

Global technology trends through patent data analysis

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Abstract. The future success of companies directly depends on their innovative activity, research and development of newly technologies. The article examines global technological trends by comparing the number of patent applications in different fields and the degree of development of prominent business areas. These areas are also identified by the highest-ranking positions of the companies in the annual research of innovation in the world. The study highlights the most patentable technological fields, as well as those with the highest average growth of this indicator. The emphasis is made on the regional context of technology patenting and the most active companies in patenting.

1. Introduction

The development and competitiveness of companies, and as a consequence, of national economies, are constantly influenced by shifts in the global economy, political processes, environmental and climatic dynamics, replacement and dominance of scientific and technological paradigms. Moreover, the scientific and technological factors in recent decades have formed an absolutely new vector of development of entire industries and sciences, which, in turn, radically transform the key factors of competitiveness. The leading role among them plays the development and active implementation of innovations, the main place among which is given to radical innovations. The impact for the emergence and already noticeable spread of radical innovations are new exponential technologies that lead to the emergence and disappearance of big corporations and even entire industries.

2. Theoretical base of the research

The global technological trends contribute to the expansion of innovations and the strengthening of competition, therefore, the ability of an organization to use technology to its advantage will determine its effectiveness in the future. Modern technologies define the strategic context and become an apparent priority of many businesses.

2.1. Overview of emerging technology trends

Leading consulting firms and analysts identify technology trends and determine their greatest global impact over the next few years. Consultants from Deloitte and Forbes predict some groups of technological changes that form innovations and enabling organizations to transform [1, 2]. Among them are the following.



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1. Artificial intelligence (AI) –machines and mechanisms, that have human abilities and can learn from the own experience in order to adapt to specified parameters. At the same time, AI is the trigger technology for the future innovations.
2. Internet of Things (IoT) -Internet-connected "smart" devices and items designed to collect and transmit significant data. This technology is considered as the foundation for innovative business models, platforms and capabilities.
3. The technology of digital reality, including augmented reality (AR) and virtual reality (VR) - systems that combine in real-time three-dimension image, location, sound, kinesthetic, and other features. It could be used in the wide range of areas - from military to art, from manufacturing companies using Digital Twins to training and trade. The goal of this technology is seen as a natural, intuitive and understandable interaction with core business technologies.
4. Blockchain - the most secure technology of registration and verification of transactions, record keeping and data protection. The rapid development of this technology by fintech companies can revolutionize many business models in the health care, mass media and telecommunications sectors.
5. The quantum computing - processing the large volumes of information on universal quantum machines that use quantum-mechanical phenomena and are able to perform new types of calculations. Such technologies can stimulate the development of innovative discoveries in science, machine learning methods for the quick diagnosis of diseases, life-saving therapies, etc.
6. The exponential intelligence - data interpretation techniques, that use a number of innovative tendencies (analytics, big data, artificial intelligence, the Internet of Things, machine learning, etc.) that contribute to speed up the meaning-making processes by machines or mechanisms.

These groups of technology particularly and many other innovations will generate, in the opinion of the consultants, the greatest influence on the business landscape and development of the Industry 4.0 all over the world. As evidenced by scientific research on the development of technology trends in different countries, such macro-technological forces remain the basis for innovations and business transformation. Thus, the authors [3] underline that the focus of research and characteristics of innovations (for example, usage of the Internet of Things technology) are different in many countries. Consequently, the dynamics and coverage of such technology in patent documents, for example, in Korea and the United States, are also differ.

It is important, in our opinion, to compare innovative technological trends followed by leading companies during recent decades. It is well known that at the beginning of the third millennium, manufacturing companies such as General Electric, Ford, BMW and others were prevailed in the ranking of the largest companies all over the world. However, in the first decade of the twenty-first century tech Apple, Facebook, Amazon, eBay and others began to move more convincingly to the first positions in the ratings. The second and especially forecasts for the third decade of the twenty-first century foreshadow a significant preponderance of innovative tech companies in the ranking. Moreover, in pursuit of the goals to increase efficiency, speed and adaptability to work with customers and partners, such mega companies as Walmart are also digitized. Since 2015, this company has been modernizing its core systems by introducing mobile technologies, cloud storage, digital and augmented reality technologies and personalizing customer relationships.

Researchers call technological foresight as a modern methodology for identifying new technologies [4]. The authors conduct a patent analysis of the telecommunications equipment sector in order to find areas that may be influenced by such scientific and applied investigations. As a result of the study of patents over the eight-year period up to 2010, the authors managed to classify technology areas into four categories, depending on their relevance and growth rate.

2.2. Global technological shifts in the modern economy

The history of Kodak is an example of such dramatic changes. In 1998, the company produced 85% of the world's volume of paper for cameras and there were 170 thousands employees. However, three years later digital cameras have replaced the company with its market and it became bankrupt. In addition to

digital technologies, exponential technologies include artificial intelligence, nanotechnology, three-dimensional printing, virtual reality, electric vehicles, as well as self-driving cars and some others. These technologies already change or will significantly change our lives in the next 5-10 years. Computer software radically changes an architecture and logic of business processes. Uber is the largest taxi company in the world, but it is practically a computer program and does not physically own the cars that provide transportation. The automotive industry will also undergo dramatic changes. In addition to electric vehicles, autonomic (self-piloted) transport will be extended. It will solve the exploitation problem of the traditional personal cars, because the purchase costs, maintenance, refueling or charging, parking will be not necessary, moreover, taking into account the fact that the majority of car owners often use their machines not more than 15% of the daytime.

One of the features that unite these technologies is their high science intensity, which arises as a result of the high-level intellectual activities of researchers and scientists. Created objects of intellectual property (IP) provide the overwhelming added value for the new products and the higher capitalization of companies. Among such objects, the greatest importance have inventions, industrial designs, trademarks and brands. On average, intellectual property can form 40 to 80% of a company's value. Its value at the most valuable companies in the world (Table 1) [5] indicate the importance of a brand as an intellectual asset of a company.

It has sense, in our opinion that in the top of the rating there are high-tech companies. They demonstrate the dominance (according to Forbes) in this rating, for the most of them the impetus for development were given by exponential technologies.

The power of influence and importance of innovations in building successful business is illustrated by comparison rankings of the most expensive brands and the most innovative companies in the world, provided by the one of the world-renowned consulting companies – BCG (Boston Consulting Group) [7]. In 2019, the list of the most innovative companies includes Alphabet/Google, Amazon, Apple, Microsoft, Samsung, Netflix, IBM, Facebook, Tesla, Adidas and others.

Table 1. Top 10 Most Valuable Brands 2019

Rank 2020	Brand	Brand Value	1-Yr Value Change, %	Brand revenue	Industry
1	Apple	\$ 241.2 B	17	\$ 260.2 B	Technology
2	Google	\$ 207.5 B	24	\$ 145.6 B	Technology
3	Microsoft	\$ 162.9 B	30	\$ 125.8 B	Technology
4	Amazon	\$ 135.4 B	40	\$ 260.5 B	Technology
5	Facebook	\$ 70.3 B	-21	\$ 49.7 B	Technology
6	Coca-Cola	\$ 64.4 B	9	\$ 25.2 B	Beverages
7	Disney	\$ 61.3 B	18	\$ 38.7 B	Leisure
8	Samsung	\$ 50.4 B	-5	\$ 209.5 B	Technology
9	Louis Vuitton	\$ 47.2 B	20	\$ 15 B	Luxury
10	McDonald's	\$ 46.1 B	5	\$ 100.2 B	Restaurants

Duplication of many companies in these rankings confirms, in our opinion, the relationship and the key role of intensive research and implementation of innovations. The belonging of these companies to new rapidly developing industries and technologies demonstrates the direction of changes in technological trends and the formation of a new paradigm for the development of society. In 2018, about nineteen out of fifty companies in this rating initially built their business on digital technologies, and two more such companies were recently included in this rating - the Chinese Alibaba Group and Uber. This technological change is particularly noticeable when the brand rankings are compared among the companies that peaked in their value before the last decade. Most of those rating companies have built their businesses in the traditional industries, including oil industry. Innovative companies that operate

in digital, nanotechnology and artificial intelligence spheres have pushed now all of those companies out of this ranking.

3. Results of the study

As was mentioned above, intellectual property is the source of development and main asset of innovative companies. Changes and dynamics of indicators in this area are in direct relationship with global economic trends. At the same time, the dynamics of indicators in the field of intellectual property is an indicator of global technological changes. They reveal technologies and industries in which active patenting processes are taking place and indicate the most dynamic and rapidly growing technological trends (figures 1-6) [6]. Thus, in the Figure1 the global amount of the published patent applications in electrical engineering is presented. Some of them demonstrate high growth rate over ten year period from 2007 to 2017. They are electrical machinery, apparatus, energy (average growth 6.8%), digital communication (8.5 %), computer technology (6.2 %), IT methods for management (10.1 %). Most of all patents were published in 2017 in the field of computer technology - almost 230 thousands (229269 patents). It is the maximum figure not only in the electrical engineering field, but also among the all patented technologies in the world. 197645 patents were published in electrical, apparatus, energy machinery and 144669 – in digital communication. The decline in patenting activity in audio – visual technology and telecommunications is understandable. For the analyzed period, the average growth of these industries is negative (-1.2% and -1.3%, respectively).

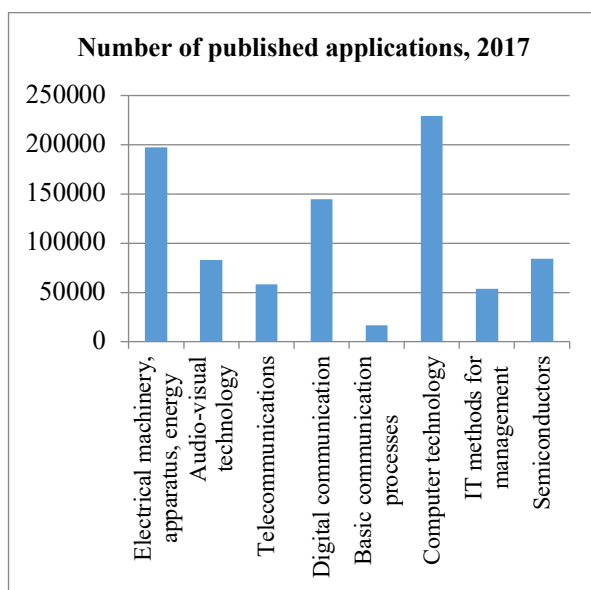


Figure 1. Published applications for the period 2007-2017 in electrical engineering field

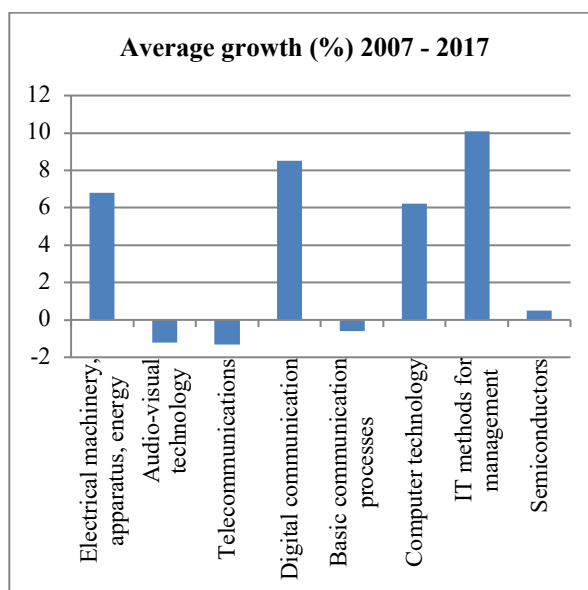


Figure 2. Average growth for the period 2007-2017 in electrical engineering field

Among chemistry technologies (figure 3,4), patents were published the most actively in organic fine chemistry with 132,863 patents (average growth in 2007-2017 was 5.8%), pharmaceuticals with 106312 published patents (3.5% average growth), basic materials chemistry (95776 patents and 9.2% average growth), as well as chemical engineering (80378 patents and 9.0% average growth). The highest average growth in the chemistry field demonstrate food chemistry (13.4%), environmental technology (9.8%), and basic materials chemistry (9.2%). In general, in this field of technology, all areas have a positive average growth of patent applications. On average, the number of applications increase every year by the range from 3.5% (pharmaceuticals) to 13.4% (food chemistry). The micro-structural and nanotechnology fields have the smallest number of applications (5294) within chemistry technologies,

but there is an active increase in their growth - 7.4%. It can be explained most likely by the insufficiently accumulated knowledge base (including expensive equipment and materials) for a technological breakthrough in the use of nanomaterials.

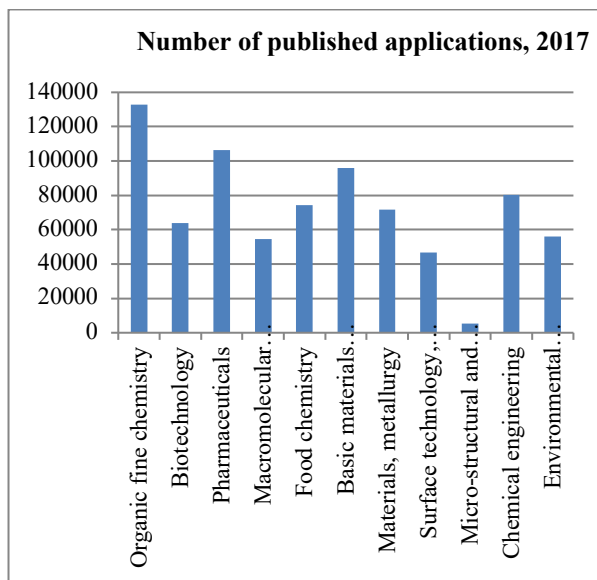


Figure 3. Published applications for the period 2007-2017 in chemistry field

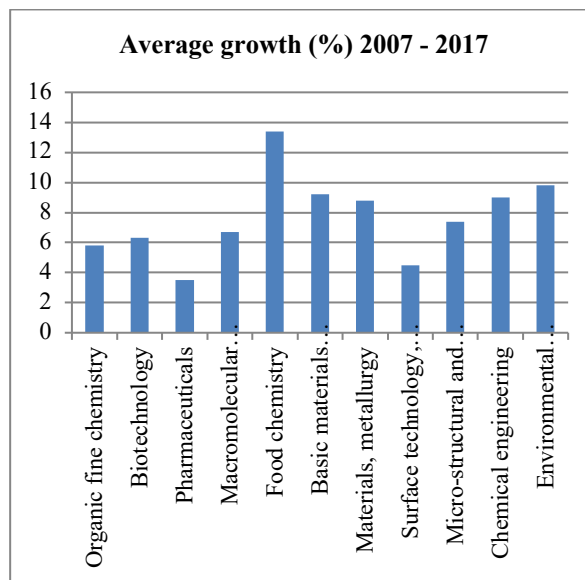


Figure 4. Average growth for the period 2007-2017 in chemistry field

In the mechanical engineering field (figure 5, 6), the largest number of patents were published in transport (124203 applications), other special machines (117901). The latter direction also shows the greatest average growth for the analyzed period (10.1%). There is also a high growth rate (9.2%) and 89742 published applications in machine tools field in 2017.

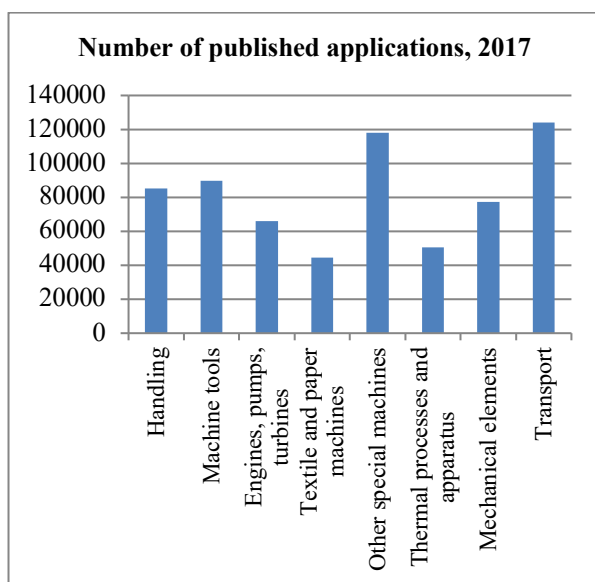


Figure 5. Published applications for the period 2007-2017 in mechanical engineering field

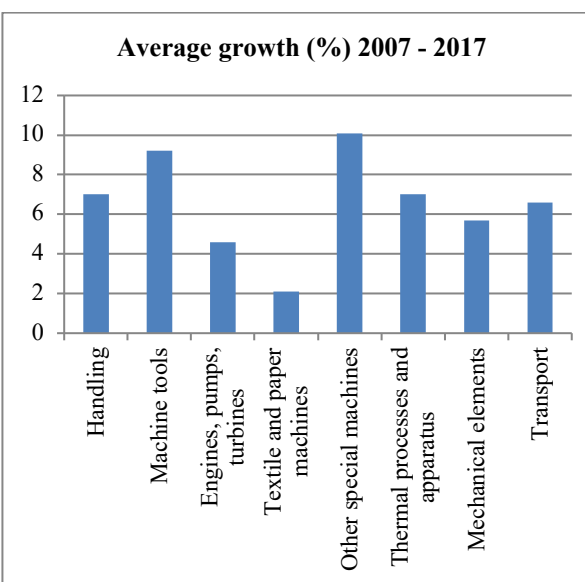


Figure 6. Average growth for the period 2007-2017 in mechanical engineering field

2,950,605 applications were published in 2017 in all areas of technology all over the world; the average growth between 2007 and 2017 was 5.6%. Thus, food chemistry, other special machines and IT

methods for management turned out to be the most innovatively active (actively patentable) with an average growth rate of more than 10%. Electrical machinery, apparatus, energy have been the most patented in Japan, Republic of Korea and Germany. The largest applicants in this area of technology are State Grid Corp of China, Mitsubishi Electric Corp, Toyota Jidosha KK and Robert Bosch GmbH. The USA and China were more active in computer technology, Switzerland in pharmaceuticals and Russian Federation in food chemistry. IBM is actively filing patents in digital communication, computer technology and semiconductors. Huawei Technologies and Samsung Electronics specialize in digital communication and computer technology, LG Electronics Inc emphasizes research on digital communication and telecommunications.

4. Discussion and conclusion

The conducted research confirms the existence of the relationship between the number of patents in a certain technological area of business and global trends in technological development in the world. In this regard, an increase in patenting activity is observed simultaneously with market success (brand value) and innovative activity of companies in the same technological fields. Some of these fields (computer technology, for example) form the basis for emerging technology trends. Regional displacement of innovation activity in developing technology fields towards Asian countries is also diagnosed from analysis of research data.

In our opinion, the conclusion is also confirmed about the connection between the strengthening of patenting activity, for example, in some fields of electrical engineering, which is happening today, with these fields' possible upcoming development and stimulation of related areas, machine learning methods or diagnostic technologies.

Exponential technology trends rapidly change the business landscape around the world, which will obviously increase the number of patent applications in connected fields. We continue to study with interest new trends and results in technological development and activity on their patenting.

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