European Research Studies Journal
Volume XXIV, Issue 2B, 2021

pp. 1104-1116

The Criterion of Human Resources in the Assessment of the Degree of the Engagement of Knowledge in the Activities of Enterprises

Submitted 18/03/21, 1st revision 17/04/21, 2nd revision 22/05/21, accepted 30/06/21

Magdalena C. Mojsiewicz[1]

Abstract:

Purpose: *The objective of this paper was to develop a new classification of the types of activity of enterprises, taking into account the degree of involvement of research and development in production and service activity.*
Design/Methodology/Approach: *After analyzing the subject scope of the statistical surveys that are the source of data on which the calculation of the two proposed indicators (degree of R&D intensity, R&D personnel involvement) was based, a classification of R&D intensity sectors was developed. The experimental classification was prepared for Polish enterprises, for which statistical material was collected for the years 2014-2016.*
Findings: *Among classifications created due to the experimental work, one of the most reliable classifications was selected. In the classification framework, the R&D intensity is divided into three sectors: intensified R&D intensity, moderate R&D intensity, low R&D intensity. The compatibility of this classification based on R&D expenditures with the classification taking into account R&D personnel makes it possible to work out a unified classification for leaders and non-leaders innovators*
Practical Implications: *After analyzing the magnitude of the R&D personnel involvement rate (measured in %) across all business groupings, a classification was created distinguishing three sectors: intensive R&D personnel involvement (R&D personnel involvement rate value above 2%), moderate R&D personnel involvement (0.25% to 2%), and low R&D personnel involvement (less than 0.25%). This delimitation can be considered a proposal for a universal method.*
Originality/Value: *The developed and estimated indicator of R&D personnel involvement is a new approach not used before in sectoral comparisons.*

Keywords: *R&D expenditures, R&D personnel, classification of knowledge intensity.*

JEL classification: *J24, J44, O15, O30, C38.*

Paper Type: *Research study.*

Acknowledgement: *The Author is grateful for comments from the audience at the IBSCO Conference in Coventry, where an earlier version of this paper was presented.*

[1] *Institute of Economics and Finance, Unversity of Szczecin, Poland, magdalena.mojsiewicz@usz.edu.pl;*

1. Introduction

The level of enterprises' involvement in research and development and the implementation of innovations based on the research results should provide competitiveness and stability of the enterprises on the domestic and international market. There can be many factors, such as unique solutions or quality of services offered by the enterprises, constituting determinants of competitiveness.

In recent decades, there has been a visible development of the concept of distinguishing branches of economic activity, conditioned by using the "state-of-the-art knowledge" component in the production process. The concept of high technology has been modified and extended to include manufacturing and service activities. OECD countries and the European Union use jointly agreed and periodically modified lists of economic activities (the list of industries according to the International Statistical Classification of Economic Activities in the European Community, ISIC, and the International Standard Industrial Classification of all Economic Activities, NACE) in measurements and analyses according to the criterion of technological intensity. The fundamental doubt of such a way of carrying out classification procedures is that expenditures on research and development - a fundamental indicator in the procedures - in the same division of production differ significantly between countries.

It was hypothesized that there is a lack of universality of international classifications used in assessing the degree of technology in manufacturing and knowledge involvement in services. At the same time, the possibility of working out delimitation criteria of sectors of high knowledge involved in the activity of enterprises omitting variables expressed in monetary units was tested. Such an approach allows eliminating from delimitation the inflation factor and the necessity of relativization by referring to value-added.

In the study of enterprises by sectors of R&D intensity, new classifications of business activities (NACE) were developed, based on surveys conducted by Statistics Poland, reflecting the situation of non-financial and financial enterprises in Poland. This goal was achieved based on international classifications, which depend on the levels of advanced technology in section C and involvement of knowledge in services (G-U sections) on the number of expenditures on R&D.

The verification procedures of this work were described, which made it possible to revise the assumptions of international typologies in the field of broadly understood high technology in the conditions of the Polish economy. The article describes two delimitation proposals to identify sectors of R&D intensity. There was elaborated a classification procedure dividing the R&D intensity sectors from among the methodological proposals. This procedure was discussed in detail in comparing its information capacity in connection with other concepts developed in the experimental phase.

2. Literature Review

Research, education, innovation, and the development of new technologies are considered as leading aspects of production, economic growth, employment, and social cohesion. The need to quantify the impact of new technologies on industrial productivity and international comparisons has led to the need to develop standardized and comparable indicators to measure the level of knowledge involved in industrial and service production and, consequently, the intensity of technological innovation. Therefore, it is worth taking a critical look at the methodological aspects of classifying firms according to the intensity of knowledge use in production. Statistics describing the advanced technology in the industry and the advanced knowledge in services - high technology statistics for short - include economic, employment, and science, technology, and innovation (STI) data describing industrial and service enterprises. Three approaches are used to determine technological intensity: by sector, by product, and by patent. Key indicators that assess the advancement of the latest knowledge into the production process include the measurement of R&D expenditures.

Industrial enterprises are divided according to the degree of the intensity measured by the relation of R&D expenditures to the added value, based on the Statistical Classification of Economic Activities in the European Community NACE Rev.2 at the level of PKD sections and groups. This method was developed to define the High technology sector and the Medium-high, Medium-low, and Low-technology sectors. It is difficult to say when the term High technology was used for the first time, but it is attributed to Robert Metz - the author of one of the most popular regular columns in the New York Times, the so-called Market Place, which was published between 1966 and 1982. The term came into everyday use and referred to those products and sectors of the economy based on the latest achievements of science and technology. In the late 1970s, an attempt was made to systematize this area of the economy, and the discussion about what is and what is not so-called high technology continues to this day. The specificity of this issue lies in the fact that it changes dynamically in time, and making an unambiguous classification is problematic. However, such attempts should be made since the HiTech sector mainly contributes to the growth of welfare.

This distinction between high and low technology has been made only for enterprises in the manufacturing section. In response to this limitation of the method, an approach has been proposed in Eurostat to distinguish high knowledge engagement in services. A classification based on the share of people with tertiary education is applied to service enterprises as an indicator of knowledge intensity. Accordingly, we divide service enterprises based on the NACE Rev.2 classification at PKD divisions into Knowledge Intensive Services KIS and less Knowledge Intensive Services LKIS.

As part of the sectoral approach, based on NACE Rev.2 classification at the level of PKD divisions, another classification was created that divides industrial and service

enterprises according to the share of people with higher education, the so-called KIA (Knowledge Intensive Activities). The KIA classification is equally applicable to both industrial and service enterprises and public sector entities.

Somewhat parallel, the product approach was created to complement the sectoral approach and define high technology in foreign trade. The product breakdown is based on the conversion of R&D intensity by product group (R&D expenditure/total sales). High-tech products in the product approach are divided according to the Standard International Trade Classification (SITC). The patent approach in high-tech and biotech is based on the International Patent Classification (IPC 8th edition).

The OECD used several ways to determine the belonging of an area to the appropriate level of technology (measuring R&D intensity), but three indicators were most often used:

- the ratio of R&D expenditures to value-added,
- the ratio of R&D expenditure to the value of production (sales),
- the ratio of R&D expenditures plus intermediate expenditures related to technology contained in capital goods and intermediate products to the value of output (sales).

Groupings of types of activity were based on data that concerned the most developed countries belonging to the group of OECD countries, including the United States, Japan, France, Great Britain, Canada. However, disadvantages can be found in both the domain approach and the product approach. According to the domain approach, some enterprises declared to belong to a high-tech sector do not manufacture products meeting the criteria of high-tech, whereas entities are not belonging to a department classified as high-tech may manufacture HiTech products. As K. Matusiak noted: "The consequence of this may be an overestimation of technological intensity in some sectors, at the cost of its underestimation in others (it is assumed, for example, that a significant part of R&D expenditures in the aeronautics industry concerns electronics, which results in overestimation of technological intensity in the former area and underestimation of R&D intensity in the latter)." Theoretically, the product approach solves this problem, but it faces the barrier of not having access to detailed data on all products produced by firms.

According to M. Trajtenberg, when analyzing high technology activities, it is worth focusing on two additional criteria - the number of patents obtained by the company or license agreements signed, and the share of highly qualified scientific and technical staff in the company. However, these criteria are used locally rather than globally, mainly due to insufficient data to make international comparisons based on them. The OECD stresses that due to lack of data, only R&D intensity can be a valuable criterion for international comparisons.

Currently, it was assumed based on research by Thomas Hatzichronoglou in 1997, and its revision carried out at the European Commission's Joint Research Centre (JRC) in

2000, that according to the intensity of R&D work in particular fields, industrial enterprises are classified into the levels of advanced technology shown in Table 1.

Table 1. *Criteria for advancement of technology (1980, 1990)*

	R&D expenditure in the value of sales in the allocated NACE divisions		
	Min	*Range 1980*	*Range 1990*
High Technology	7.50%	9.33%÷16.06%	9.40%÷17.30%
Medium-High Technology	2.50%	2.00%÷4.69%	2.58%÷6.55%
Medium-Low Technology	1.00%	0.80%÷2.20%	1.33%÷2.47%
Low Technology	0.00%	0.55%÷0.68%	0.65%÷0.88%

Note: *Min: criterion set in the revision for international comparisons.*
Source: *Hatzichronoglou, T. (1997), "Revision of the High-Technology Sector and Product Classification", OECD Science, Technology and Industry Working Papers, No. 1997/02, OECD Publishing, Paris.*

The intensity of R&D work in particular fields of technology advancement in countries where innovation is imitative rather than an absolute novelty in world markets differs from the levels presented in Table 1. In particular, in Poland, the intensity of direct and indirect R&D work in each selected class is several times lower. It remains at the level of more than 1.00% for high technology, but no more than 2.00%. It gives the reflection of the inadequacy of the criteria for all countries.

For a long time, research on innovation has been based on industrial enterprises, including high-tech enterprises and technical innovations, while the service sector and non-technical innovations have not been taken into account. The main problem in research on KIS (knowledge-intensive services) service enterprises is identifying appropriate indicators for measuring knowledge intensity in services. Therefore, some researchers do not precisely define knowledge-intensive services but characterize them by the characteristics that these services have or the phenomena that occur in them. Such researchers include Sari Kemppilä and Paula Mettänen (2004), who attribute the following characteristics to KIS:

- knowledge is their significant input,
- they are largely based on the competence and knowledge of the employees who provide these services,
- they are a source of knowledge for clients or are used as an input in the process of developing the client's own knowledge, and
- there is a strong interaction between the customer and the provider of these services that enables the distribution and creation of new knowledge.

Peter Wood (2002) also does not define knowledge-based services but emphasizes that these services, provided by professionals in the fields concerned, consist of various management and technical advice forms, including computer advice. He equates KIS with consulting services, using the terms interchangeably. Paul Windrum

and Mark Tomlinson (1999) attempted to define knowledge-based services by describing the firms that provide these services as private sector organizations that rely on professional knowledge and expertise in a particular technical or functional area. These entities can be primary sources of information and knowledge (through reports, training, consulting, etc.), and the products of these firms can be key intermediates in the production processes of other organizations (e.g., communication and computer services).

Ibrahim Laafia, in the publication "Employment in high tech and knowledge-intensive sectors in the EU continued to grow in 2001," published in the series "Statistics in Focus" (2002) presented, based on Eurostat data, the divisions included in the KIS according to the NACE Rev.1.1 classification. A slightly more detailed division of knowledge-intensive services based on NACE Rev.1.1 classification was presented by August Götzfried (2004).

International statistics assessing the degree of new knowledge in enterprises have not developed a common sectoral approach for manufacturing and services. In the following section, an approach will be discussed that attempts a unification that can be applied to all NACE divisions in which enterprises have their main activities.

The classifications of enterprises discussed in the previous section, using the degree of technological and knowledge involved in a given economic activity, can be helpful in many comparative analyses. However, they have certain limitations, which include: lack of complete coverage of all activities, unverified over time advancement of technology and involvement of knowledge, and inadequacy of the established classification criterion for enterprises of those countries whose data were not taken into account in the process of creating the classification. Given the significant limitations of the international classification, this paper attempts to create a classification based on the concept of technological advancement and knowledge engagement, but adequate in time and space. It was assumed that the new classification will apply to all types of economic activities and will be created after a thorough analysis of variables and indicators reflecting the level of knowledge engagement in Poland in the recent period. Poland was used as an empirical example of a country that is not an innovation leader.

The new classification uses the concept of the intensity of state-of-the-art knowledge measured by the contribution of research and development work to the production process of a given economic activity. However, a simple and adequate measurement of the mentioned component is not possible due to many limitations in studying national economic entities. Three independent attempts at the desired reclassification were made, and in the end, the variant giving the complete picture of the diagnostic variables and indicators was selected. Two approaches were used to verify the intensity of the latest knowledge component in Polish enterprises:

- an approach that takes into account the value of research and development (R&D) expenditures, and

- an approach using the level of involvement of research personnel.

Because of the assumption of universality of the proposed method, the focus will be more intensive on personnel. This is because it is assumed that the human resource would have a better comparability property against cross-country salary inequality.

The first approach was considered to be closest to the idea of Robert Metz's classical classification of the degree of technology advancement, verified by Thomas Hatzichronoglou - in the following part of the paper; it is called the classical approach, using the degree of R&D intensity. However, it is distinguished from the commonly used approach by not being limited to the Manufacturing section. Some similarities to the classification derived from the concept of knowledge-based services by Paul Windrum and Mark Tomlinson can also be observed. The reclassification attempts undertaken by the research team allowed for the first time to obtain an assessment of the degree of knowledge involved in services in Polish conditions. The second approach, using the involvement of R&D personnel in a given economic activity, has not been proposed in the literature so far.

The main idea of the first approach was to use R&D expenditures and revenues from sales of products, goods, and materials to determine the intensity sectors of the state-of-the-art knowledge component, called R&D intensity sectors. Under this approach, an index of R&D intensity in a given economic activity I1 was prepared:

$$I_{1i} = \frac{N_{i,2014}+N_{i,2015}+N_{i,2016}}{S_{i,2014}+S_{i,2015}+S_{i,2016}} \cdot 100\%,\ i = 1, \dots, 92 \qquad (1)$$

where, N_i - R&D expenditures in the *i*-th economic activity grouping 2014:2016, S_i - revenue from sales of products, goods and materials in the *i*-th grouping of economic activity 2014:2016.

All economic activities have been grouped into 92 classes. These groupings are not derived from homogeneous levels of the Polish Classification of Activities. The idea of such grouping emerged due to the analysis of the diversification of the R&D component in the enterprise sector in Eurostat and OECD analyses. In most cases, the grouping has been prepared based on NACE divisions, and for the divisions for which both mentioned international organizations observe a significant dispersion between the groups, the data have been broken down to the level of NACE groups. Since research and development activities in some sections of NACE may not be continuous, and in some entities, this type of investment may even be incidental, in order to avoid misclassification caused by a one-time increase in R&D expenditures in the analysis used data for three years (2014-2016). It was considered that in Polish conditions, this approach would allow obtaining more reliable results.
In the other part of this experimental approach, a new variant of the estimation of the value of R&D expenditures was adopted (the first of which assumed the use of the value of intramuscular expenditures on R&D) closest to the concept of the OECD

database, the Analytical Business Enterprise Research and Development (OECD, ANBERD Database), which includes own expenditures on a given type of economic activity and expenditures dedicated to this type of activity by the entities of Section 72 Research and Development. In Poland, the OECD concept was modified by expanding. Section 72 outlays dedicated to specific industries and extended this approach to universities' outlays, provided that they were aimed at specific applications in economic entities. In the first variant, internal expenditures dedicated to a given type of activity Ni(a) were estimated, and consequently, the indicator I1i(a).

The research paper uses data on the value of both internal and external expenditures on research and development activities obtained from the Report on Research and Development (R&D) forms. Following the survey methodology, internal R&D expenditures are expenditures incurred in the reporting year on R&D work performed in the reporting unit, regardless of the source of funds. They include current, and capital expenditures related to R&D activities but exclude depreciation of these resources and VAT. Extramular expenditure on R&D is the expenditure on R&D performed outside the reporting unit by other domestic and foreign entities or individuals. External expenditures include funds transferred to purchase R&D services and products and the transfer of funds without obtaining a specific R&D service or product in return (e.g., transfer of contributions to international organizations, transfer of money within one's group to another enterprise).

They determined the R&D intensity ratio in each of the 92 groupings required to estimate Si's revenue from sales of products, goods, and materials. The critical data source for this approach was the Annual Enterprise Survey form, from which the value of revenue from sales of products, goods, and materials (excluding VAT) was obtained. Data were aggregated; missing values were obtained by using the structure of net revenues from sales of products, goods, and materials extracted from the Innovation Survey for Industry.

Table 2. *Criteria for delimitation of advancement of technology (Poland 2014:2016)*

	ANBERD expenditure in the value of sales in the allocated NACE divisions	
	Min	*Range 2014:2016*
Intensified R&D intensity	2.00%	2.23%÷82.56%
Moderate R&D intensity	0.25%	0.27%÷1. 96%
Low R&D intensity	0.00%	0.00%÷0.24%

Note: *Min: criterion set for* $I_1(a)$ *in the revision for non-leaders innovators.*
Source: *Own elaboration.*

In the next step of the experimental phase, an attempt was made to reclassify using the intensity of the state-of-the-art knowledge component measured by the involvement of research personnel in a given economic activity. This approach is novel in nature, and it produced an indicator of R&D personnel involvement in the

type of economic activity I_2:

$$I_{2i} = \frac{B_{i,2014}+B_{i,2015}+B_{i,2016}}{P_{i,2014}+P_{i,2015}+P_{i,2016}} \cdot 100\%,\ i = 1,\dots,92 \quad (2)$$

where, B_i - R&D research personnel (researchers) in the *i*-th economic activity grouping 2014:2016, P_i - employees in the *i*-th grouping of economic activity 2014:2016.

The second approach used analogous data sources, as in the case of classical approaches. The research paper assumed that the size of the research staff in the i-th grouping of economic activities is the same as the internal staff (employees) in R&D. Unit data on R&D personnel were obtained from the Report on Research and Development Activities (R&D). The R&D survey methodology defines internal R&D personnel as all persons directly involved in R&D work and those providing direct services. Data on employees are not converted to FTE. Data on R&D personnel are measured in several persons and the so-called full-time equivalents (FTE).

In the methodological work, it was decided to use the size of the internal R&D staff expressed in FTE because the actual involvement of people working on R&D activities can be accurately determined. Measuring internal R&D personnel in FTE avoids overestimating the size of the R&D personnel resulting from the fact that many people associated with this activity devote part of their working time to activities other than R&D. One full-time equivalent means one person-year devoted exclusively to R&D activities. Employees working in R&D activities in full-time equivalents were determined based on the proportion of time worked by individual employees during the reporting year on R&D activities to the full-time working time prevailing in a given institution for a given job position. The total number of employees in the i-th business grouping used in approach two was obtained from the Annual Business Survey form.

Table 3. *Criteria for delimitation of advancement of technology according to human resources (Poland 2014:2016)*

	ANBERD expenditure in the value of sales in the allocated NACE divisions	
	Min	*Range 2014:2016*
Intensified R&D intensity	2.00%	2.03%÷40.50%
Moderate R&D intensity	0.25%	0.31%÷1. 98%
Low R&D intensity	0.00%	0.00%÷0.25%

Note: *Min: criterion set for I_2 in the revision for non-leaders innovators. The lack of a value for the R&D personnel involvement index prevented the indication of the R&D intensity sector for the six NACE divisions: 64, 65, 66, 84, 91 and 94.*
Source: *Own elaboration.*

A vital disadvantage of this approach is that it is impossible to compare the delimited sectors with another method used internationally until similar studies have been carried out for other countries.

3. Empirical Results

The obtained results indicate a significant correlation between the R&D intensity sector, in which enterprises with specific NACE were classified, and the number of internal expenditures on research and development activities incurred in 2016. The highest internal expenditures on research and development activities were incurred by non-financial enterprises classified in the intensified R&D intensity sector (PLN 5,004.6 million). Enterprises classified as moderate-intensity incurred outlays of PLN 3,648.7 million, and those classified as low-intensity R&D based on NACE allocated the least resources to R&D (PLN 3,648.7 million). Calculated per 1 research-active enterprise, the value of internal expenditures on R&D in intensive, moderate, and low R&D intensity enterprises amounted to, respectively: PLN 1,408.5 thousand, PLN 221.3 thousand, and PLN 25.8 thousand. A similar trend was observed concerning the level of innovativeness of non-financial enterprises.

The intensified R&D intensity sector recorded the highest share of enterprises that incurred outlays on innovative activities - 24.6% against 13.4% in moderate and 11.1% in low R&D intensity. In addition, on a per-company basis, the highest outlays on innovation activity in 2016 were incurred by enterprises included in the intensive R&D intensity sector (PLN 1,370 thousand), while in moderate and low R&D intensity, these values amounted to respectively, PLN 556 thousand and PLN 655 thousand. Analyzing the share of enterprises that in 2014-2016 were innovative, innovation active, introduced product, process, organizational, marketing innovations, it can be noted that the percentage of enterprises in each of these cases was the highest in the sector of intensive R&D intensity, and the lowest - in low R&D intensity.

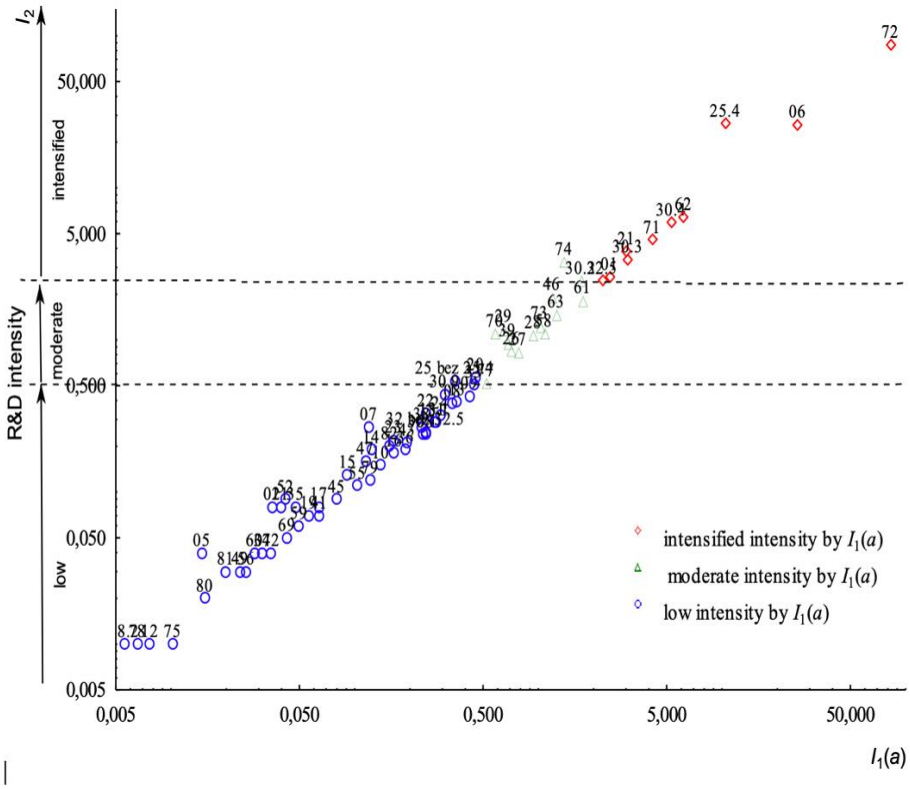
Figure 1 presents a summary of both approaches used in the experiment, based on which the delimitation of R&D intensity sectors were developed, which are marked as:

$I_1(a)$ - the first variant of the classical approach using expenditures on R&D,
I_2 - approach using the involvement of R&D personnel,

Figure 1 presents a comparison of the similar values of the indicator used in the final classification and the indicator for R&D staff involvement. In this comparison, the differences are significant, especially in the moderate R&D intensity group. Therefore, it was considered that this classification would act as a supporting classification. Should similar studies be undertaken in future years, it is recommended that this approach be tested. In groupings such as Telecommunications and Publishing, the W2 index reached values in the upper range, and the conclusion of high R&D intensity in these groupings was not confirmed by classical analysis. This may

indicate, for example, a lower level of involvement of fixed assets in researching these types of economic activity. This conclusion is only a conjecture requiring possible verification in the subsequent editions of the survey.

Figure 1. *Consistency of the classification obtained with the $I_1(a)$ and I_2 indicators*



Source: *Own elaboration.*

The linear arrangement of points in Figure 1 demonstrates high agreement between the two approaches (linear correlation coefficient 0.962). With thresholds set at the levels presented in Tables 2 and 3, inconsistencies appeared for:

- divisions and groups of NACE, which in the approach obtained for indicator I1(a) were classified into intensive R&D intensity, while for indicator I2 into moderate R&D intensity: 01 - Crops, animal husbandry, hunting and related service activities, 30.4 - Production of military fighting vehicles, and 74 - Other professional, scientific and technical activities.
- NACE divisions and groups, which in the approach obtained for indicator I1(a) are classified as moderate R&D intensity, while for indicator I2 as intensive R&D intensity: 26 - Manufacture of computers, electronic and optical products, 58 - Publishing, and 61 - Telecommunications.
- The following divisions and PKD groups were classified as low R&D intensity for the indicator $I_1(a)$ and as moderate R&D intensity for the

indicator I_2: 9 - Service activities supporting mining and quarrying, 13 - Manufacture of textiles, 18.1 - Printing and service activities related to printing 19 - Manufacture and processing of coke and refined petroleum products, 22 - Manufacture of rubber and plastic products 23 - Manufacture of other non-metallic mineral products 24 - Manufacture of basic metals 30.9 - Manufacture of transport equipment n.e.c, 31 - Manufacture of furniture 32.1+32.2+32.3+32.4+32.9 - Other manufacturing of goods (excluding Manufacture of machinery, instruments and medical and dental products) 79 - Travel agency, tour operator and other reservation service and related activities.

4. Conclusions

Based on the research work conducted, the following recommendations can be made:

- The study's strength was to verify the validity of applying international standards in the field of high technology statistics in Polish conditions. This will allow, in the future, to broaden the perspective of entrepreneurship research in regional analyses. We emphasize the fact of omission in the existing international classifications of activities related to mining and quarrying and agricultural activities, important in the assessment of national subjects.
- A weakness of the prepared procedures is the lack of possibility to verify their universality in the international arena. Any comparisons with the statistics of other countries are also impossible. However, it is possible to prepare analogous delimitations for other countries, including non-innovation leaders.
- The study was an experiment of its own. The results are not universal, timeless or permanent. In the event of further attempts to identify R&D intensity sectors in the future, appropriate revisions should be made on the basis of subsequent years (in this study, the years 2014-2016 were adopted for the identification of R&D intensity sectors).
- Possible revisions to the scope of R&D intensity sectors can be based on the R&D intensity indicators presented in the paper - $I_1(a)$- using a methodology similar to the OECD ANBERD analysis, taking into account direct and indirect R&D expenditures.
- The greatest opportunity for unification of methods for countries with different types of innovation is seen in the development of a method based on the I2 indicator, which uses only the number of research personnel expressed in full-time equivalents, excluding the wage component. This would eliminate the incomparability of the delimitation criteria between countries.

References:

Drucker, P.F. 1989. The New Realities: In Government and Politics/In Economics and Business. In Society and World View. New York: Harper & Row.

Eurostat. 2008. Working Group Meeting on Statistics on Science, Technology and Innovation, Luxembourg, 27-28 November 2008. Eurostat/F4/STI/2008/12.
Eurostat. 2010. Working Group Meeting on Statistics on Science, Technology and Innovation, Luxembourg 22-23 November 2010. Eurostat/F4/STI/2010/14.
Eurostat. High-tech industry and knowledge-intensive services (htec).
Götzfried, A. 2004. Who are Europe's highly qualified human resources and where they all work? Statistics in Focus, Science and Technology, 11, Luxembourg, Eurostat.
GUS. 2016. Działalność przedsiębiorstw niefinansowych w 2016 r.
GUS. Modernizacja europejskiej statystyki gospodarczej.
GUS. Nauka i technika, Urząd Statystyczny w Szczecinie za lata 2014, 2015 i 2016.
GUS. Rachunki Narodowe według sektorów i podsektorów instytucjonalnych w latach 2012-1015.
Hatzichronoglou, T. 1997. Revision of the High-Technology Sector and Product Classification. OECD Science, Technology and Industry Working Papers, No. 1997/02. OECD Publishing, Paris.
Kozłowski, J. 2011. Statystyka nauki, techniki i innowacji w krajach UE i OECD. Stan i problemy rozwoju. MNiSW.
Laafia, I. 2002. Employment in high tech and knowledge intensive sectors in the EU continued to grow in 2001. Statistics in Focus.
Matusiak, K. 2011. Innowacje i transfer technologii. Słownik pojęć. Matusiak, K. (Ed.). Wydanie III, PARP, Warszawa.
OECD. 2015. Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development. The Measurement of Scientific, Technological and Innovation Activities. OECD Publishing, Paris.
Revised Definitions for Statistical Units – Methodology, Application and User Needs. The Main Conceptual Issues of the "Units Discussion" of the Years 2009–2014.
Rostek, K., Skala, A. 2014. Warszawskie Przedsiębiorstwa Wysokiej Techniki – raport analityczny. Stołeczne Forum Przedsiębiorczości, Warszawa.
Trajtenberg, M. 2001. Innovation in Israel 1968-1997: a comparative analysis using patent data. Research Policy.
Węgrzyn, G. 2014. Stopień zaawansowania wiedzy w usługach w krajach Unii Europejskiej. UE Wrocław.
Windrum, P., Tomlinson, M. 1999. Knowledge-intensive services and international competitiveness: a four country comparison. Technology Analysis & Strategic Management.
Wood, P. 2002. Knowledge-intensive services and urban innovativeness. Urban Studies.
Zięba, M. Sektor usług wiedzochłonnych oraz jego dynamika i struktura zatrudnienia w krajach Unii Europejskiej.