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## **KEY ENABLING TECHNOLOGIES IN THE EUROPEAN UNION AND IN POLAND<sup>1</sup>**

### **Summary**

*Purpose* – To analyse the situation in Key Enabling Technologies (KETs) in the European Union and in Poland.

*Research method* – Desk research and the analysis of available literature. The sources of data used were, among others: European Patent Office, Central Statistical Office, IMD World Competitiveness Centre and High Level Expert Group reports as well as the reports and data of the European Commission. KETs' analysis in Poland was conducted based on the published CSO data. The article presents selected variables characterising the activity of enterprises operating in the field of biotechnology and nanotechnology, and the analyses of research and development activities as part of the executive sectors in both of the analysed fields. In addition, data on the number of registered patents in Poland and the share of the number of registered patents in the field of biotechnology in relation to their total number were presented.

*Results* – The article covers topics connected with the measurement of KETs' competitiveness, describes the situation of KETs in Europe and in Poland, not being a very innovative EU country.

*Originality / value* – The problem of KETs and their importance for the EU and its members' sustainable development is recognized in a limited scope. There is not much literature on the topic. There is no strategy for KETs at the national level in Poland.

**Keywords:** key enabling technologies, technological competitiveness, EU strategy

**JEL Classification:** M10

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## 1. Introduction

To improve the innovative economy is one of the main goals of each member state of the European Union (EU) and it is one of the biggest challenges that the European Commission (EC) faces. Innovations, new technologies and competitive advantage are key factors driving the economy. The accomplishment of this goal demands multi-dimensional actions on many levels of the economy, such as the analysis and restriction of barriers for innovation, encouraging companies to innovate, defining a framework and conditions conducive to innovations, including public funding, regulation, financing and competitiveness.

The key factors driving innovation in the economy are new technologies. They create new development opportunities in production, processes and technological progress. The main innovative competitors of the EU are the United States, Japan and China. The European Commission data from 2009 showed that only 25% of R&D capital is invested in highly advanced production technology, while in the US over 30% of R&D investments are focused on highly advanced technologies. The share of technologically advanced production in total European manufacturing is 33% lower than in Japan and 50% lower compared to the US.

The aim of this article is to analyse Key Enabling Technologies (KETs) as an important part of EU competitiveness and development strategy and assess the situation of KETs in Poland. The article was prepared based on desk research method and uses data presented by various institutions, such as the European Patent Office, Statistics Poland and IMD World Competitiveness Centre. It is based on reports of the High Level Strategy Group and the European Commission, concerning, inter alia, the development of Key Enabling Technologies, the development of innovation, the creation of new jobs, sustainable development and globalisation.

## 2. Key Enabling Technologies' importance and impact – EU perspective

KETs are a special kind of technology which has an influence and finds its application in many areas. The significance of KETs and its impact on the economy is multidimensional and interdisciplinary. KETs become a link not only between individual economic sectors, but, above all, a link between knowledge from various fields and its practical applications, which gives Europe opportunities for great technological development and for becoming one of the world's leaders in innovation [Evangelista et al., 2018]. KETs are a group of six technologies: micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies. These technologies constitute the basis for innovation in many sectors of the industry, such as the automotive, pharmaceutical, telecommunications, food and energy industries. They can not only enrich the existing sectors of the economy but, more importantly, develop completely new branches of industry [*High-level expert...*, 2011].

Regardless of belonging to a group, each technology recognized as KET can be described by the following features:

- expected significant impact on improving economic indicators in the EU and in each member state which develops and supports KET,
- requiring high expenditure on R&D and having highly qualified personnel, researchers and scientists,
- combines knowledge from various fields and areas, arranging new technologies or enriching the existing ones, thanks to which technologically advanced goods, services or manufacturing processes are created,
- long-term, oriented on real implementation of research results and innovations, create a link between university studies and private and public business,
- create new jobs, increase competitiveness in the economy, and encourage cooperation not only among the members of the European Union, but also cooperation with teams from outside the European community to achieve technological innovation,
- all of these technologies are highly knowledge- and capital-intensive [*High-level expert...*, 2011].

Key Enabling Technologies have the potential for influencing growth and development of workplaces. It is estimated that small and medium enterprises will be responsible for most future jobs in the KET industry. In the *European Competitiveness Report* [2013] it was estimated that KETs might generate 10-20% growth, and in some particular submarkets, they can display an even larger growth potential. It is expected that member countries and regions that implement the key enabling technologies' development plan will achieve a high level of economic development and a sustainable economy. KETs will also have a positive impact on the climate change mitigation, the use of alternative energy sources and reindustrialisation [*European Competitiveness...*, 2013].

The report of High-Level Strategy Group on Industrial Technologies Conference of February 2018 states that the EU has not achieved outstanding economic results in recent years (2000-2017). Europe has not noted high economic growth, it has recorded high unemployment rates, and, what is most disappointing, large differences in indicators among member states. The best example is the difference in the average annual GDP growth from about 0.4% to 4.4%. The difference in average rates of unemployment fluctuated from 4.6% to 15.5%, while youth unemployment fluctuated from around 8.3% to 35.7%. This is truly saddening bearing in mind the European Union's stated goal, which was to invest 3% of the EU gross domestic product (GDP) in Research and Development (R&D) in order to create new jobs. In the evaluated period, the R&D investment rate stagnated at 2% of GDP, and the disproportion between members was from 0.6% to 3.3% [*Re-finding Industry...*, 2018].

It does not seem that the main goals guiding the idea of KETs have been implemented. Problems in financing and non-disclosure of the Research and Innovation (R&I) policy with internal policies of the member states do not lead to mutual

cooperation and common economic and industrial policy of all EU countries. The European Union's leadership in the field of innovation seemed to be an opportunity to promote performance equality and solidarity among all members, which would translate into a very good standard of living.

Since 2009, the European Union has been consistently implementing an economic plan based on KETs. It is evident through the emergence of new technologies, processes and inventions based on six KETs. It manifests itself, inter alia, in the number of applications for awarding a patent to the European Patent Office (EPO). This shows not only a great deal of effort in working on new technologies, but also numerous significant effects of work, which are granted patents [www 3].

In 2009, 134 511 applications were filed for the granting of the EPO patent. More than 46% of all applications came from the European Union countries, which constituted the largest share of all applications and gave the EU a leading position compared to its largest competitors in the United States, Japan and China, which represented 24.42%, 14.77% and 1.21% respectively. In the same year, 51 952 applications were positively assessed and above 48% of the granted patents belonged to the member countries of the European Union. The main goal of the European Union is to reach a world-class level of competitive industry, which will allow to achieve a significant advantage over the largest market actors which are not only limited to the United States, Japan, China and Korea. Meeting the current and forthcoming challenges will be possible only through the development and implementation of KETs [Gwarda-Gruszczyńska, Dobrowolska, 2017].

The Europe 2020 Strategy is connected with KETs. KETs actions are currently implemented by various actors which are the EU, the national and regional authorities [*Key Enabling ...*, 2013]. The overarching goal of the EC is to create interaction and cooperation between EU policies and instruments and to ensure coordination between the activities of the European Union and the national activities. Horizontal strategy is relevant for all KETs because it assumes the best, most effective use of public resources in order to obtain specific, valuable results. The European Union's strategy for KETs is based on three pillars: technological research, product demonstration and competitive manufacturing activities. The strategy for KETs could help reversing the trend of de-manufacturing and accelerate the rate of transfer, use and exploitation of KETs in the EU, in order to stimulate growth and jobs [*Boosting the potential of ...*, 2016].

Some of the sources of financing the development and implementation of KETs are: the Horizon 2020 program, "Leadership in Enabling and Industrial Technologies" (LEIT) and "cluster policy". Also the European Investment Bank (EIB) Group supports EU policy goals by financing profitable capital projects, which makes it a key player in building a knowledge-based EU economy.

### 3. KETs as a source of technological competitiveness

Technological competitiveness is a complex concept, but the most generalised definition presents technological competitiveness as generating knowledge and techniques that bring an economic benefit, which has a certain economic value [Klincewicz, 2011]. This perception of technological competitiveness is related to the technology market, where individual entities compete with each other by creating new paths in technological development, becoming pioneers in the commercialization of technology, patenting completely new technologies that are unknown to a competitor, which provides a market advantage [Weresa, Kowalski, 2018].

However, the analysis and assessment of technological competitiveness are not straightforward. Many new technologies are at the pre-commercial stage and there is no guarantee that they will be commercialised in the future. There are few companies on the market that are clearly specialised in one field of knowledge or technology and do not deal with other products and technologies. In the case of KETs, we are dealing with a multi-branch use of various technologies, which are applicable not only in many unrelated companies but, above all, in many different products, products that are created using sometimes more than one KET. The problem is also an inability to use classic methods of evaluating competitiveness, such as market share, trade performance, productivity and growth in value.

A question arises how to measure technological competitiveness related to KETs? It seems that patent data may be a good tool to evaluate technological competitiveness based on KETs. However, applying for the patent only proves the completion of the research and development stage, the result of which is the creation of a technical invention in a certain state of feasibility, but not every patent application ends with being granted the accreditation. Moreover, not every invention is novel and of significance to the development of knowledge and technique. Also, most patents vary in terms of the level of technological advancement and the degree of novelty, which translates into different economic value and commercial potential.

There is no doubt, however, that patent data is a useful source for the analysis of the spread of technology, the evaluation of development and dynamics in some areas of technology, and of the way that some countries focus on specific technologies. Depending on the country and the national patent office, there are some differences in legal regulations and the type of patents granted.

In order to facilitate the analysis based on patents, the Centre for European Economic Research (ZEW) [*European Competitiveness in ...*, 2010] used the so-called patent family, which represents a group of patent applications that are related to a single invention and are filed by the same applicant(s) in one or more countries. This method reduces the frequency of double counting of the same invention in patent data, which severely hampered measurement. The patent family takes into account the EPT or a PCT application, the so-called EPO / PCT patents [*Regional distribution of ...*, 2015].

The ZEW calculation was used by the EC in KETs Observatory Country Report for calculating the worldwide share of patents for member countries in all KETs.

The share of patents is measured by dividing the number of patent applications of the country by the total number of patent applications in specific KETs. Another indicator related to the worldwide performance of a country in each KET is the share of production, which is measured by the share of production of the country in the total KET production of all European countries. The last indicator showing the country's performance is the share in total export which is measured as the share of export from the country over total exports of all countries in specific KETs. However, when comparing the performance between countries, it needs to be taken into account that large countries will achieve a higher market share than smaller competitors. That is why the country significance indicator was created. The country significance measures were relative to the size of the country's performance in production, total export and in patenting. The country significance in patenting is calculated as the share of production in a certain KET over a country's total production. The country significance in total export is accounted as the share of a country's export in a certain KET over the country's total export. The last country significance indicator is the country significance in patenting, to calculate which we use the number of patent applications in a certain KET divided by the total number of patent applications across all fields of technology.

Another way to assess the country's competitiveness can be the ranking presented by IMD World Competitiveness database. IMD World Competitiveness Online is a comprehensive database containing information on the competitiveness of many countries. The database comprises a series of data from the IMD World Competitiveness Yearbook, which has been published since 1989 by IMD and is considered to be the leading annual report published. The data also comes from the IMD World Talent Ranking and from the IMD World Digital Competitiveness Ranking. In its methodology, the IMD World Competitiveness database uses the combination of statistical data, which constitutes 2/3, and the survey data, which constitutes 1/3, and is obtained through its exclusive business executives' opinion survey. The database presents three rankings: the IMD World Competitiveness Ranking, the IMD World Digital Competitiveness Ranking and the IMD World Talent Report, each ranking taking into account 63 countries [*World Competitiveness...*, 2019]. The IMD World Competitiveness Ranking uses 235 indicators. 'Hard' data includes, among others, national employment and trade statistics and is weighted twice as much as the 'soft' data which comes from an Executive Opinion Survey that measures the business perception of issues, such as corruption, environmental concerns and quality of life. The IMD World Digital Competitiveness Ranking assesses the degree of adoption and research of digital technologies in the country, which lead to the transformation of government practices, business models and the society. The IMD World Talent Report includes measurement in three categories: investment and development, attractiveness and readiness of the country. This enables assessing the country's performance in numerous areas, such as education, apprenticeships, workplace training, language skills, cost of living, quality of life, remuneration and tax rates. Thanks to this, it is possible to identify the development

of which competences is necessary for enterprises and the economy to achieve long-term value creation.

#### 4. Key Enabling Technologies in Poland

Poland has been a member of the European Union since May 2004. As a member of the EU, Poland is obligated to respect and implement European Union policy and strategy, which is a necessary factor not only for common growth and wealth but, above all, for contributing to reducing economic and social differences between Poland and the western countries. KETs may be a great chance for Poland to reduce unemployment, create new products and services, fight against climate change, effectively use natural resources and reduce carbon dioxide emissions. Unfortunately, there is no national policy or plan for KETs in Poland. It does not mean, however, that Poland takes no actions related to the development and implementation of KETs in the Polish economy or society. When the European Commission came up with the plan of KET-based industry, Poland did not find the sixth technology – advanced manufacturing technologies. It might, to some extent, explain Poland's position in the European Innovation Scoreboard 2018, where Poland is in the group of moderately innovative countries. It is worth noting that Poland's position in the ranking has not changed since 2014, when Poland was also among the moderate innovators. However, it is observable that even if Poland's position has not changed, slow progress in innovation performance is taking place.

In 2015, the EC created *Key Enabling Technologies (KETs) Observatory Country Report* [2015] which reported on the progress and improvement in KETs' implementation and development in Poland in the period between 2013 and 2015. The report was divided into three sections. The first section described worldwide performance of Poland in each KET. According to this paper, the share of KETs-related patents in Poland is small but increasing. A strong increase in the number of patents in industrial biotechnology has been observed since 2009. In 2013, the lowest share of patents was observed in nanotechnology. The Polish share of production, however, was dominated by nanotechnology, followed by advanced materials, which demonstrates a significant and steady increase. The share of Poland in total exports in 2015 was the highest in advanced materials and nanotechnology and had been increasing especially for advanced materials. The second part of the report focused on the performance of Poland compared to other countries by using the 'country significance indicator'.

Poland was ranked second among EU countries in terms of the country significance in nanotechnology and had the second highest share in domestic production resulting from products based on nanotechnology. It proved that Polish production in 2012 specialised more in nanotechnology than that of most other member countries, but as far as exports and patenting in nanotechnology are concerned, Poland ranked eighth and fifth respectively. The last section dealt with regional performance in KETs. The evaluation showed that the largest number of patent applications were filed in the Masovian region. The Malopolskie region focused on

the development of advanced materials, micro- and nanoelectronics, and advanced manufacturing technologies, while the Silesian region performed well in the field of advanced materials and photonics. It also noted a changeable patent activity in the field of micro- and nanoelectronics, nanotechnology and advanced manufacturing technology.

The Key Enabling Technologies Database [www 2] which operates in Poland is supervised by the Polish Chamber of Commerce for High Technology. The KETs Database was created for enterprises and research teams seeking new forms of communication and promotion in scientific and industrial activities. The database allows for placing a large amount of data in a simple and transparent way by using apps, which is one of its greatest advantages. The KETs Database is an open and dynamically developing system, which contains implemented, highly useful apps, and also adds new apps proposed directly by users. Anyone interested in the subject of KET technology can become a KET Database user. Currently, in the KETs Database there are 257 registered companies that perform their activities in the area of industrial biotechnology, 151 companies from the field of photonics, 252 from the field of advanced materials, 215 registered companies related to microelectronics and 122 companies operating in the field of nanotechnology.

**TABLE 1**

**The KET Technology Centres in Poland**

Name of KET Technology Centre	Location
CAMT – Centre for Advanced Manufacturing Technologies	Wroclaw
Centre of Bioimmobilisation and Innovative Packaging Materials	Szczecin
CNBCh – Biological and Chemical Research Centre	Warsaw
Institute of Micromechanics and Photonics	Warsaw
Institute of Natural Fibres and Medicinal Plants	Poznan
Institute of Precision Mechanics	Warsaw
Institute of Electron Technology	Warsaw

Source: [www 1].

There are seven KETs Technology Centres that operate in Poland (table 1). KET Technology Centres are public or private organizations carrying out applied research and close-to-market innovation in the field of KETs. They help small and medium enterprises enter the new KET-based products into the market and reduce the time-to-market for new innovation ideas by helping them get out of the so-called “Valley of Death” which is stalling the development and implementation of the product in the lab stage and the possibility of its commercial use. Technology Centres have to comply with three qualitative criteria: providing services to industry and SMEs, being active in at least one KET and being active in the higher Technology Readiness Levels (TRL5, TRL6, TRL 7 or TRL 8).



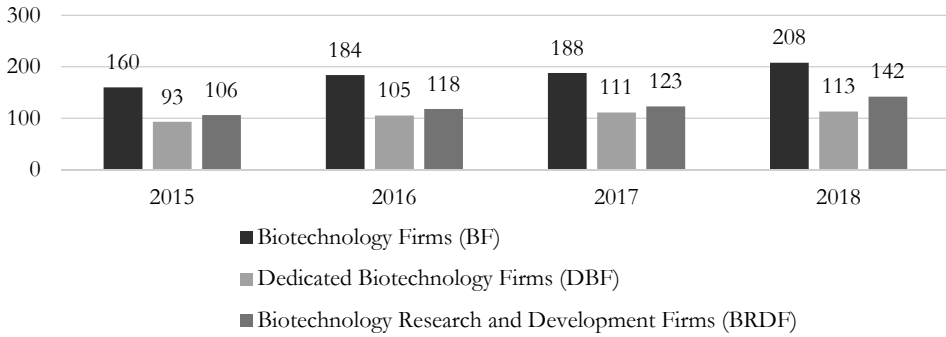
The last IMD World Competitiveness Ranking was made in 2019 and included 63 surveyed countries. Poland holds the 38th position in the ranking. It represents a decrease by four positions compared to the previous year and the result that Poland achieved in 2017. As far as factors affecting competitiveness are concerned, they were divided into four groups: Economic Performance, Government Efficiency, Business Efficiency and Infrastructure. In the Economic Performance group, Poland achieved its best result – 9th place in the Price category, while Poland's worst performance in this group was in the International Investments category (40th position). In the Government Efficiency group, Poland ranked 38th in Public Finance and 49th in the Tax Policy category – it was Poland's worst result in the whole ranking. In the Business Efficiency category, the best Polish result was 27th position in Productivity and Efficiency and the worst – 48th position in Attitudes and Values. In the last category – Infrastructure, Poland achieved the same result, 39th position, in three fields: Basic Infrastructure, Scientific Infrastructure and Education, while ranking the lowest (43rd place) in Health and Environment. The World Competitiveness Ranking also includes the 15 biggest Improvements and the 15 biggest Declines in the overall performance of the economy that have an impact on the perception of the attractiveness of the country and are associated with its competitiveness. The country profile referring to the state of KETs prepared by the European Commission in 2015, revealed that Poland performed well in generating technology related to nanotechnology and biotechnology among all KETs.

Since 2015, the Central Statistical Office has published a study on the state of biotechnology and nanotechnology in Poland. The analysis covered the period from 2015 to 2018 in terms of entities operating in the field of biotechnology and nanotechnology, financial outlays, personnel, research and development activity [*Biotechnologia i nanotechnologia...*, 2018].

In 2018, 208 biotechnology firms (BF) were identified, which represented a 10.6% increase compared to previous years – 2017 (188 biotechnology firms), and in comparison, to 2015, a 30% increase was observed. Among all biotechnology firms there were 113 companies specialising in biotechnology itself – dedicated biotechnology firms (DBF) and 143 companies from the field of research and development – biotechnology research and development firms (BRDF), (chart 1). 54.3% of all biotechnology firms, were enterprises identified as specialising in biotechnology (DBF). Enterprises conducting research and development (R&D) in the field of biotechnology (BRDF) accounted for 68.3% of the total number of biotechnology enterprises, of which almost 70% only conducted R&D in the field of biotechnology. The remaining part of enterprises (BRDF) combined R&D activity with biotechnological production.

**CHART 1**

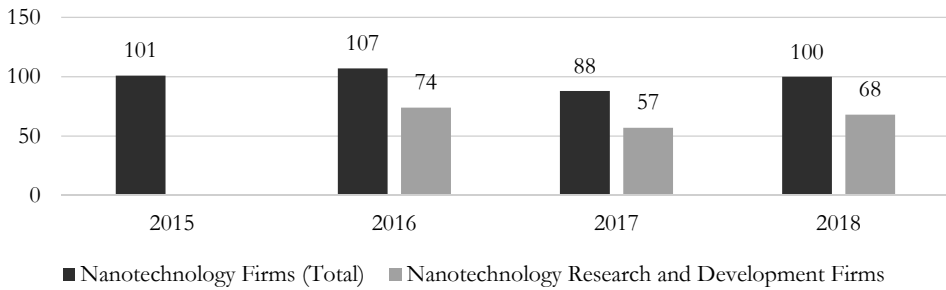
**Number of biotechnology firms in Poland in the years 2015-2018**



Source: [*Biotechnologia i nanotechnologia ...*, 2018, 2019].

**CHART 2**

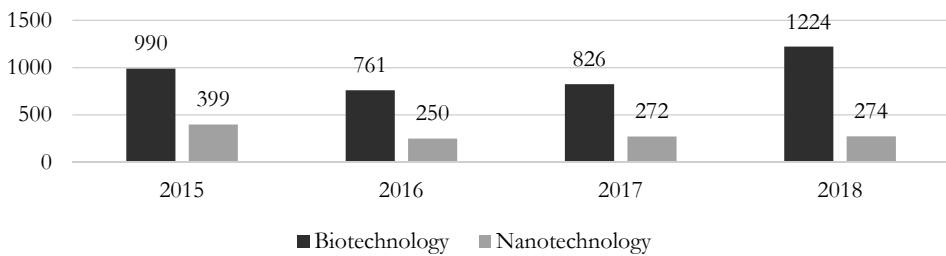
**Number of nanotechnology firms in Poland in the years 2015-2018**



Source: [*Biotechnologia i nanotechnologia ...*, 2018, 2019].

**CHART 3**

**Internal outlay in million PLN in biotechnology and nanotechnology in Poland in the years 2015-2018**



Source: [*Biotechnologia i nanotechnologia ...*, 2018, 2019].

Nanotechnology activity in enterprises refers to production in which nanotechnology is used to produce intermediate and final goods. The use of nanotechnology in production also includes the indirect involvement of enterprises in nanotechnology as users or integrators. Nanotechnology is also used in research and development, i.e. in scientific research and experimental development. In the study on nanotechnology activities, enterprises identified the areas of application of nanotechnology in production and in research and development, and also indicated the dominant area. In 2018, 100 companies operating in the field of nanotechnology were identified in Poland, which represented a 13.6% increase compared to 2017, and in comparison, to the year 2015, the number of nanotechnology firms decreased by 1%. 68% of all nanotechnology firms were enterprises specialising in research and development. Nanomaterials were the dominant area of application of nanotechnology in the firms' activity, production or research and development, which accounted for 74.1% of all areas (chart 2). The least developed areas of nanotechnology in Poland are nanophotonics, nanomagnetism, nanomechanics and catalysis.

Internal expenditure of biotechnology enterprises on activities in the field of biotechnology in 2018 amounted to PLN 1223.7 million and was 23.6% higher in comparison to the year 2015. Taking into account the value of expenditure in the previous year, the increase was definitely higher and amounted to over 48% (chart 3). Internal expenditure of firms accounted for 87.7% of internal outlay in 2018. Regarding the size of companies, 530.6 million zlotys of expenditure was incurred by companies employing 250 or more employees.

In the field of nanotechnology in 2018, the internal outlay also increased in comparison to 2017 and amounted to 274.3 million zlotys, however, as in the case of biotechnology, it did not exceed the expenditure from 2015. Compared to the previous year, a 0.8% increase in outlays on nanotechnology activities was observed.

High expenditure on research and development activity is one of the main features of all Key Enabling Technologies. Poland is not an exception – 238 and 172 entities focusing their research and development activity on the area of biotechnology and nanotechnology respectively were identified in 2018.

**TABLE 2**

**Research and Development activity in the field of biotechnology and nanotechnology in Poland in the years 2016-2018**

Field	Biotechnology			Nanotechnology		
	2016	2017	2018	2016	2017	2018
Category/Year						
Entities	238	243	258	172	146	150
Expenditure in million PLN	652.3	911.9	916.8	203.1	208.7	242.1
Employees	6968	7547	8072	3017	3095	3006

Source: [*Biotechnologia i nanotechnologia ...*, 2018, 2019].

Expenditure on research and development activity in the field of biotechnology was about 916.9 million zlotys in 2018, while funds allocated for research and development in the field of nanotechnology in Poland were estimated at 242.1 million zlotys (table 2). In 2018, 8072 employees worked in the R&D of biotechnology industry, while 3006 people were employed in R&D area of nanotechnology, fewer by more than half compared to the biotechnology field. Taking into account the number of research and development units in the case of biotechnology, this number has been steadily increasing, and at the end of 2018 the number of these units was 258. In the case of entities specialising in nanotechnology activities, the number of these units in 2018 was 150 and was lower by 22 entities, compared to 2016.

**TABLE 3**

**Research and Development in the field of Biotechnology (A)  
and Nanotechnology (B) in Poland in 2017**

A.

Division	Entities	Expenditure in thousand PLN	Employees
Enterprise sector (including enterprises)	144	490637.1	2188
Enterprises	123	420825.6	1375
Government sector and private non-profit institution sector	19	17396.6	366
Higher education sector	80	403822.4	4993
In total	243	911856.1	7547

B.

Division	Entities	Expenditure in thousand PLN	Employees
Enterprise sector (including enterprises)	76	60897.1	995
Enterprises	57	40630.7	536
Government sector and private non-profit institution sector	7	8589.2	94
Higher education sector	63	13919.6	2006
In total	146	208677.9	3095

Source: [*Biotechnologia i nanotechnologia ...*, 2018].

Interesting information was provided thanks to the analysis of R&D expenditure by executive sectors. Unfortunately, the data was not available for the year 2018. The largest group of entities conducting R&D activity in the field of biotechnology is the enterprise sector (59.3%) comprising 123 enterprises (table 3). The enterprise sector also represents the largest group of entities in the area of R&D of nanotechnology with the number of 76 entities, including 57 enterprises. In both cases, the

smallest number of entities belong to the government sector and private non-profit institution sector – 19 and 7 entities respectively. The number of entities in the higher education sector surpasses the number of enterprises in the field of nanotechnology. The largest expenditure, amounting to 490.6 million zlotys, was allocated to research and development activities in the sector of enterprises in the field of biotechnology, and only 60.9 million zlotys was allocated in the field of nanotechnology in the same sector. Regarding the nanotechnology field, the largest expenditure was in the higher education sector – 139.2 million zlotys was allocated to R&D. The higher education sector employed the largest number of R&D employees compared to other sectors, in both biotechnology and nanotechnology fields.

The most popular area of R&D biotechnology interests consisted of health care and accounted for 80.2% of total R&D activity. In 2017, compared to the previous year, a 39.8% increase (in total 911.9 million zlotys) in expenditure on research and development in the field of biotechnology was reported. The number of people employed in the area of R&D in biotechnology increased by 8.3% as compared to 2016 and almost three-quarters of employees in the area of research and development are employees performing research and development work. In the case of nanotechnology, it has been identified that the industrial sector accounts for 52.1% of entities performing research and development in this area. As already mentioned, nanomaterials were the largest area of interest for nanotechnologies. Regarding personnel, a 2.6% increase in employment was noted in relation to the previous year (2016).

**TABLE 4**

**Total number of patents and in the area of biotechnology  
in Poland in the years 2009-2018**

Year	Number of patents in biotechnology	2009 = 100	Total number of patents	2009 = 100	The share of patents indicator
2009	7	100.0	174	100.0	4.02%
2010	9	128.6	205	117.8	4.39%
2011	13	185.7	246	141.4	5.28%
2012	10	142.9	383	220.1	2.61%
2013	20	285.7	372	213.8	5.38%
2014	14	200.0	482	277.0	2.90%
2015	20	285.7	566	325.3	3.53%
2016	13	185.7	393	225.9	3.31%
2017	6	85.7	446	256.3	1.35%
2018	27	385.7	534	306.9	5.06%

Source: [www 3].

Due to the lack of data about the status of KETs in Poland, it is impossible to perform the analysis using the indicators described in the second chapter. Despite all efforts, no data related to industrial biotechnology in Poland has been found in databases, such as the European Patent Office or the Central Statistical Office in Poland, neither has a current European Commission report regarding KETs in Poland been found.

The data provided by the European Patent Office enables the calculation of worldwide performance of Poland in biotechnology in general, it means in all areas of biotechnology, including industrial biotechnology, food biotechnology, medical biotechnology and other. According to the European Commission's KETs Observatory Report, the share of patents indicator has been calculated by dividing the number of patent applications of Poland by the total number of patent applications in the biotechnology field. The share of patent applications in the field of biotechnology kept growing year by year. The largest share of patents in the field of biotechnology was recorded in 2011 (5.28%), 2013 (5.38%) and 2018 (5.06%). The share of patents indicator usually fluctuated around 4-5%. In the analysed period, the average of the share of patents indicator amounted to 3.78% (table 4).

## 5. Conclusions

The study of literature and reports of the European Commission shows that the European Union took the necessary steps to implement the KETs plan. This is evident in the continuation of the strategy of creativity and innovation, the individual elements of which are combined and complemented. The data presented by the European Patent Office shows that the European Union has a strong position in patent applications, which means that funds allocated for R&D bring some effects in the form of new inventions and techniques. However, the biggest problem of new technologies in the European Union is the translation of knowledge and technology from the level of the lab into the industrial level, which means generating new goods and products based on the acquired knowledge. In relation to patent applications in the European Union, not many goods, products and services based on KETs are generated there compared to the EU's competitors – the USA, Japan and China.

One of the goals of KETs policy is mutual cooperation at the level of member states, countries and regions, which was to condition a faster development and spread of new technologies and, at the same time, economic, technological and social unification in the European Union. It has not been entirely successful and there is a large disparity between some member states.

Poland does not belong to the European innovation leaders. The problem with commercialization and application of new technologies in the Polish industry, the way it is done in the whole of the European Union, poses a major challenge. The situation is slowly changing for the better, but it can be stated that there is still not enough scientific research in Poland that would lead to the creation and commer-

cialization of new technologies. The data presented by the European Patent Office shows that Poland has more and more patent applications every year, and most importantly, the number of patents granted to Poland is also increasing.

A comprehensive examination of KETs in Poland, based on publications and statistics, is currently impossible without conducting one's own research. This is the result not only of the lack of uniform classification and division of KETs in Poland and in the European Union, but, above all, of the lack of data. There is no general and individual statistical data about KETs in Poland. The only identified source of information on the current state of two of the KETs, is the data published by Central Statistical Office describing biotechnology and nanotechnology in Poland in the analysed period. However, this publication only provides data on the division of enterprises, number of employees and financial outlays. There is no data on patents, production, market share and other information which would enable the assessment of the state of these technologies by using the indicators described in the article.

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