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PATENT ACTIVITY OF THE AGRARIAN SECTOR IN THE CONTEXT OF ITS DEVELOPMENT IN GLOBAL ECONOMY

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ABSTRACT

This paper address the question, whether states' level of participation and share in patents granted and patent activity development trend in different world's regions is consistent with the sustainable development paradigm? Presently, this problem is very important and topical, not only due to the states' and regions' struggle for their economic position in the world, but also in the social and cultural dimension. The paper analyzes patent activity in the agrarian sector globally, in the context of the level and its trends by state group characterized by different level of development. This two-part analysis was performed at the macro level. The first part highlights the diminishing level of europe and north america in generating patents with a high rate of growth in asia. The second part of the paper documents low patent activity in the agrarian sector. Consequently, an attempt has been made to interpret the causes and effects of this phenomenon in the context of the drive to improve food security in the world, as an important element of sustainable development. To achieve the objective we used scientific literature and data collected by the world intellectual property organization (WIPO) and the world trade organization (WTO). The paper covers the years 2005 to 2016.

Key words: patents, intellectual property, agrarian sector, innovation

INTRODUCTION

It is currently recognized, that the main factor of economic growth, as well as social and economic development, is the intellectual capital, which, being intangible, in response to the needs of economic entities leads to innovations which later are transformed into intellectual goods. Access to such goods is limited by intellectual property rights which cover copyright and industrial property right [Biga 2014]. The latter comprises, among others, patent right that protects inventions, access to which is available only after the purchase of a license. The boom in natural and technical sciences in the 18th and 19th centuries enabled rapid development of the second technological wave, called the industrial revolution, and characterized by an increase in the number of inventions. It lead to changes in all aspects of daily life and influenced social development, including the demographic development of societies. However, it was only in the

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20th century that the theory of economics started to appreciate, describe, and analyze the role of innovations [Schumpeter 1950]. It should be noted that the dissemination of information and know-how exchange through information technology in the late 20th century formed conditions for rapid improvement of processes, products, organizations, and marketing management methods in countries rich in intellectual and technology capital. Intellectual capital is the sum total of all the knowledge in a company and its environment, as well as the capabilities of using such knowledge to achieve competitive advantage [Nahapiet and Ghoshal 1998]. Technology capital, on the other hand, is "unique know-how from investing into research and development, brands, and organization capital" [McGrattan and Prescott 2009]. At the same time there was a large imbalance in the access to new technologies and innovations available for different countries and regions.

As already mentioned, intellectual and technology capital is closely connected with intellectual property rights which can be subject to purchase and sale on both domestic and international markets. This applies to patents, design rights, commercial brands, trade secrets, commercial designs, which constitute elements of private knowledge [Gomułka 1989], which is legally protected. Countries and companies which are leaders in patent activity, i.e. in effective protection of their achievements in the area of innovations by patents, enjoy the highest economic benefits. World technological leaders achieve the highest advantage not so much in the area of R&D outlays, but in financial benefits connected with legal protection of intellectual property.

The research problem raised by this paper is comprised in the question whether the patent level and structure of entities holding patents in the world in the agrarian sector drive world food security, in conformity with the sustainable development paradigm, in the process of growing competitiveness using innovations as an advantage. The purpose of the paper is to analyze patent activity in the agrarian sector globally, in the context of its level and trends in different groups of states with different development levels in the years 2005–2016. In order to complete the task set forth herein we applied desk research, description, comparative analysis, induction, and visualization.

COUNTRY PATENT ACTIVITY

A country's patent activity is the result of companies' activities leading to the obtaining of a patent for a specific period of time and territory, and is legal, financial, technical, and organizational in nature. In 2016, the number of patents obtained by highly developed countries was significantly higher than in 2005, however, its global share declined in the same period from 80.3 to 62.7%. During the same time, countries with a level of development higher than middle increased the number of granted patents nearly five times and doubled their global share. However, the share of low developed countries in the patents granted worldwide, although up from ca. 4,000 to ca. 8,000, is still marginal and under 1%. Their distribution by the country's level of development is given in table 1.

The granting of a patent is the final stage of the journey that starts with the awareness of a need, fol-

Table 1. Patent grants by income group in years 2005, 2015 and 2016

Item	Number of grants (thous.)			Share in the world (%)			Average growth 2005–2016 (%)
	2005	2015	2016	2005	2015	2016	
High	509	785	848	80.3	63.3	62,7	3.3
Upper-middle	104	171	474	16.5	34.6	35.1	16.1
Lower-middle	16	19	22	2.5	1.5	1.6	1.5
Low	4	8	8	0.7	0.6	0.6	4.8
World	634	1 296	1 296	100.0	100.0	100.0	6.0

Source: WIPO [2016a, b; 2017].

lowed by finding ways to fulfill it, its conversion by trial and error into an innovative solution, through a number of technological trials and tests at laboratory, semi-technical, and technical levels, up to the filing of an application with the relevant institution of the patent system. "The patent system is designed to encourage innovation by providing innovators with time-limited exclusive legal rights, thus enabling them to appropriate the returns from their innovative activity. The examination process usually consists of determining whether the claimed innovation is novel, non-obvious and industrially applicable" [WIPO 2017].

It must be noted, that among the fields with a high share in the number of patents both applied for and granted are fields important for agriculture, husbandry, fish and seafood farming, as well as the storage, preservation, processing, and transport of food (Table 2).

It has been known for a long time, that presently, given the need of high spending on R&D, even large global company groups and companies are unable to pursue all directions of basic and developmental research, which are both interesting and important for them. Additionally, with the development of IT technology it is increasingly difficult to maintain secrecy of the progress and results of such scientific work. Increasing patent activity of own innovations is also a significant cost driver due to fees for patent offices, especially if the protection is to cover many countries in the world. Furthermore, patents are also created to mislead competitors (so-called patent trolls). Consequently, the old paradigm of closed innovations is being superseded by, so-called open innovations [Chesbrough 2003]. This means, that ideas for solutions, and process and product innovations from one field of manufacture or service are often transplanted into another one, finding completely unexpected applications [Zalewski 2013, WIPO 2017].

PATENT ACTIVITY IN THE AGRARIAN SECTOR IN THE WORLD

The data presented above shows a picture of a world divided in the area of the creation and circulation of intellectual goods. Medium and highly developed countries assign significant outlays on R&D (on average USD 17.6 per capita). Other countries, on the other hand, on average spend only USD 1.51 per capita [Pardey et al. 2016]. The share of outlays on R&D in the agrarian sector compared to total spending on R&D is also diversified by region (16% in Africa, 11% in South America and the Caribbean, 4% in Europe, 6% in Asia). This significant polarization is caused by

Table 2. World patent applications by selected field of technology, potentially connected with the agrarian sector, in years 2005, 2010 and 2015

Item	Applications in a year (thous.)			Share in 2015 (%)	Average growth 2005–2015 (%)
	2005	2010	2015		
Total number of applications, of which:	1 617	1 763	2 517	100.0	4.6
computer technology	108	129	187	7.4	6.9
IT methods for management	18	23	42	1.7	8.8
measurement instruments	62	78	124	4.9	7.3
analysis of biological materials	13	12	15	0.6	2.0
control	27	29	50	2.0	6.4
biotechnology	39	39	55	2.2	3.8
pharmaceuticals	73	71	103	4.1	3.4
food chemistry	23	28	63	2.5	10.9
environmental technology	21	26	43	1.7	7.5
transport	66	68	105	4.2	4.8

Source: WIPO [2016, 2017].

current needs and capabilities to satisfy them according to Unesco's Institute for Statistics.

This creates in the world a number of barriers and division criteria, among others, in access to food. Latest estimates indicate that "ca. 800 million people remain undernourished globally, down 167 million over the last decade, and 216 million lower than in 1990–1992. This decline is more visible in developing regions, despite an increase in their populations (…) in particular in Africa and Southern Asia" [FAO 2016]. What is required to overcome this barrier is common access to resources, new technologies, an improvement of the global system of food distribution, changes of consumer habits, and changes of intellectual property laws. Patent law in the world favors highly developed countries by the mere fact of protecting an invention. It is argued, that given the current demographic forecasts, which anticipate a further growth of the population to 9.7 billion in 2050 [DESA UN 2015], mankind will not be able to fully feed itself. The problem is so serious that it requires the cooperation of governments, various industries, many international and domestic organizations, as well as research and development by both the public and private sectors [Ryan 2017]. After the crisis of 2007–2011, one can see that there is a trend of reducing R&D expenditure in the agrarian sector by the public sector. According to Pardey et al. "Rich countries accounted for 56% of global public-sector spending on R&D in agriculture in 1960, but only 47% in 2011. By this point, government spending in middle-income countries – 50% of global R&D public-sector spending – had overtaken that in high-income countries (…) Meanwhile, middle-income countries (including China, Brazil and India) were responsible for 43% (their share was 29% in 1980)" [Pardey et al. 2016].

It can be noticed that technological challenges facing the agrarian sector are more complicated now than in the past. In the past, growth factors comprised of chemical fertilizers, improved methods of care and protection of plants and animals, mechanization, genetic engineering, which all ensured quantitative and qualitative yields. Presently, these are innovations, and, as Kałuża and Ginter [2014] say "these are new production techniques ensuring better use of farm resources and lower consumption of inputs, use of solutions safe for the environment (…) these are also activities connected with the dissemination of biological progress among farms (…) implementation of breeding progress in the form of new animal breeds ensuring higher yields (…) new organizational solutions are also used".

Agriculture, animal breeding, food production and processing have a significant deteriorating impact on the environment, due to its contamination with waste, use of large amounts of water, application of intensive plant protection products, electricity consumption etc. A growing demand for food means that it must be satisfied, among other things, by:

- increasing cereal production and yield;
- reducing food losses within the supply chain, in sales and consumption;
- better adaptation to climate changes and extreme weather conditions;
- using new cultivation hnologies adapted to the specificity of a location, type of soil; and climate characteristics, e.g. by sensors monitoring the quality of crop;
- applying drones to create 3D soil maps to optimize irrigation and the dozing of nitrogen fertilizers [Jarman et al. 2016, Mazur 2016];
- developing CRISPR (clustered regularly interspaced short palindromic repeats) technology, which enables the creation of specific genes in plant and animal organisms as a counterbalance for GMO [Montenegro 2016];
- using robots to automate field crop and breeding operations [Lenain et al. 2006, Gebbers and Adamchuk 2010].

The above are just examples pointing to three key directions in developing innovations in agribusiness. The first is higher yield, the second is an improvement in productivity of resources at hand, and the third – sustainable growth. Over the last dozen-or-so years, innovations and related patents in the agrarian sector have resulted mainly from the successes of biotechnology, knowledge of plant cultivation, animal breeding, digitization, and robotics.

On the other hand, the share of patents resulting from R&D in the agri-food sector conducted by some EU and OECD countries in the total number is presented in Table 3.

Table 3. Share of patents in the agri-food sector and total number of patent applications submitted to the European Patent Office by selected country in 2014

Item	Netherlands	Belgium	France	Germany	EU-15 average	OECD
Share (%)[a]	1.0	0.5	1.3	2.7	0.6	17.8
Number[b]	3 498	1 551	8 527	21 874	–	–

Source: a – Figiel [2016]; b – OECD Patent Database.

Let us note, that the data above indirectly confirm the information presented earlier. Specifically, the small number of patents in the agrarian sector is due, among other things, to the fact that it uses patents granted in other areas of activity, e.g. biotechnology. Every year, operators in the sector file several thousand patents worldwide (Table 4), which are of particular use to the sector itself and to the pharmaceutical sector.

Moreover, the number of patents granted for new plant varieties is also growing, as illustrated by data published by the U.S. Patent Office. Table 5 summarizes them by year for the period 1991–2015 and by country which received more than 500 in total.

Meanwhile, according to latest data [WIPO 2017] in the period between 2006 and 2016 highly developed countries reduced their share in the structure of patent applications for plant varieties from 74% down to 57%, in favor of countries with more than a middle level of development, which currently hold a share of 32%. These changes are taking place despite a growing trend in the number of applications, from ca. 12,000 to ca. 16,500 in the same period. Out of 13,280 patents in 2016 for new plant varieties, 2,980 patents were granted by the Community Plant Variety Office and by patent offices in China (2,132), USA (1,703), Japan (941), and South Korea (824) [WIPO 2017].

Plant variety patent activity is rated both positively and negatively [cf. Sekar and Kandavel 2009, Nambisan 2016]. According to Barton and Berger [2001] "an intense drive to patent agricultural biotechnologies may hurt those who would benefit most: people in developing countries".

Desk research leads to the conclusion that particularly controversial are patents for:

- whole plant families, e.g. transgenic cotton or soya, which allows the patent holder to control all varieties of these plants;
- specific technical procedures used in agriculture and genetic engineering;
- tools for gene exchange in plants;
- creation of transgenic varieties of basic cereals (rice, soya) requiring specific herbicides and purchase of seeds every year.

The growing phenomenon of patenting is visible in biotechnology used in agriculture. Around half of the patent market in this area is controlled by five transnational corporations (Aventis, Dow Chemical, DuPont, Monsanto, and Syngenta), who despite conducting

Table 4. Number of patent applications in the biotechnology sector in the period 1999–2013 by selected countries of the world

Item	1999	2002	2004	2006	2008	2010	2012	2013
Denmark	154	180	229	151	189	151	151	144
France	428	402	401	451	503	476	460	450
Germany	898	1 162	932	889	871	798	714	637
Netherlands	200	226	248	320	273	192	172	184
UE-28	2 987	3 139	2 862	2 968	2 928	2 675	2 528	2 433
USA	4 324	4 000	3 641	3 356	2 978	2 681	2 711	2 976
World	9 100	9 413	8 628	8 312	7 823	7 235	7 026	7 274

Source: OECD Patent Database.

Table 5. Number of patents for plant varieties[a] granted by the U.S. Patent and Trade Mark Office in the years 1991–2015 for countries with the highest share

Item	Year						Total in years 1991–2015
	1991–2001	2002	2006	2010	2014	2015	
Total	4 871	1 133	1 149	981	1 072	1,074	18 832
of which:							
USA	2 615	518	430	297	401	400	7 883
foreign	2 256	615	719	684	671	674	10 949
The Netherlands	594	218	212	188	228	200	3 257
Germany	473	145	98	160	82	141	2 244
Japan	129	30	84	50	86	52	963
Denmark	169	79	71	25	59	39	803
UK	189	35	68	47	42	32	756
Australia	104	27	45	45	47	41	591
France	183	26	23	48	12	34	536

[a]New plant varietes show higher yield, better quality, and higher resistance to pests and diseases, which increases productivity minimizing negative environmental effect. They are created using genetic engineering.

Source: U.S. Patent and Trademark [2016].

their own research and development work also take over many small biotech companies to obtain access to new technologies. This is also possible by using "open innovations" [Chesbrough 2003] and cooperation with pharmaceutical and chemical corporations to strengthen their own intellectual capital. In the future this may bring about a standstill in agriculture R&D by the public sector, and market commercialization [Barton and Berger 2001]. Among other dangers is making agriculture dependent on commercial attitudes of transnational corporations in the whole food chain, especially in developing countries.

The main applicants for these patents are companies from the US and EU. However, data provided above shows that the share of China and other Asian countries is rising. On the other hand, the involvement of African countries and Oceania is at present at ca. 3% for each of these regions (OECD Patent Database – data of 2014) [U.S. Patent and Trademark office 2016].

Furthermore, it can be concluded (assuming proportionality of shares) that the number of patents granted in the agricultural sector worldwide is also low. This most probably should be attributed to incomplete use of available resources (both human and intellectual) and is closely related to the quality of formal institutions, instruments, and systemic solutions.

CONCLUSIONS

The 21st century offers to entities in the world broader opportunities for the development of innovations and patent activity. To a large extent this is the result of growing spending on R&D, development of intellectual capital, but also intensification of companies' both internal and external communication. This includes social-related communication. The phenomenon of open innovations and network innovations is on the rise, the latter being the outcome of cooperation between different industries. The analysis above found that more than 1.3 million patents were granted in global economy in 2016 (more than twice as many as in 2006), most in Asia, followed by North America and Europe (in total over 95.5% patents worldwide). An analysis of patent applications requires "both formal and substantial examination. The substantive examination process usually consists of determining whether the claimed innovation is novel, non-obvious and industrially applicable. The patent system is designed to encourage innovation by providing innovators with time-limited exclusive legal rights, thus enabling them to appropriate the returns from their innovative activity" [WIPO 2017]. At present, the patent granting procedure takes three to five years.

There can also be other drivers leading to increased patent activity and its differentiation in different country groups. Firstly, currently we have an economy that is unsustainable, among other things, in terms of products and technologies. What is used in economic competition nowadays is a shortened life cycle of products, the phenomenon, i.e. a conscious shortening of the life cycle of many market products (e.g. household appliances, consumer electronics) and the need for new design solutions in this area [Guiltinian 2009, Bartels 2012]. Secondly, developing countries, in their attempts to reduce the technological gap towards the developed countries of Europe and North America increased their patent activity.

This activity in the agrarian sector in global economy is not well identified. Moreover, there is little information on this subject on a country-by-country basis and their groups categorized according to geographic or economic criteria. Studies indicate, that the agrarian sector in the world contributes little to the creation of patent protected intellectual property, however, it uses IP from other industries. Consequently, the interdisciplinary nature of many patents is conducive to a faster growth of the agrarian sector than would result from its internal patent activity.

Despite all the procedures and with a fast-rising number of patent applications, opinions are voiced that the current patent system is inefficient, absurd, and hindering progress and innovations [Jaffe and Lerner 2004, The Economist 2012 and 2014]. It is also speculated, that most patented innovations do not meet the criterion of significance, i.e. are not radical, but merely basic, or incremental.

In the postindustrial economy currently taking shape, there will be a growth in interdisciplinary, networking, and multifunctional innovations. Consequently, the role of the human capital in the agrarian sector is to develop application capabilities. All the more, as companies own patent activity is costly. Meanwhile, entities in lower income countries and sectors have reduced access to the intellectual property market. Research shows that there is a high increase in patent activity in countries with incompletely satisfied food needs. This phenomenon deserves praise, as "innovations are the only way to improve the balance of the situation" [Braga de Andrade and Domingos 2017]. One must agree with the opinion that "no transnational corporation, government, or other institution will solve this problem independently" [Ryan 2017]. In order to achieve world food security, there is a need for better use of available intellectual and technological capital within the framework of greater international cooperation.

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AKTYWNOŚĆ PATENTOWA SEKTORA AGRARNEGO W KONTEKŚCIE JEJ ROZWOJU W ŚWIATOWEJ GOSPODARCE

STRESZCZENIE

Problem badawczy zawiera się w pytaniu, czy stan i struktura udziału państw w przyznanych patentach na świecie oraz tendencja rozwoju aktywności patentowej w poszczególnych regionach są zgodne z paradygmatem zrównoważonego rozwoju? Problem ten jest obecnie bardzo ważny i aktualny w świetle walki nie tylko o pozycję ekonomiczną państw i regionów na świecie, ale również w wymiarze społeczno-kulturowym. Celem pracy jest analiza stanu aktywności patentowej w sektorze agrarnym w kontekście poziomu i tendencji tej aktywności na świecie, w grupach państw o różnym stopniu rozwoju. Analizę dwuczęściową wykonano na poziomie makro. W pierwszej części wskazano na malejący udział Europy i Ameryki Północnej w generowaniu patentów przy dużej dynamice wzrostu tego zjawiska w Azji. W drugiej części udokumentowano małą aktywność patentową sektora agrarnego. Podjęto próbę interpretacji przyczyn i skutków tego zjawiska w kontekście dążenia do wzrostu bezpieczeństwa żywnościowego na świecie jako istotnego elementu równoważenia rozwoju. W realizacji celu wykorzystano dane zgromadzone przez World Intellectual Property Organization (WIPO) i World Trade Organization (WTO). Zakres czasowy analizy obejmuje lata 2005–016.

Słowa kluczowe: patenty, własność intelektualna, sektor agrarny, innowacje