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THE COMPETITIVE POTENTIAL OF THE ADVANCED TECHNOLOGY SECTOR

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Abstract: The increasing use of advanced technologies by enterprises increases the importance of the advanced technology sector in national economies. For this reason, the purpose of the research presented in the study was to determine the competitive potential of the advanced technology sector on the intra-EU market in recent years. The evaluation was conducted using the labour productivity index, labour costs and the share of the number of high technology sector enterprises in the total number of enterprises in the EU sector. Based on partial indicators, a synthetic indicator was built which allowed for the precise determination of the potential of each of the countries studied. Enterprises in countries with a strong and stable economy have higher potential, are more developed and more easily tackle the new challenges that occur in the economy. Enterprises with low competitive potential are located primarily in smaller countries with smaller support possibilities. The decisive factor was, above all, the high productivity of work.

Keywords: competitive potential, high technology sector, labour productivity, labour costs, the European Union.

1. Introduction

The concept of technology does not have a straightforward definition in the literature on the subject. It is usually identified with the technical fields, beneficial processing and production processes for raw materials, semi-finished and finished products. The definition of technology should start with the important issue that Limański and Drabik (2018, p. 50) raise, which is the division of technology into tangible and intangible. Tangible technology applies to products noticeable in patents and

computer software, while intangible technology concerns knowledge and know-how. Defining advanced technology also causes many problems that result from the specifics of the sector. According to Stankiewicz (2008, p. 12), it is assumed that this sector emerged at the interface between science and industry and is based on the processing of scientific research results in industry. It is also assumed that the advanced technology sector consists of industries that incur the highest expenditure on innovation activities compared to other industries (Korpus and Banach, 2017, p. 133). In foreign literature, the names of the sector in question are used interchangeably. Most often it is referred to as high-tech or high-technology. Polish scientific publications and statistical systems lack a specific definition of the concept in question (Ratajczak-Mrozek, 2010, p. 78). The terms used include high-tech enterprises (Gurbała, 2007, p. 61), high technologies (Kozioł, 2006, p. 21), high technology (Niedbalska, 1999, p. 4), technological (Martin, 2004, p. 90), based on new technology (Cichowski, 2005, p. 123) and high-tech (Obłój, Obłój, Bruton, and Chung Ming, 2008, p. 6). Please note that not all of these terms are synonymous with each other. Some of them have a narrow range, e.g. new technology, while others are much wider, e.g. advanced technology. Their interchangeable use leads to statistical and analytical errors.

The methodology for classifying industries to the advanced technology sector in contemporary literature is just as complicated to define and name the sector in question. The key solution, in this case, seems to be the criteria and terminology used by organizations such as the European Statistical Office (Eurostat) or the Organization for Economic Cooperation and Development (OECD) (Ratajczak-Mrozek, 2011, p. 26). Table 1 shows the division of the advanced technology sector proposed by Eurostat, the OECD and the equivalents used in the Polish Classification of Activities (PKD).

The OECD's high technology sector breakdown only applies to manufacturing companies. This is due to the fragmentary presentation of advanced technology issues contained in the series of the international Frascati Family Manual. Ratajczak-Mrozek (2010, p. 83) draws attention to the lack of consistency between studies based on the sources of one author, T. Hatzichronoglou. In one study, four industries are accepted, in another five, in addition to including knowledge-based services without distinction, all of which are advanced technology (OECD Science, Technology and Industry Outlook 200634; OECD Science, Technology and Industry Scoreboard 200735). In the Eurostat nomenclature, high-tech knowledge-intensive services are distinguished. Eurostat publications are characterized by the consistency and uniform terminology used in studies (Ratajczak-Mrozek 2010, p. 83). Siuta-Tokarska (2017, p. 245) notes that according to PKD-2007, the advanced technologies sector is divided into technologically advanced industries and services. In foreign literature, the authors note the importance of knowledge-based services in economic growth (Brenner, Capasso, Duschl, Frenken, and Treibich 2018, p. 175; Desmarchelier, Djellal, and Gallouj, 2013, p. 190). The advanced technology sector, as it results from

Table 1. Division of the high technology sector

High technology industries	Advanced technology services
Organization for Economic Cooperation and Development (OECD)	
<ul style="list-style-type: none"> • production of aviation equipment, • production of pharmaceutical products, • production of computers and office machines, • production of radio, television and communication equipment and apparatus (Ratajczak-Mrozek, 2010, pp. 82-83). 	
European Statistical Office (Eurostat)	
<ul style="list-style-type: none"> • production of aviation equipment (NACE 35.331), • production of pharmaceutical products (NACE 24.4), • production of computers and office machines (NACE 30), • production of radio, television and communication equipment and apparatus (NACE 32), • production of scientific and precision instruments (NACE 33) (Ratajczak-Mrozek, 2010, pp. 82-83). 	<ul style="list-style-type: none"> • post and telecommunications (NACE 64), • information technology (NACE 72), research and development (NACE 73) (Ratajczak-Mrozek, 2010, pp. 82-83).
Polska Klasyfikacja Działalności (PKD) – 2007	
<ul style="list-style-type: none"> • section 21: production of basic pharmaceutical substances as well as medicines and other pharmaceutical products, • section 26: manufacture of computers, electronic and optical products, • section 30, group 3: production of aircraft, spacecraft and similar machinery (Siuta-Tokarska, 2017, pp. 245-246). 	<ul style="list-style-type: none"> • section 59: activities related to the production of films, video recordings, television programmes, sound and music recordings, • section 60: broadcasting of public and subscription programmes, • section 61: telecommunications, • section 62: IT related software and consultancy activities and related activities, • section 63: information service activities, • section 72: research and development works (Siuta-Tokarska 2017, p. 246).

Source: own study based on (Siuta-Tokarska, 2017, p. 245; Ratajczak-Mrozek, 2010, p. 82).

the presented definitions and divisions, is so complex and is a relatively new sector that it should be studied from the beginning. The discrepancy in the method of analysis requires systematization as is important to establish a clear definition and division. This will prevent statistical errors, research and scientific analysis. Knowledge-based economies are the most competitive global economies that directly rely on production, distribution and the use of knowledge and information (Juchniewicz and Łada, 2020, p. 31). Due to the rapid development of the sector in question and the changes that are taking place in the domestic and international economy through it,

it is important to examine its resources and possibilities related to the competitive potential of the sector. The idea of competitive potential is skillful building of competitive advantage through the use of possessed resources and predispositions. Enterprises have a better chance of influencing the market independently, not limiting themselves to the decisions of the environment (Tłoczyński, 2017, p. 32). This was the premise for undertaking research aimed at assessing the competitive potential of the advanced technology sector in EU countries.

2. Research method

The research encompassed the advanced technologies sector comprising the sections and product groups presented in Table 1 under the Eurostat classification. The analysis covered three years (the latest available data in the Eurostat database, as of 03.04.2020), namely 2015, 2016 and 2017. The research encompassed 27 countries that are members of the European Union (EU).

The focus was on competitive potential. It was assumed in the study that competitive potential means broadly understood possibilities of enterprises which result from their tangible and intangible capital. The concept of competitiveness, under the influence of liberalization processes, has expanded its reach to the international dimension. The competition is no longer only between entities coming from the same country, but more often between foreign entities. In these conditions, enterprises gain both new opportunities and threats (Dzikowska, 2012, p. 4). For this reason the advanced technology sector was assessed on the European Union market.

Competitive potential was characterized based on the following indicators: labour productivity, labour costs and the share of the number of advanced technology enterprises in the total number of enterprises in the sector in the EU. Labour productivity was calculated as the ratio of production value to the number of employees, labour costs were calculated as the ratio of labour costs to the number of employees. The share of the number of advanced technology enterprises in the total number of enterprises in the sector in the EU was calculated, however, as a percentage of a given country in the entire European Union. Using the presented partial indicators, a synthetic indicator of competitive potential was calculated according to the methodology proposed by Juchniewicz and Łukiewska (2014, p. 123).

The previously mentioned simple features describing the competitive potential were chosen as variables. Two features (labour productivity and the share of the number of enterprises) were considered to be stimulants, as their higher level indicates greater competitiveness. One feature (labour costs) was recognized as a destimulant. The synthetic indicator was constructed using the reference method. It consists of creating a reference object, i.e. a hypothetical country characterized by the greatest competitiveness of the analysed industry. The reference unit is presented using a vector (Wysocki and Lira, 2003, p. 175):

$$z = (z_{01}, z_{02}, \dots, z_{0m})^2,$$

where:

$$z_{0j} = \begin{cases} \max_i \{z_{ij}\}, & \text{where variable } z_{ij} \text{ is stimulant} \\ \min_i \{z_{ij}\}, & \text{where variable } z_{ij} \text{ is destimulant.} \end{cases}$$

In the next step, the distance of each of the analysed EU countries from the pattern was calculated using the following formula (Suchecky and Lewandowska-Gwarda, 2010, p. 60):

$$d_{i0} = \sqrt{\sum_{j=1}^m (z_{ij} - z_{0j})^2},$$

where: d_{i0} – Euclidean distance of the i -object from the reference object.

Using the obtained values, a synthetic meter was calculated in line with the formula:

$$s_i = 1 - \frac{d_{i0}}{d_0},$$

where: s_i – synthetic index for the i -country, d_0 – critical distance of a given unit from the standard, calculated according to the formula:

$$d_0 = \bar{d}_0 + 2S_{s0},$$

where: \bar{d}_0 – arithmetic mean of taxonomic distances, S_{s0} – standard deviation of taxonomic distances.

Table 2. Criteria for grouping countries

Level	The basis for grouping
High	$(s_i \geq \bar{s} + S_s)$
Average	$(s_i \leq \bar{s} + S_s)$
Low	$(\bar{s} - S_s \leq s_i < \bar{s})$
Very low	$(s_i < \bar{s} - S_s)$

Source: own study based on (Wysocki, and Lira, 2003, p. 176).

The synthetic meter constructed in this way takes values from 0 to 1 (the higher its value, the better the competitiveness). The indicator construction procedure was used to assess the partial indicators of competitive potential and the synthetic measure of the advanced technique sector in EU countries. On this basis, countries were allocated to groups with high, medium, low and very low levels. Groups of countries were distinguished using the arithmetic mean value

and the deviation of the synthetic index, based on the methodology proposed by Wysocki and Lira (2003, p. 176). This facilitated the assessment and assignment of a given country to the appropriate group based on its distance from the country being

a benchmark for potential or synthetic competitiveness of the advanced technology sector in EU countries (Table 2).

3. Research results and discussion

Competitive potential is determined by the availability and efficiency of the use of resources and inputs of production factors. Productivity is an issue in the field of competitive potential. The aforementioned indicator is used to assess the sector’s competitiveness by many authors of economic thought (Zielińska-Głębocka, 2003, p. 84). The assessment should examine the ratio of production volume to the number of employees, in this case concerning the advanced technology sector. The results are presented in Table 3.

Table 3. Productivity of work in the advanced technology sector in European Union countries and their typology (euro/employed)

Country	Year			Level
	2015	2016	2017	
1	2	3	4	5
Belgium	303 741	321 405	337 993	high
Netherlands	256 215	261 603	271 701	
Finland	–	220 145	231 460	
Italy	192 163	187 065	192 271	average
Austria	161 913	165 009	170 949	
Germany	159 501	159 566	160 699	
Spain	142 995	140 028	140 560	
Czechia	123 568	120 639	125 386	low
Portugal	116 704	120 802	117 984	
Estonia	111 872	–	104 336	
Greece	86 807	97 549	102 120	
Hungary	94 456	93 056	98 340	
Poland	81 140	78 357	82 933	
Lithuania	53 062	54 265	59 671	
Latvia	55 332	54 855	56 516	
Romania	52 285	53 862	54 624	very low
Bulgaria	42 714	42 478	44 673	
Denmark	204 970	235 316	–	–
Ireland	–	–	–	
France	–	–	–	
Croatia	–	78 035	–	

Table 3, cont.

1	2	3	4	5
Cyprus	–	–	–	–
Luxembourg	–	–	–	
Malta	192 482	189 761	–	
Slovenia	–	–	–	
Slovakia	–	123 200	–	
Sweden	–	–	–	

Source: own study based on sbs_na_sca_r2 (Eurostat, n.d.)

Regarding the assessment of the labour productivity index, growing values that testify to economic development are desirable. In the analysis of this indicator, countries were grouped according to four levels. Belgium, the Netherlands and Finland were qualified as countries with a high level of labour productivity. Stachowiak (2009, p. 131) came to the following conclusions regarding Finland's high position as compared to EU countries, i.e. behind the success of Finnish enterprises lies a favourable environment allowing for dynamic development and skilful use of advanced technologies. The Finnish economy is largely based on ICT-related activities (mainly mobile communication). The countries with an average level of labour productivity were: Italy, Austria, Germany and Spain. In the largest number of countries, the level of labour productivity was considered low, namely: the Czech Republic, Portugal, Estonia, Greece, Hungary, Poland, Lithuania and Latvia. Romania and Bulgaria were assigned to a group of countries with a very low level of labour productivity. According to Miles, Belousova and Chichkanov (2018, p. 5), emerging economies may see a trend of emerging knowledge-based enterprises that will meet the needs of national and global markets. The level of productivity of low and very low levels varied significantly – from EUR 44 673/employed to EUR 125 386/employed. Low value-added products and much more labour-intensive production technologies influenced the lowest efficiency of Central European enterprises (Rachwał, Wiedermann, and Kilar, 2008, p. 80). Other countries were not assigned to any of the groups due to partial or complete lack of data. Referring to the research carried out by Koziół (2007, p. 130), differences in the advanced technology industry occur between the countries of the new and old European Union. According to the author, the impact on the productivity of work has, among others, the phase of the sector's life cycle in a given country. However, Rachwał et al. (2008, p. 80) in their research on labour productivity note that the largest difference in the studied indicator was between former socialist countries and the most developed countries of Western and Northern Europe. In the overwhelming number of countries, the level of productivity remained at a similar level or increased during the period considered.

Labour costs are another indicator for assessing competitive potential. According to the International Labour Organization (ILO) definition, labour cost is the total cost incurred by the employer in connection with employing the employee.

The cost of work consists of: remuneration for work performed, remuneration for non-performance of work, bonuses and gratuities, cost of meals, payments in kind, the cost of housing for employees incurred by the employer, employer’s expenses on social insurance, training costs incurred by the employer, benefits – social and others, such as: costs of transporting employees, work clothes, recruitment costs and taxes treated as labour costs (Spoz, 2017, p. 42; Grzesiak, 2018, p. 33). Table 4 presents data on labour costs incurred in the advanced technologies sector in EU countries.

Table 4. Personnel costs in the advanced technology sector in the European Union and their typology (euro/employed)

Country	Year			Level
	2015	2016	2017	
Bulgaria	11 616	12 751	14 019	very low
Romania	13 278	14 579	16 041	
Latvia	14 277	15 111	16 247	low
Poland	15 404	15 292	16 518	
Lithuania	14 604	15 855	17 291	
Hungary	17 076	17 922	19 110	
Czechia	20 486	21 200	22 919	
Estonia	20 631	–	23 758	
Greece	23 342	24 997	26 020	
Malta	26 983	24 830	28 213	
Portugal	28 255	28 598	28 474	
Spain	46 849	42 372	40 949	
Italy	46 181	45 356	46 352	
Germany	50 800	51 480	52 227	high
Netherlands	50 600	52 061	52 460	
Finland	–	56 703	56 750	
Austria	59 266	59 092	59 517	
Belgium	64 681	62 308	63 087	
Denmark	59 700	67 400	–	–
Ireland	–	–	–	
France	–	–	–	
Croatia	–	19 121	–	
Cyprus	–	–	–	
Luxembourg	–	–	–	
Slovenia	–	–	–	
Slovakia	–	18 973	–	
Sweden	–	–	–	

Source: own study based on sbs_na_sca_r2 (Eurostat, n.d.).

The labour costs presented in Table 4 are ranked from the lowest to the highest, because in this indicator enterprises strive for its lowest possible value. It is well known that one of a company's main goals is to maximize profit and minimize costs. Labour costs, as mentioned earlier, are made up of several factors that in such specialized activities that focus on the sector are not possible to reduce significantly. An example can be remuneration which in the discussed sector is higher than in other industries due to the high qualifications of employees. It can also be concluded that in smaller countries, and in underdeveloped economies, costs are lower. After the analysis, 61% of the surveyed countries found low or very low levels of labour costs. These were: Bulgaria, Romania, Latvia, Poland, Lithuania, Hungary (costs below EUR 20,000 per employee), the Czech Republic, Estonia, Greece, Malta and Portugal (costs above EUR 20,000 per employee). Spain and Italy were classified as countries with average labour costs. The highest costs among the European Union countries were incurred by Germany, the Netherlands, Finland, Austria and Belgium. Rachwał et al. (2008, p. 80) explained in their research the relationship between labour costs and labour intensity based on the example of Central and Western Europe. In the countries of Central Europe, lower labour costs are incurred because products with high labour intensity are transferred to these countries. The transfer of production concerns the least complex products. According to the authors, there is no need to implement full production automation in this part of Europe because it is more expensive and unprofitable for products and elements with a short life cycle. Therefore, attention should be paid to the relationship between favourable relations between productivity and labour costs, and the inflow of investments as well as the closure of existing branches of companies with less favourable relations. As with the analysis of labour productivity, many Member States were omitted due to the lack of statistical data.

The last indicator used to assess the competitive potential of the high technology sector was the share of the number of high technology enterprises in the total number of enterprises in the sector in the EU. Competitive potential is linked to factor competitiveness assessed by the availability and efficiency of resources and factor inputs of production. When assessing the competitive potential, the share of the number of advanced technology enterprises in the total number of enterprises in the sector in the European Union was determined as presented in Table 5.

The data obtained show that the largest share of the number of enterprises occurred in Germany, followed by France, Italy, Poland and the Netherlands. Poland turns out to be an attractive country for foreign enterprises that willingly locate their research and development centres there. In Poland, opportunities are also forecast for the production of chemicals for electronic devices, in particular biotechnology. The share of the number of enterprises in the sector in countries with a high level of this indicator was in the range of 9.07% – 14.76%. In total, this amounted to 60% of the European Union share. Spain, Sweden, the Czech Republic, Hungary and Belgium were considered as medium-share countries. The largest number of countries, i.e.

Table 5. Share of the number of high technology enterprises in the total number of enterprises in the sector in the European Union and their typology (%)

Country	Year			Level
	2015	2016	2017	
Germany	14.98	14.22	14.76	high
France	12.82	12.67	12.11	
Italy	11.75	11.16	11.01	
Poland	9.26	9.62	10.55	
Netherlands	9.46	9.09	9.07	
Spain	7.01	7.74	8.25	average
Sweden	5.74	5.44	5.45	
Czechia	4.23	4.25	4.64	
Hungary	4.29	4.11	4.23	
Belgium	3.32	3.23	3.40	low
Romania	2.37	2.32	2.45	
Greece	2.89	2.49	2.10	
Austria	1.96	1.82	1.88	
Denmark	1.76	1.72	1.76	
Portugal	1.70	1.64	1.74	
Bulgaria	1.37	1.36	1.42	
Finland	1.08	1.00	1.03	
Slovenia	1.03	1.00	1.02	very low
Lithuania	0.72	0.75	0.83	
Latvia	0.72	0.74	0.73	
Croatia	0.72	0.69	0.70	
Estonia	0.49	0.47	0.53	
Luxembourg	0.24	0.23	0.24	
Malta	0.10	0.11	0.12	
Ireland	–	–	–	
Cyprus	–	–	–	–
Slovakia	–	2.13	–	–

Source: own study based on sbs_na_sca_r2 (Eurostat, n.d.).

15 out of 24 analysed, were attributed to the low share of the number of high-tech enterprises in the total number of enterprises in the EU. Skórska (2016, p. 249) draws attention to the important role of the state, which should create long-term strategies

assuming support for modern sectors of the economy, such as the sector of advanced technology. Such strategies support enterprises in their activities and create easier conditions for, among others, exporting goods. The studies omitted Ireland, Cyprus and Slovakia for the reasons previously mentioned.

The summary of the research was the creation of a synthetic indicator based on the previously discussed partial indicators. Figure 1 presents the level of competitive potential in the European Union countries.

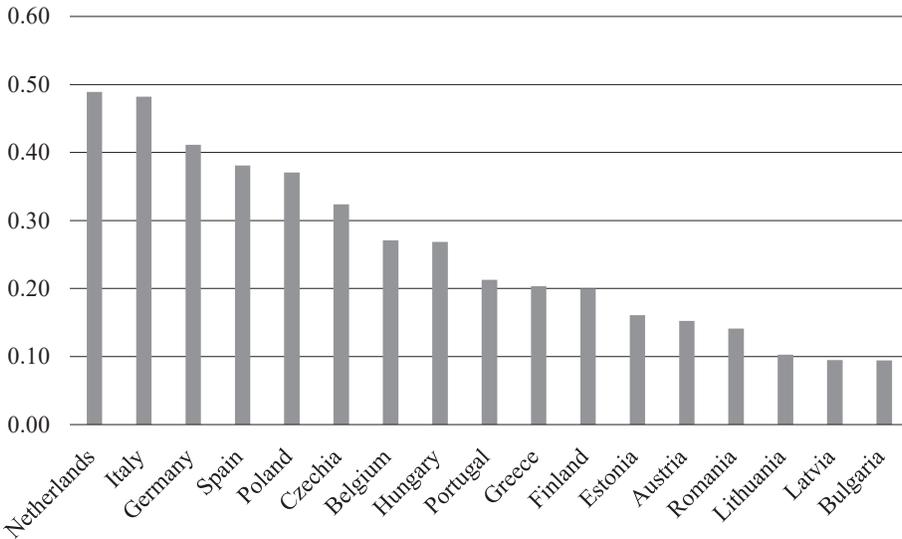


Fig. 1. A synthetic indicator of the competitive potential of the advanced technology sector in the European Union (2017)

Source: own study based on sbs_na_sca_r2 (Eurostat, n.d.).

The analysis included only those countries that were examined in terms of all three partial indicators. The difference in the value of the synthetic index ranges from less than 0.10 to close to 0.50. It was assumed that the ranking was influenced by all partial indicators equally. This means that both productivity and costs, as well as the share of a given country in the number of technologically advanced enterprises, have been recognized as equally important in shaping the economy. The highest competitive potential is demonstrated by countries with the highest labour productivity: the Netherlands, Italy and Germany. Next in the ranking were Spain, the Czech Republic, Belgium and Hungary. Portugal, Greece, Finland, Estonia, Austria and Romania have low potential. The lowest positions in the ranking were filled by Lithuania, Latvia and Bulgaria.

4. Conclusion

In the countries belonging to the European Union, the development of the advanced technology sector is notable and increasing competitive potential is seen. The characteristic features of developed economies of the advanced technology sector are the use of technologies, which are commonly classified as areas with the highest degree of use. It should be remembered that these areas are also highly dependent on specialized production factors, such as knowledge and human capital.

Partial tests show that Belgium, the Netherlands and Finland have the highest productivity. These countries also have some of the highest labour costs. In this example the relationship between labour productivity and labour costs mentioned in the work is visible. Bulgaria and Romania have the lowest levels of labour productivity and at the same time the lowest labour costs. Poland is characterized by low levels of labour productivity and labour costs, while it is at the forefront of countries with the highest share of the number of enterprises in the sector. The analysis carried out with the use of a synthetic indicator assessed the total competitive potential of the advanced technology sector, which selected the countries with the highest competitive potential: the Netherlands, Italy and Germany, due to the high level of the share of the number of high technology enterprises in the total number of enterprises in the sector in the EU. In the Netherlands, labour productivity was also at a high level. It was the only country characterized by both high efficiency and a high share of technologically advanced enterprises. The Lithuanian, Latvian and Bulgarian economies are characterized by the lowest competitive potential. Productivity indicators and participation in these countries were at a low level. Poland was in a high position among countries with a medium level of competitiveness due to the high rate of the share of the number of enterprises in the sector concerned and the low rate of productivity. The results obtained after the synthetic analysis confirmed the interaction of the partial indicators. The study attempts to assess the competitive potential using a coherent source, which was Eurostat. This allowed the sector to be explored in its entirety, and manufacturing and service industries were also taken into account, making use of Eurostat's recommendations. Data for analysis was also obtained from this database. The problem with conducting thorough research was the lack of data from a given country, or including only services or products in the database. This is confirmed by the fact that, despite the rapid and significant impact of the advanced technology sector, it is still not well recognized in terms of economic analyses.

In the future, research on the high technology sector will address the relationship between potential and competitive position. An important topic is the innovations of the high technology sector, which will also be explored.

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POTENCJAŁ KONKURENCYJNY SEKTORA ZAAWANSOWANEJ TECHNOLOGII

Streszczenie: Coraz to większe wykorzystanie zaawansowanych technologii przez przedsiębiorstwa powoduje wzrost znaczenia sektora zaawansowanej technologii w gospodarkach narodowych. Z tego względu celem badań przedstawionych w opracowaniu było określenie potencjału konkurencyjnego sektora zaawansowanej technologii na rynku wewnętrznym w ostatnich latach. W ocenie posłużono się wskaźnikiem produktywności pracy, kosztami pracy oraz udziałem liczby przedsiębiorstw sektora zaawansowanej technologii w ogólnej liczbie przedsiębiorstw sektora w UE. W oparciu o wskaźniki częściowe zbudowano wskaźnik syntetyczny, który pozwolił na precyzyjne ustalenie możliwości każdego z badanych państw. Przedsiębiorstwa w krajach o silnej i stabilnej gospodarce posiadają wyższy potencjał, są bardziej rozwinięte i łatwiej odnajdują się w nowych wyzwaniach jakie pojawiają się w gospodarce. Przedsiębiorstwa o niskim potencjale konkurencyjnym są zlokalizowane przede wszystkim w mniejszych państwach, o mniejszych możliwościach wsparcia. Czynnikiem decydującym była przede wszystkim wysoka produktywność pracy.

Słowa kluczowe: potencjał konkurencyjny, sektor zaawansowanej technologii, produktywność pracy, koszty pracy, Unia Europejska.