is an American company that manufactures personal and tablet computers, music players, smartphones and related software. With innovative technology and aesthetic design, Apple has built its unique reputation in consumer electronics. The company has the world record for market capitalisation [21; 22; 23].

Source: Compiled by the authors based on 2016 Top 100 Global Innovators by Clarivate Analytics

In general, the global distribution of innovators is as follows: the USA - 39%, Japan - 34%, France - 10%, Germany - 4%, South Korea - 3%, Switzerland - 3% and the Netherlands - 2%. All the other innovators shown in the ranking and representing other countries (Sweden, Ireland, Finland, China and Taiwan) account for 1% each.

The Americas are represented by two countries, which are the USA and Canada. Herewith, the number of innovation-active companies in the USA increased by 14% in the reporting period from 35 to 39 units, while none of Canadian companies was ranked in 2016, unlike 2015 when Canada was represented by 1 firm in the ranking.

Asia has a more extensive geographical structure and is represented by four countries (Japan, South Korea, China and Taiwan) in the 2016 ranking, whereas the number of countries in the 2015 ranking was three. It is not surprising that Asia is represented by the regions mentioned above because that is where the largest global manufacturers, such as Bridgestone, Canon, Fujifilm, Honda Motor (Japan), Huawei (China), LG Electronics and Samsung Electronics (South Korea).

Europe with its eight countries is most widely represented in the ranking. The largest number of innovation-active companies is in France (10), Germany (4) and Switzerland (3). According to the ranking, the largest companies that introduce innovations are Safran, Arkem and Alstom in France;

BASF, Fraunhofer and Bayer in Germany, and TE Connectivity, Novartis and Roche in Switzerland.

As regards the top 100 global innovators in terms of industries in 2016, it should be noted that Hardware & Electronics is the undisputed leader with its 29% of the total number of companies. It is followed by Manufacturing & Medical, while Automotive and Chemicals & Cosmetics with their 9% hold the third position in the ranking.

7% of the total number of innovative companies is engaged in Household Goods, while Telecommunications accounts for 12% of the companies. The share of companies in Oil, Gas & Energy and Institution & Government Research is 5%. Meanwhile, Aerospace & Defense accounts for 4% of the total number of innovative companies.

Importantly, the share of Hardware & Electronics increased by 4%; however, it is lower by 10% if compared with 2014 (29% in 2015 to 39% in 2014). Altogether, the companies constituting this industry had the lion's share (40%) of the ranking in the 2012-2014 period.

With regard to Manufacturing & Medical, we notice a reduction in the share, which was 3%-9% in 2016 compared to 12% in 2015. There is a need to emphasise an increasing share of pharmaceutical companies. Their share had been steadily growing since 2011 and reached 7% in the 2015-2016 period. Significant reduction in profits, increased prices both on the part of

competitors and suppliers, as well as on the part of other market participants, and changes in both national and international regulation of the pharmaceutical market are the factors that have promoted most companies to develop and implement innovations. The largest innovation-active companies are American and European manufacturers such as Abbot Laboratories, Bayer, Bristol-Myers Squibb, Johnson & Johnson, Merck, Novartis and Roche.

In 2015, the segment of manufacturers of medical equipment was represented by a number of leading innovative companies, among which are Olympus Optical, Siemens, Toshiba, Samsung, Terumo, Philips, Canon, Medtronic and Covidien.

Olympus Optical is a leading manufacturer of optical and digital products using advanced technology in the field of audio-visual equipment, endoscopy, microscopy, bioanalysis and diagnosis. According to the Derwent World Patents Index, the number of inventions by Olympus Optical was 818 in 2015.

Siemens is one of the world's largest manufacturers of medical equipment. In 2015, the company patented 638 inventions.

Toshiba, a Japanese global company, is also among three leading manufacturers of medical diagnostic equipment. In 2015, the company obtained 627 invention patents.

As mentioned previously, automotive companies have the largest share in the ranking. Largely, the automotive industry is represented by Asian manufacturers (7 out of 9 companies), among which are Aisin Seiki, Bridgestone, Honda Motor, JTEKT, Nissan Motor, Toyota Motor and Yazaki. In 2015, the innovation activity of the above companies decreased by 17.5% when compared to the year 2014 (15,000 inventions in 2015 to 18,300 in 2014).

As regards innovations in the area of vehicles operating on alternative energy sources, the Japanese company Toyota significantly surpasses its competitors: it has patented approximately 10,000 inventions over the past year. The German company Bosch ranks second with its 3,000 inventions. Altogether, 10 out of 12 segments show a positive trend in the global automotive market. Here, maximum values have been achieved with regard to alternative energy vehicles (21% of the total number of innovations in the global automotive

market), navigation systems (11%), safety (11%), transmission (11%), car seats, seat belts and airbags (10%).

Chemicals & Cosmetics accounts for 9% of innovative developments worldwide. Skin Care, Make-up and Hair Care have been leaders in the relevant sectors since 2014. Toiletries and Antiperspirants are in top five. All the industry sectors under analysis, except for Skin Care, showed a decrease in innovative activity in the 2014-2015 period, which resulted in a reduction in the number of innovative developments.

Brazil became a leader with regard to scientific research in the field of cosmetics. The University of São Paulo is ranked 1st on the list, while the University of Campinas is in the 8th place. It is not surprising because Brazil is among the top five countries by the annual number of cosmetic surgery operations.

5. Conclusions

The study on the global innovation activity has identified the world's most innovative companies in various sectors of the economy. For instance, Boeing is the leading manufacturer in the aerospace and defense industry; the following companies occupy the relevant positions: Aisin Seiki is ranked 1st in the automotive industry, 3M Company - in chemicals and cosmetics, Alstom - in oil, gas and energy.

The companies' shares by industry sectors show that Hardware & Electronics is the undisputed leader in the area of innovations with its 29% of the total number of companies. It is followed by Manufacturing & Medical. The Automotive and Chemicals & Cosmetics sectors hold the third position in the ranking. According to official statistics, 39% of innovative companies are located in the USA; 34% of innovative companies is registered in Japan, while France accounts for 10% of innovative companies.

The Americas are represented by two countries, which are the USA and Canada. Asia has a more extensive geographical structure and is represented by companies located in Japan, South Korea, China and Taiwan. According to the ranking by Clarivate Analytics, Europe represented by eight countries has the largest number of companies. The largest number of innovation-active companies is in France, Germany and Switzerland.

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