

# Innovative activity of Polish enterprises – a strategic aspect. The similarity of NACE divisions

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## Abstract

**Purpose:** The innovativeness of enterprises is dependent on many variables, including decisions regarding innovation, possessed resources and competences, and the sector of their activity. Therefore, it should be considered in a strategic dimension, both at the level of the enterprise's strategic innovativeness and overall strategy. Strategic innovativeness, which is a long-term process that takes into account the interpenetration of various types of innovation together with strategic thinking, can be an effective tool for achieving high operating efficiency and maintaining a competitive advantage in the market. The analysis of literature on the subject, as well as observations, indicates that even within one industry, there are differences in this respect. A plethora of publications focusing on the problem of innovativeness in individual enterprises, sectors, industries, and regions were found. The authors aimed to divide industries classified by NACE (the Statistical Classification of Economic Activities in the European Community) divisions into homogeneous groups in terms of the innovative undertakings of said enterprises in a given industry. **Methodology:** The empirical part presents the results of own research using the cluster analysis method, while all calculations were performed with the use of R software. **Findings:** It can be concluded that industries can be grouped into homogeneous clusters in terms of the share of innovative enterprises. The authors can also conclude that clusters listed on the basis of the share of innovative companies that introduced new or improved products and clusters listed on the basis of the share of innovative companies that introduced new or improved business processes are very similar. **Implications for theory and practice:** The combined value of the considerations presented in the paper is the possibility of obtaining supplementary information about the homogeneity of

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*innovative activities of said enterprises in an individual NACE division. These results can be used for further in-depth analysis of individual groups. **Originality and value:** However, there is no study presenting the similarity between industries and their division into homogeneous groups in terms of the share of innovative enterprises. Such a gap became an inspiration for the research, which allowed for the verification of this scientific problem.*

**Keywords:** *strategy, innovation strategy, sector, NACE divisions, cluster analysis, similarity*

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## INTRODUCTION

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The issues related to the innovativeness of modern enterprises, regions and countries remain relevant, and are considered an important area of research by both theoreticians and practitioners around the world (Szopik-Depczyńska, 2018; Dyduch, 2018; Zartha et al., 2016; Dyduch, 2015; Casadeus-Masanell & Zhu, 2013; Pichlak, 2012; Christensen, 2010; Conway & Steward, 2009; Baldwin & Gelletly, 2003; Pomykalski, 2001; Kay, 1996). On the one hand, the reasons for the continued interest in innovativeness can be seen in the heterogeneity and diversity of its understanding, and on the other hand, as an accelerator of change and improvement, success and wealth. However, the complexity of processes taking place in the modern world, including the dynamics of ICT technology development and the related digital revolution, shortening the life cycle of products, networking, force enterprises to make decisions in the field of innovation and implementation of innovation strategies. They allow for raising the level of their competitiveness and obtaining wider social, cultural and economic benefits for the regions in which they operate and in which they constitute an important pillar of economic, technological, and civilization development (Block, Fisch, & van Praag, 2017; Rahimi, Rostami, Shad, & Vafaei, 2017). Moreover, as researchers rightly point out (Nogalski & Karpacz, 2012; Branzei & Vertinsky, 2006), the creation of innovation strategies that are effective in shaping competitiveness requires building the innovative capacity of enterprises. This is done through the implementation of various activities in generating or absorbing new ideas and their implementation and supporting processes of innovativeness and a properly oriented action strategy. The scope of these activities is not unified and it differs not only between sectors but also between enterprises operating in the same industries.

In the subject literature concerning research in the field of innovative enterprise activity patterns, two main research trends can be distinguished (Wziątek-Kubiak, 2010). The first focuses on studying the homogeneity of enterprise innovation behaviors in various fields of industrial production

from the perspective of how diversified the enterprise innovation strategies are (Urbankova & Krizek, 2020; Jakimowicz & Rzeczkowski, 2019; Srholec & Verspagen, 2008; Llerena & Oltra, 2002; Elliott, Greenaway, & Hine, 2000). The second trend, which emerged in the 1990s, assumes cross-industry differentiation of enterprise innovation behaviors, and focuses on the study of the specificity of patterns in terms of the innovation of companies with high, medium, and low technological intensity. These studies contributed to the capture of the inter-sectoral differentiation of factors and patterns in the field of innovation between these two groups of enterprises (Wziątek-Kubiak, 2010; Hirsch-Kreisen, Hahn, & Jacobson, 2008).

The above-mentioned approaches raised the question of whether industries are similar in terms of the share of innovative enterprises. The lack of such studies was the main factor that inspired the authors to take up this topic and fill the research gap.

Therefore, the aim of the paper is to divide industries, classified according to NACE (the Statistical Classification of Economic Activities in the European Community) divisions, into groups that will be homogeneous in terms of the share of innovative enterprises in a given industry based on the original concept. Based on the goal defined in this way, the following research hypotheses were formulated:

- H1: Within NACE divisions, there are industries that can be grouped into clusters in terms of the share of innovative enterprises.*
- H2: The specified clusters include industries in which enterprises run a similar type of business.*
- H3: Clusters listed on the basis of the share of innovative companies that introduced new or improved products, and clusters listed on the basis of the share of innovative companies that introduced new or improved business processes, are very similar.*

The aim of the study was achieved and the research hypotheses were verified on the basis of the results of an empirical study using the methods of multivariate statistical analysis. The structure of the study includes three main parts. In the first, the authors describe the concept of innovation as an unwavering subject of interest for researchers. Moreover, they pay attention to the typology of innovations and the dimensions of organizational innovativeness and describe innovativeness as the fundamental dimension of enterprise strategic innovativeness. The second part deals with the methodological aspects of the discussed issues. The third and last part presents the results of the quantitative methods used for the statistical evaluation and verification of

the adopted goal. The research procedure includes a cluster analysis method and calculations that were performed using R software.

As part of the research, the classification of industries adopted by the Polish Central Statistical Office (GUS) was used, divided into service and industrial enterprises, and the classification of innovations divided into the introduction of new or improved products and new or improved business processes, including the type of innovation.

Moreover, the data used in the analysis came from a report published in January 2020 by the Polish Central Statistical Office – Innovative activity of enterprises in the years 2016–2018 (GUS, 2020). The following tables were adopted as the source of input data for the grouping procedure, which are an integral part of the indicated report: 1) Product innovations in the years 2016–2018; 2) Enterprises that introduced new or improved business processes in the years 2016–2018. This tool was also supported by a classic review of foreign and domestic literature and a narrative review. Undoubtedly, the advantage of the study is that it fills a research gap by presenting the similarity between industries and attempting to divide NACE divisions into homogeneous groups in terms of the share of innovative enterprises.

## LITERATURE REVIEW

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In an era of digital revolution and globalization, it is known that there is no escape from change, continuous improvement, and the implementation of innovative solutions at the level of an individual, enterprise, region, or country. However, the essence of these changes should focus on replacing those solutions that are no longer sufficient with strategies that are based on the implementation of innovative solutions, allowing in the long-term perspective the achievement of lasting competitive advantage and favoring the achievement of sustainable development (Mallinguh & Zoltan, 2020; Szopik-Depczyńska, 2018; Okwiet, Grabara, 2016; Stawarz, 2013; Bowonder, Dambal, Kumar, & Shirodkar, 2010; Low & Kalafut, 2004; Gadomski, 2004). The authors do not doubt that the implementation of innovations is perceived as a key determinant of enterprise development.

Although the topic of innovation is not new, one can still observe the heterogeneity and difficulties in interpreting the very concept of innovation and a number of analyses and scientific research in this field. There are many definitions and classifications, ways of understanding it, and levels of its perception (Jansza & Koziół-Nadolna, 2011; Białoń, 2010). Due to its nature, there has not been one unified definition so far, there is none presently, and there will not be one in the future. It seems that, like the concept of

technology, innovation often carries a large interpretative burden and, therefore, it is pointless to spend too much effort on attempting to solve this challenge (Bielińska-Dusza, 2020). However, for the accuracy and correctness of the research, the main assumptions in this matter should be accepted.

Innovations resulting from creative and planned activities are related to technological and non-technological areas, such as operational, organizational, process, financial, marketing, and economic. They are a key intangible asset and the main tool for improving and shaping competitiveness and are a fundamental process of organizational renewal. They arouse the interest of both practitioners and theoreticians, not only in the field of management and applied sciences, but also economists, lawyers, and politicians. Innovations are becoming the engine of change and the driving force behind changes in enterprises as well as economies, regions, and countries. With their growing importance, innovations are treated more and more widely, and today they constitute a condition for development and an inherent attribute of the enterprise (Dyduch, 2018; Szopik-Depczyńska, 2018; Łunarski, 2016; Low & Kalafut, 2004).

Also, the issue of the typology of innovations is challenging to characterize unambiguously due to the large diversity and varied criteria of division. As a result, this division is not standardized, precise, or transparent (Penc, 1999) and numerous research and literature reviews have attempted to systematize this issue (Szopik-Depczyńska, 2018; Szatkowski, 2016; Łunarski, 2016; Dyduch, 2015, Karlik, 2013).

Due to the limitations on content, the authors present the typology contained in the Oslo Manual. This is due to the fact that this paper uses the data contained in the GUS report, which is based on the methodology developed by Eurostat and the OECD, presented in the same manual (GUS, 2020).

The Oslo Manual distinguishes four main types of innovation: 1) Product innovations – new or significantly improved compared to the previous version of a good or service, taking into account technical specification, components and materials, software, user-friendliness or other functional features; 2) Process innovations – new, significantly improved methods of producing or delivering a product, taking into account techniques, tools and/or software; 3) Marketing innovations – new marketing methods consisting of a significant change in the appearance of the product, packaging, distribution, promotion or price; 4) Organizational innovations – new organizational methods in business practice, consisting of modifications to the workplace or external relations (OECD, 2005).

When discussing the issues of comprehending and the typology of innovations, one cannot ignore the critical and unresolved issue, which is the distinction between two closely related concepts: innovation and

innovativeness. As rightly noted by Klimas (2013), many authors (Binti et al., 2011; Jalonen, 2012; Semerciöz, Hassan, & Aldemi, 2011) use these concepts interchangeably, while others consider them inappropriate, incorrect, or even erroneous (Lynch, Walsh, & Harrington, 2010). Klimas (2013) refers to an interesting approach proposed by Wang and Ahmed (2004), according to which organizational innovativeness is the entire ability of an organization to introduce new products to the market, and open new markets through the appropriate configuration of strategic orientation with the innovative behavior of employees and implemented processes.

Researchers believe that the four types of innovation defined in the Oslo Manual, i.e. product, organizational, technological, and marketing innovation, are components of organizational innovativeness. They propose five dimensions of organizational innovativeness: 1) Product innovativeness; 2) Process innovativeness; 3) Behavioral innovativeness; 4) Strategic innovativeness; 5) Market innovativeness.

This proposal inspired the research conducted by Crossan and Apaydin (2010), which resulted in the identification of four dimensions of innovativeness: 1) Product innovativeness understood as the novel and pioneering nature of new products implemented on the market at the right time; 2) Process innovativeness understood as the implementation of new production methods, technological and management solutions for the improvement of production and management processes; 3) Behavioral innovativeness understood as individual, team or managerial activities aimed at building an internal culture of innovation and the overall openness of the organization to new ideas and innovations; 4) Strategic innovativeness understood as the ability of an organization to manage a bundle of ambitious goals, identify resource gaps that prevent the achievement of ambitious goals set for itself, take creative actions to minimize resource gaps, as well as innovative approaches and methods of operation necessary for entering new markets and deeper exploitation of the existing target markets.

These proposals provide an interesting perspective of the problem under study, but the conclusion is that no matter how one classifies the set, the distinguished types will interpenetrate, complement, overlap and merge into each other, while the enterprise may implement them jointly. And it may do so, often treating them as one, because the distinguished types do not constitute separate, isolated entities, but constitute an interdependent whole (Dyduch, 2015).

This is because innovativeness is the fundamental dimension of enterprise strategic innovativeness and a growth factor. Many studies have been written on the subject of innovativeness, highlighting that it is a source of organizational effectiveness but that it also initiates changes. It is a factor

in building a competitive advantage and is not so much a feature of the country as a feature of individual enterprises (Gomułka, 2006). Numerous researchers have also attempted to answer the question of how innovative activity within a company impacts its competitiveness (e.g., Bogdanienko, 2004; Zastempowski, 2013; Lemanowicz, 2014; Prajogo & Ahmed, 2006; Poznańska, 2002a). Most often, subject literature focuses on analyzing the innovativeness of a selected enterprise or group of enterprises, industry, economy, state or regions. Moreover, as mentioned earlier, the problem is dealt with by distinguishing within two groups: the diversity of innovativeness behaviors and homogeneity (Wziętek-Kubiak, 2010). It should also be underlined that the adopted research methodology, based on different criteria and reflecting different research perspectives, may show discrepancies in the obtained results and present them in different cross-sections. Furthermore, due to technological changes, the time period adopted for the analysis may be an interesting variable showing the nature of changes in the level of innovativeness in the long term.

Cyclical surveys conducted since 2011 by the Polish Central Statistical Office show slight changes in the innovativeness of industries over the years. In Table 1 and Table 2, five industries are presented that are the most and the least innovative in terms of the share of innovatively active enterprises.

**Table 1.** Innovatively active industrial enterprises in the years 2011–2018 by NACE divisions

	2016-2018	2014-2016	2011-2013
The most innovation	<ol style="list-style-type: none"> <li>1. Manufacture of pharmaceutical products</li> <li>2. Manufacture of computer, electronic and optical products</li> <li>3. Mining of coal and lignite</li> <li>4. Manufacture of electrical equipment</li> <li>5. Manufacture of coke and refined petroleum products</li> </ol>	<ol style="list-style-type: none"> <li>1. Mining of coal and lignite</li> <li>2. Manufacture of pharmaceutical products</li> <li>3. Manufacture of computer, electronic and optical products</li> <li>4. Manufacture of chemicals and chemical products</li> <li>5. Manufacture of coke and refined petroleum products</li> </ol>	<ol style="list-style-type: none"> <li>1. Manufacture of coke and refined petroleum products</li> <li>2. Manufacture of pharmaceutical products</li> <li>3. Manufacture of computer, electronic and optical products</li> <li>4. Manufacture of chemicals and chemical products</li> <li>5. Mining of coal and lignite</li> </ol>



	2016-2018	2014-2016	2011-2013
Least innovation	<ol style="list-style-type: none"> <li>1. Remediation activities</li> <li>2. Manufacture of wearing apparel</li> <li>3. Manufacture of products of wood, cork, straw, and wicker</li> <li>4. Manufacture of leather and related products</li> <li>5. Waste collection, treatment, and disposal activities; materials recovery</li> </ol>	<ol style="list-style-type: none"> <li>1. Manufacture of wearing apparel</li> <li>2. Manufacture of leather and related products</li> <li>3. Repair and installation of machinery and equipment</li> <li>4. Manufacture of products of wood, cork, straw, and wicker</li> <li>5. Remediation activities</li> </ol>	<ol style="list-style-type: none"> <li>1. Manufacture of wearing apparel</li> <li>2. Repair and installation of machinery and equipment</li> <li>3. Manufacture of products of wood, cork, straw and wicker</li> <li>4. Manufacture of leather and related products</li> <li>5. Manufacture of food products</li> </ol>

Source: Authors' own work, based on: GUS (2014); GUS (2018); GUS (2020).

**Table 2.** Innovatively active service enterprises in the years 2011–2018 by NACE divisions

	2016-2018	2014-2016	2011-2013
The most innovation	<ol style="list-style-type: none"> <li>1. Scientific research and development</li> <li>2. Insurance, reinsurance, and pension funding</li> <li>3. Computer programming and consultancy activities</li> <li>4. Information service activities</li> <li>5. Publishing activities</li> </ol>	<ol style="list-style-type: none"> <li>1. Insurance, reinsurance, and pension funding</li> <li>2. Scientific research and development</li> <li>3. Computer programming and consultancy activities</li> <li>4. Financial service activities</li> <li>5. Publishing activities</li> </ol>	<ol style="list-style-type: none"> <li>1. Insurance, reinsurance, and pension funding</li> <li>2. Scientific research and development</li> <li>3. Computer programming and consultancy activities</li> <li>4. Financial service activities</li> <li>5. Information service activities</li> </ol>
Least innovation	<ol style="list-style-type: none"> <li>1. Architectural and engineering activities; technical testing and analysis</li> <li>2. Air transport</li> <li>3. Wholesale trade</li> <li>4. Postal and courier activities</li> <li>5. Water transport</li> </ol>	<ol style="list-style-type: none"> <li>1. Air transport</li> <li>2. Land and pipeline transport</li> <li>3. Advertising and market research</li> <li>4. Postal and courier activities</li> <li>5. Wholesale trade</li> </ol>	<ol style="list-style-type: none"> <li>1. Land and pipeline transport</li> <li>2. Air transport</li> <li>3. Architectural and engineering activities; technical testing and analysis</li> <li>4. Wholesale trade</li> <li>5. Warehousing and support activities for transportation</li> </ol>

Source: Authors' own work, based on: GUS (2014); GUS (2018); GUS (2020).



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The analysis of the tables above provides for a general observation that the highest share of innovatively active enterprises concerns those industries in which enterprise activity is based on knowledge and those that offer knowledge-intensive services and products. These industries are saturated with knowledge in the form of technology, techniques supported by IT tools or organizational and managerial methods and techniques, which are based on up-to-date information, thanks to, for example, electronic IT tools and extensive cooperation.

The lowest innovative activity, especially industrial enterprises, results from their traditional production and low or close-to-exhaustion innovative potential (Gomułka, 2006) and insufficient financial resources and a focus on the current activities of the enterprise, rather than a well-thought-out, long-term strategy. It should be noted that in both industrial and service enterprises, the decrease and the increase in innovativeness might be a consequence of the amount of financial outlays. Moreover, enterprises more often introduce business process innovations than product innovations. This is mainly related to the implementation of new or improved methods of goods production or service development and new methods of task division, decision-making improvements, or human resource management. Additionally, the higher the level of technology advancement there is in a given industry, the greater the percentage of enterprises implementing innovations (GUS, 2020).

Moreover, it seems that such activities in individual industries are characterized by diversity, which is consistent but not homogeneous. The issue of innovativeness in Polish enterprises is the center of many academic studies (Lemanowicz, 2014; Grzybowska, 2012; Mizgajska, 2002; Poznańska, 2002b; Włodarczyk, 2012; Zastempowski, 2016). However, the research focuses on the ordering of enterprises and industries in terms of their innovativeness. Still, there are no studies that show the similarity of sectors regarding the share of innovatively active enterprises. Such an approach to the problem could also be the basis for further research, which would allow for better recognition of this area. Therefore, in the further part of this study, the authors focus on the first issue: the grouping of industries similar to each other in terms of the share of enterprises introducing new or improved products and business processes.

## METHODOLOGY

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### The scope and the goals of the analysis

According to the definition given by the Polish Central Statistical Office, an innovative enterprise in the field of product innovations and business processes is an enterprise that introduced at least one innovation to the market during the period considered, in the form of a new or improved product, or new or improved business process (GUS, 2020). A new product is a product or service that differs significantly in terms of its features or purpose from the products previously manufactured by the enterprise. Improvements to existing products include changes to materials, components and more features that make these products work better. Product innovation in the field of services is about introducing significant improvements in the way the services are provided, by adding new functions or features to existing services or by introducing completely new services. Concurrently, innovation of business processes is the introduction of new solutions or the improvement of existing business processes in the enterprise within one or more business functions, which significantly change business processes used so far (GUS, 2020).

The data used in the analysis come from a report published in January 2020 by the Polish Central Statistical Office – Innovative activity of enterprises in the years 2016–2018 (GUS, 2020). The following tables were adopted as the source of input data for the grouping procedure, which are an integral part of the indicated report: 1) Product innovations in years 2016-2018; 2) Enterprises that introduced new or improved business processes in the years 2016–2018.

### Stages of conducted analysis

Research on the homogeneity of industries was carried out separately for two groups of enterprises: industrial and service. The conducted research focused on 24 NACE divisions for industrial enterprises and 33 NACE divisions for service enterprises. Because industrial enterprises belonging to the NACE division of *Extraction of crude petroleum and natural gas* did not introduce a new or improved product or business process in the period under study, they were not included in the analysis.

The analysis was carried out according to the steps presented in Table 3.

**Table 3.** Stages of conducted analysis

Stages	Goals	Variables
Stage 1.	Designating groups of industries similar to each other	<ol style="list-style-type: none"> <li>1. Share of enterprises that introduced new or improved products;</li> <li>2. Share of enterprises that introduced new or improved business processes.</li> </ol>
Stage 2.	Designating groups of industries similar to each other in terms of the share of enterprises that introduced new or improved products	<ol style="list-style-type: none"> <li>1. Share of enterprises that introduced new or improved goods;</li> <li>2. Share of enterprises that introduced new or improved services;</li> <li>3. Share of enterprises that introduced new or improved goods or services new to the market;</li> <li>4. Share of enterprises that introduced new or improved goods or services new only to the enterprise.</li> </ol>
Stage 3.	Designating groups of industries similar to each other in terms of the share of enterprises that have introduced new or improved business processes	<ol style="list-style-type: none"> <li>1. Share of enterprises that introduced new or improved methods for producing goods or providing services (including methods for developing goods or services);</li> <li>2. Share of enterprises that introduced new or improved logistics, delivery or distribution methods;</li> <li>3. Share of enterprises that introduced new or improved methods for information processing or communication;</li> <li>4. Share of enterprises that introduced new or improved methods for accounting or other administrative operations;</li> <li>5. Share of enterprises that introduced new or improved business practices for organizing procedures or external relations;</li> <li>6. Share of enterprises that introduced new or improved organizing work responsibility, decision making or human resource management;</li> <li>7. Share of enterprises that introduced new or improved marketing methods for promotion, packaging, pricing, product placement or after sales services.</li> </ol>

Source: Authors' own work, based on: GUS (2020).

## Research procedure – cluster analysis

In order to identify NACE divisions similar to each other in terms of the features listed in individual stages of the research process, cluster analysis was used. All calculations were performed using R software.

Cluster analysis is a term used to describe a family of statistical procedures specifically designed to discover homogenous groups within complex data sets. The objective of cluster analysis is to group objects into clusters, so that objects within one cluster share more in common with one another than they do with the objects of other clusters. Thus, the purpose of the analysis is to arrange objects into relatively homogeneous groups based on multivariate observations (Paul & Gore, 2000). A hierarchical method was used in the presented research. This method, in general, tries to decompose the dataset of  $n$  objects into a hierarchy of groups (Bora & Gupta, 2014). This hierarchical decomposition can be represented by a tree structure diagram called a “dendrogram”, whose root node represents the whole dataset. Each leaf node is a single object of the dataset. The clustering results can be obtained by cutting the dendrogram at different levels (Soni & Ganatra, 2012).

The clustering of similar NACE divisions in terms of the share of innovative enterprises was carried out in the following steps:

- 1) Cosine distance was determined (due to data concerning the share of enterprises in the analyzed NACE divisions). Cosine similarity measures the similarity between two vectors of an inner product space. It is measured by the cosine of the angle between two vectors and it determines whether two vectors are pointing in roughly the same direction (Han, Kamber, & Pei, 2012). Similarity increases when the distance between two vectors decreases. The *cosine* method implemented in the *philentropy* package (R software) was used to determine the cosine similarities. The formula to find the cosine similarity is as follows (Drost, 2018):

$$s = \frac{\sum_{i=1}^N (P_i * Q_i)}{\sqrt{\sum_{i=1}^N P_i^2} * \sqrt{\sum_{i=1}^N Q_i^2}}$$

and the formula of Cosine distance is expressed as: *1 - cosine similarity*.

- 2) For cluster analysis, the agglomeration method of hierarchical clustering (Ward algorithms) was used. The Ward algorithm was implemented in *agnes* from the *cluster* library (R software). Ward’s method minimizes the increase in total within-cluster sum of squared errors (Szekely & Rizzo, 2005). Clustering results were presented using a dendrogram.
- 3) The number of classes was specified. The silhouette index was adopted to assess the quality of the division. This silhouette shows which objects lie well within their cluster, and which ones are merely somewhere in between clusters. The silhouette index allows an assessment of the relative quality of the clusters and an overview of the data configuration. The average silhouette width provides an evaluation of clustering validity

- and it might be used to select an “appropriate” number of clusters (Rousseeuw, 1987). The silhouette index was implemented in *silhouette* in *cluster* library (R software).
- 4) The similarity between the two data classifications was measured using the Rand index. The Rand index has a value between 0 and 1, with 0 indicating that the two data clusterings do not agree on any pair of points and 1 indicating that the data clusterings are exactly the same. The Rand index was implemented in *fossil* package (R software).

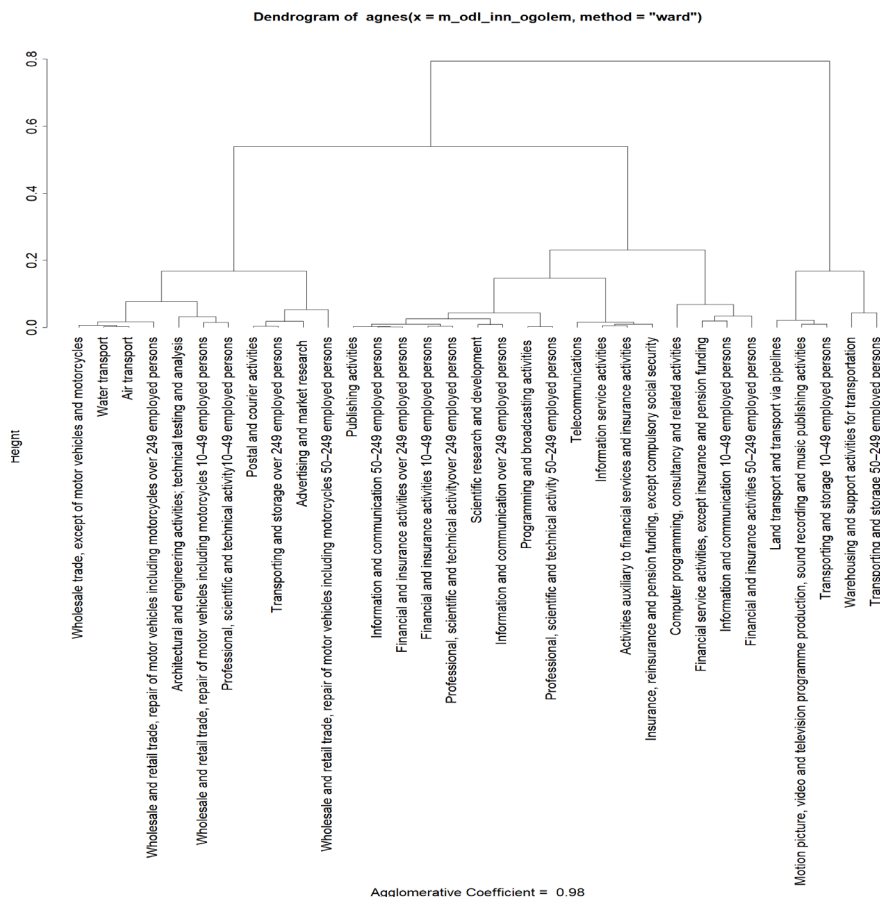
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## RESULTS AND DISCUSSION

### Analysis of the similarity of industries in terms of the share of innovative service enterprises

#### Innovation activity of service enterprises

The cluster analysis of NACE divisions similar to each other in terms of the share of service enterprises that introduced new or improved products or business processes was the main goal of this stage of the analysis. The following variables were included in the analysis: total share of service enterprises that introduced new or improved products, and total share of service enterprises that introduced new or improved business processes. For the cluster analysis, Ward’s algorithm was used with the Cosine distance. The dendrogram obtained as a result is presented in Figure 1.



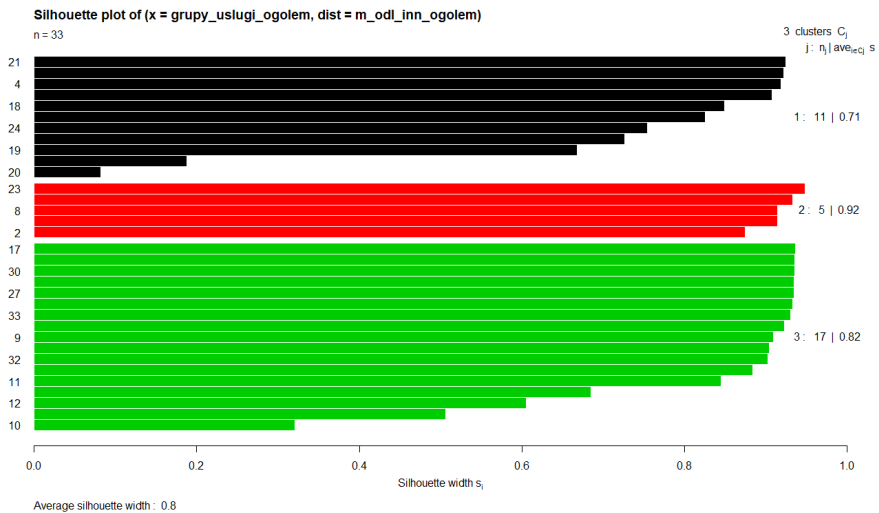
**Figure 1.** The similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved products or business processes

The next step in the analysis was to determine the appropriate number of clusters. The silhouette index was used to assess the quality of the division. As the results in Table 4 show, the best quality was found in the division of the surveyed population into three clusters. The silhouette index was 0.79, which means that strong structure has been found.

**Table 4.** The silhouette index for the similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved products or business processes

	2 groups	3 groups	4 groups	5 groups	6 groups
The silhouette index	0.6532158	0.7992131	0.6910298	0.6754593	0.6865722

Figure 2 shows the calculated coefficients for all objects and values aggregated for every cluster. As the results show, all three clusters are of high quality.



**Figure 2.** The silhouette index for three clusters of similar NACE divisions with respect to the total share of service enterprises that introduced new or improved products or business processes

Table 5 presents the NACE divisions divided into three clusters. Based on the tables published by the Polish Central Statistical Office (GUS, 2020), it can be indicated that the third cluster is characterized by a high share of enterprises that introduce both new and improved products and business processes and contains 17 NACE divisions. The highest share in introducing product and business innovations concerns enterprises belongs to the NACE division:

*Insurance, reinsurance and pension funding except compulsory social security* and amounts to 50.7% for products innovations and 77.6% for business



innovations. The second NACE division with the highest share is: *Financial and insurance activities over 249 employed persons* with a share of 42% for products innovations and 56.5% for business innovations.

**Table 5.** Similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved products or business processes

Cluster	NACE divisions
1	Wholesale trade, except of motor vehicles and motorcycles, Water transport, Air transport, Postal and courier activities, Architectural and engineering activities; technical testing and market research, Wholesale and retail trade, repair of motor vehicles including motorcycles 10–49 employed persons, Wholesale and retail trade, repair of motor vehicles including motorcycles 50–249 employed persons, Wholesale and retail trade, repair of motor vehicles including motorcycles over 249 employed persons, Transporting and storage over 249 employed persons, Professional, scientific and technical activity 10–49 employed persons
2	Land transport and transport via pipelines, Warehousing and support activities for transportation, Motion picture, video and television programme production, sound recording and music publishing activities, Transporting and storage 10–49 employed persons, Transporting and storage 50–249 employed persons
3	Publishing activities; Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, Information service activities, Financial service activities, except insurance and pension funding, Insurance, reinsurance and pension funding, except compulsory social security, Activities auxiliary to financial services and insurance activities, Scientific research and development Information and communication 10–49 employed persons, Information and communication 50–249 employed persons
	Information and communication over 249 employed persons, Financial and insurance activities 10–49 employed persons
	Financial and insurance activities 50–249 employed persons, Financial and insurance activities over 249 employed persons, Professional, scientific and technical activity 50–249 employed persons, Professional, scientific and technical activity over 249 employed persons

The second cluster is the smallest and contains only 5 NACE divisions, mainly related to transport activities, warehousing, activities supporting transport, presented by enterprises whose share in introducing new or improved products is rather low. When it comes to introducing new or improved business processes, 3 out of 5 NACE divisions are characterized by an average share. Attention should be paid to the two NACE divisions: *Land transport and transport via pipelines* (share of 3.7% for product innovations and 11.7% for business innovations) and *Transporting and storage 10–49 employed persons* (share of 3.2% for products innovations and 10.7% for business innovations), which have the lowest share in both the introduction of new or improved products and business processes.

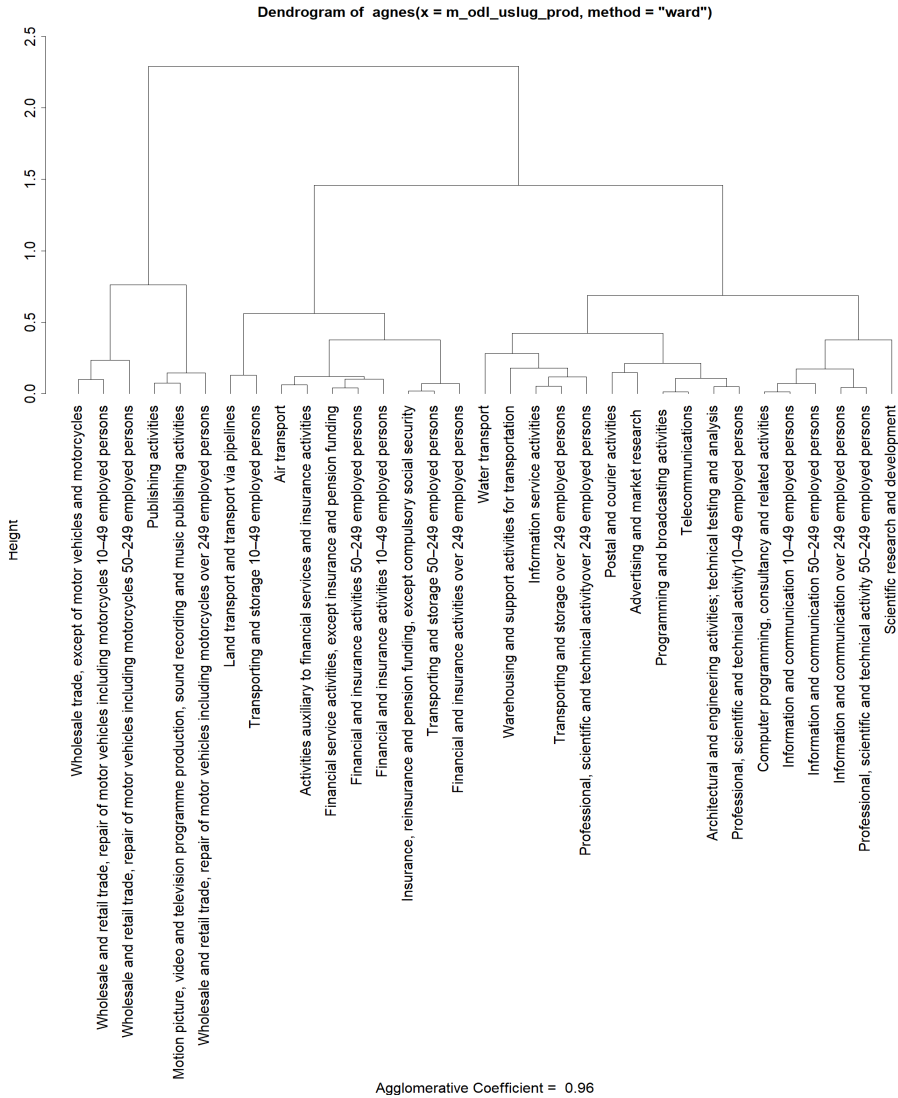
The first cluster contains 11 NACE divisions, where the share of enterprises introducing product innovations is rather at an average level, with the three clusters of the lowest share being: *Whole trade, except of motor vehicles and motorcycles* (7.5%), *Postal and courier activities* (7.3%), *Whole trade and retail trade, repair of motor vehicles including motorcycles 10–49 employed persons* (6.7%). These industries are also characterized by a low share of enterprises in the introduction of new or improved business processes. This share is accordingly: 14.8%, 17.1%, and 12%.

### **Innovation activity of service enterprises that introduced new or improved products**

The cluster analysis of NACE divisions similar to each other in terms of the share of service enterprises that introduced new or improved products was the main goal of this stage of the analysis. The following variables were included in the analysis:

- 1) Share of enterprises that introduced new or improved goods.
- 2) Share of enterprises that introduced new or improved services.
- 3) Share of enterprises that introduced new or improved goods or services new to the market.
- 4) Share of enterprises that introduced new or improved goods or services new only to the enterprise.

For the cluster analysis, Ward's algorithm was used with the Cosine distance. The dendrogram obtained as a result is presented in Figure 3.



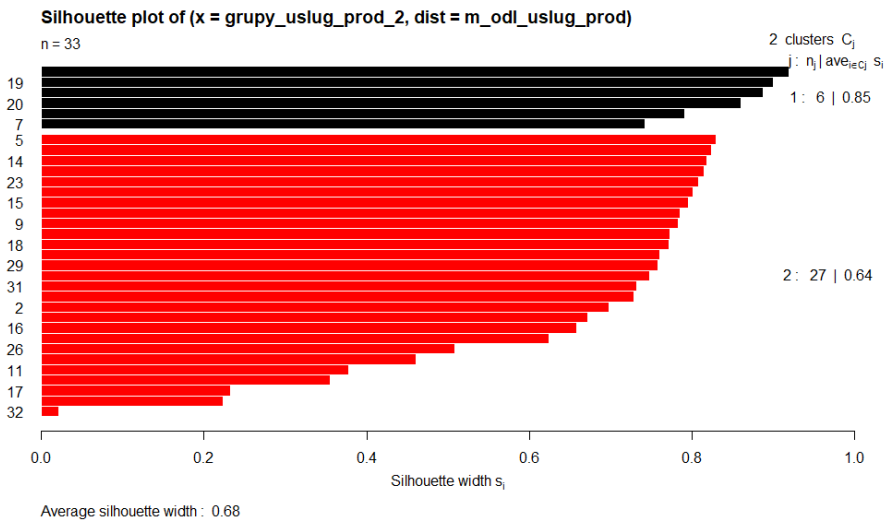
**Figure 3.** The similarity of NACE divisions with respect to the total share of service enterprises that introduced new improved products

The next step in the analysis was to determine the appropriate number of clusters. The silhouette index was used to assess the quality of the division. As the results in Table 6 show, the best quality was found in the division of the surveyed population into two and three clusters. The silhouette index was accordingly 0.6805 and 0.6738.

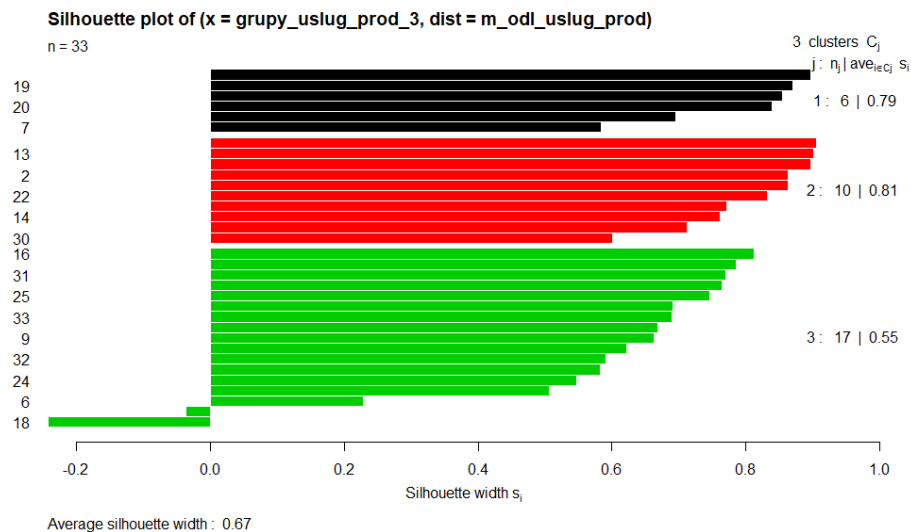
**Table 6.** The silhouette index for the similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved products

	2 groups	3 groups	4 groups	5 groups	6 groups
The silhouette index	0.6805194	0.6738426	0.5775993	0.5036341	0.4265721

Figure 4 shows the calculated coefficients for all objects and values aggregated for every cluster. As the results show, one of the clusters is of high quality and the second one presents a reasonable structure. In the case of division into three clusters, as presented in Figure 5, one group is characterized by a reasonable structure. The other two groups present a high quality of cluster structure.



**Figure 4.** The silhouette index for two clusters of similar NACE divisions with respect to the total share of service enterprises that introduced new or improved products



**Figure 5.** The silhouette index for three clusters of similar NACE divisions with respect to the total share of service enterprises that introduced new or improved products

According to the results, Table 7 shows the grouping of NACE divisions divided into two clusters. The first cluster contains 6 NACE divisions. Based on the tables published by the Polish Central Statistical Office (GUS, 2020), it can be indicated that the first cluster is characterized by a similar value of the share of enterprises that introduce new or improved goods and share of enterprises introducing new or improved services with a slight advantage in favor of the share of enterprises that introduce new or improved goods. NACE divisions belonging to the first cluster are also characterized by the fact that the share of enterprises, which introduced new or improved goods or services new only to the enterprise, is higher than the share of enterprises that introduced new or improved goods or services new to the market. The second cluster contains 27 NACE divisions, always characterized by a higher share of enterprises introducing new or improved services rather than products.

**Table 7. Similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved products**

<b>Cluster</b>	<b>NACE divisions</b>
1	Wholesale trade, except of motor vehicles and motorcycles, Publishing activities, Motion picture, video and television programme production, sound recording and music publishing activities, Wholesale and retail trade, repair of motor vehicles including motorcycles 10–49 employed persons, Wholesale and retail trade, repair of motor vehicles including motorcycles 50–249 employed persons, Wholesale and retail trade, repair of motor vehicles including motorcycles over 249 employed persons, Land transport and transport via pipelines, Water transport, Air transport, Warehousing and support activities for transportation, Postal and courier activities, Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, Information service activities, Financial service activities, except insurance and pension funding, Insurance, reinsurance and pension funding, except compulsory social security, Activities auxiliary to financial services and insurance activities, Architectural and engineering activities; technical testing and analysis, Scientific research and development Advertising and market research, Transporting and storage 10–49 employed persons, Transporting and storage 50–249 employed persons, Transporting and storage over 249 employed persons Information and communication 10–49 employed persons, Information and communication 50–249 employed persons, Information and communication over 249 employed persons, Financial and insurance activities 10–49 employed persons, Financial and insurance activities 50–249 employed persons, Financial and insurance activities over 249 employed persons, Professional, scientific and technical activity 10–49 employed persons, Professional, scientific and technical activity 50–249 employed persons, Professional, scientific and technical activity over 249 employed persons,
2	Advertising and market research, Transporting and storage 10–49 employed persons, Transporting and storage 50–249 employed persons, Transporting and storage over 249 employed persons Information and communication 10–49 employed persons, Information and communication 50–249 employed persons, Information and communication over 249 employed persons, Financial and insurance activities 10–49 employed persons, Financial and insurance activities 50–249 employed persons, Financial and insurance activities over 249 employed persons, Professional, scientific and technical activity 10–49 employed persons, Professional, scientific and technical activity 50–249 employed persons, Professional, scientific and technical activity over 249 employed persons,

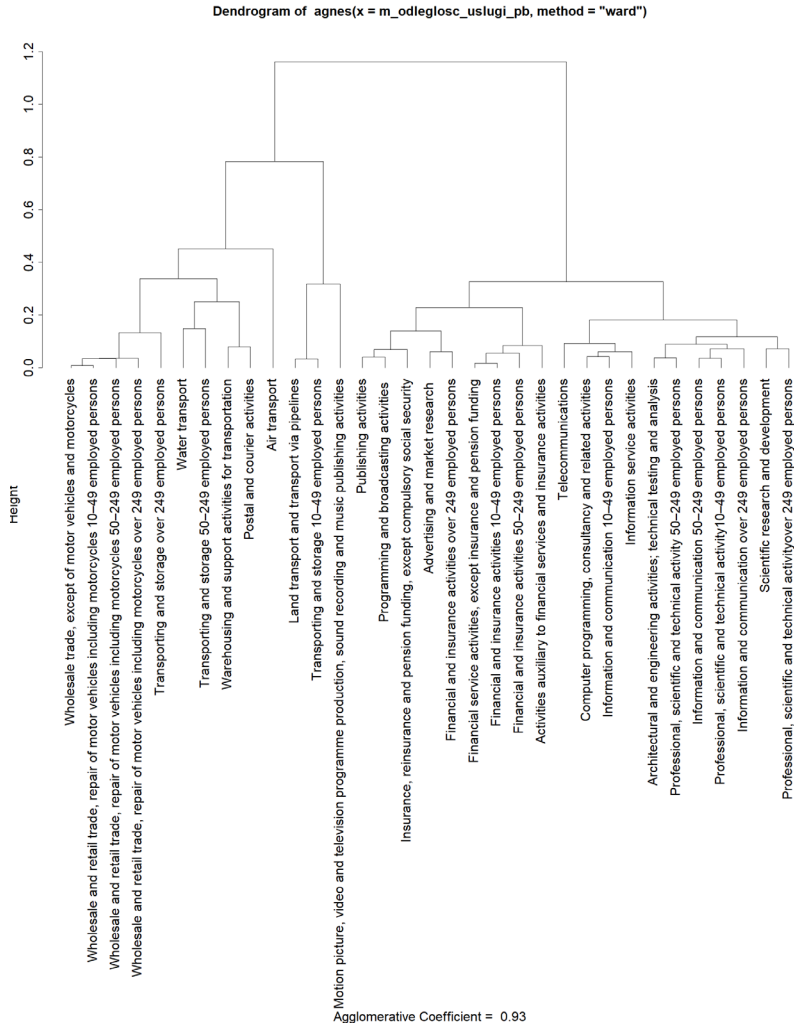
## **Innovation activity of service enterprises that introduced new or improved business processes**

The cluster analysis of NACE divisions similar to each other in terms of the share of service enterprises that introduced new or improved business processes was the main goal of this stage of the analysis. The analysis included variables related to the share of service enterprises that introduced new or improved methods for:

- 1) Producing goods or providing services (including methods for developing goods or services).
- 2) Logistics, delivery or distribution.
- 3) Information processing or communication.
- 4) Accounting or other administrative operations.
- 5) Business practices for organizing procedures or external relations.
- 6) Organizing work responsibility, decision making or human resource management.
- 7) Marketing methods for promotion, packaging, pricing, product placement or after sales services.

For the cluster analysis, Ward's algorithm was used with the Cosine distance. The dendrogram obtained as a result is presented in Figure 6.





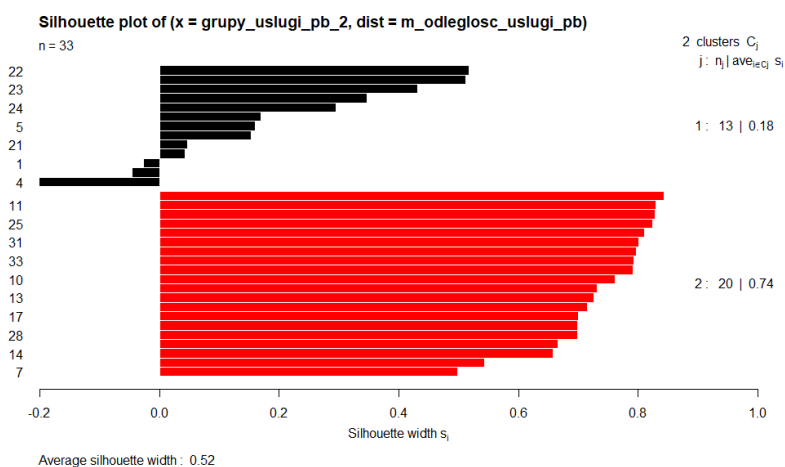
**Figure 6.** The similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved business processes

The next step in the analysis was to determine the appropriate number of clusters. The silhouette index was used to assess the quality of the division. As the results show, the best quality was found in the division of the surveyed population into two clusters. Results of the analysis are presented in Table 8.

**Table 8.** The silhouette index for the similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved business processes

	2 groups	3 groups	4 groups	5 groups	6 groups
The silhouette index	0.5185402	0.4637078	0.4671621	0.3755261	0.2079042

Figure 7 shows the calculated coefficients for all objects and values aggregated for every cluster. As the results show, one of the clusters is of high quality but the structure of the second one has very low quality.



**Figure 7.** The silhouette index for two clusters of similar NACE divisions with respect to the total share of service enterprises that introduced new or improved business processes

According to the results, Table 9 shows the grouping of NACE divisions divided into two clusters. The first cluster contains 13 NACE divisions and the second one contains 20 NACE divisions. The first cluster is characterized by a rather lower share of enterprises that introduced new or business processes and the second one contains NACE divisions such as: Insurance, reinsurance and pension funding, except compulsory social security and Financial and insurance activities over 249 employed persons where total share of service enterprises is the highest in introducing any kind of business process innovation.

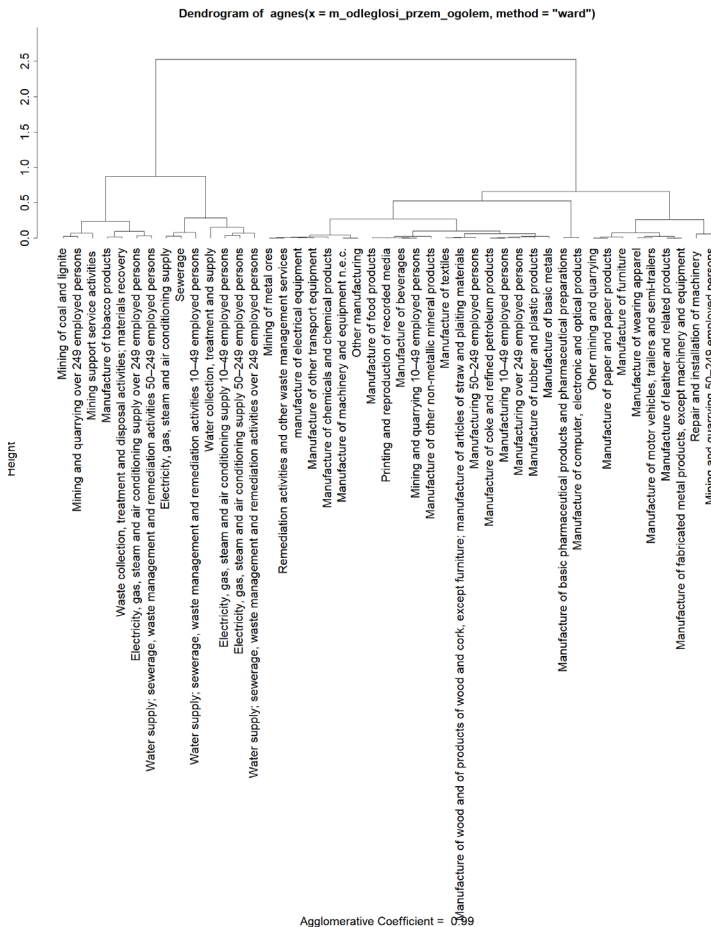
**Table 9.** Similarity of NACE divisions with respect to the total share of service enterprises that introduced new or improved business processes

Clusters	NACE divisions
1	<p>Wholesale trade, except of motor vehicles and motorcycles, Land transport and transport via pipelines, Water transport, Air transport, Warehousing and support activities for transportation, Postal and courier activities, Motion picture, video and television programme production, sound recording and music publishing activities, Wholesale and retail trade, repair of motor vehicles including motorcycles 10–49 employed persons, Wholesale and retail trade, repair of motor vehicles including motorcycles 50–249 employed persons, Wholesale and retail trade, repair of motor vehicles including motorcycles over 249 employed persons, Transporting and storage 10–49 employed persons, Transporting and storage 50–249 employed persons, Transporting and storage over 249 employed persons</p>
2	<p>Publishing activities, Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, Information service activities, Financial service activities, except insurance and pension funding, Insurance, reinsurance and pension funding, except compulsory social security, Activities auxiliary to financial services and insurance activities, Architectural and engineering activities; technical testing and analysis, Scientific research and development, Advertising and market research, Information and communication 10–49 employed persons, Information and communication 50–249 employed persons, Information and communication over 249 employed persons, Financial and insurance activities 10–49 employed persons, Financial and insurance activities 50–249 employed persons, Financial and insurance activities over 249 employed persons, Professional, scientific and technical activity 10–49 employed persons, Professional, scientific and technical activity 50–249 employed persons, Professional, scientific and technical activity over 249 employed persons</p>

## Analysis of the similarity of NACE divisions in terms of the share of innovative industrial enterprises

### Innovation activity of industrial enterprises

The cluster analysis of NACE divisions similar to each other in terms of the share of industrial enterprises that introduced new or improved products or business processes was the main goal of this stage of the analysis. The following variables were included in the analysis: total share of industrial enterprises that introduced new or improved products and total share of industrial enterprises that introduced new or improved business processes.



**Figure 8.** The similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products or business processes

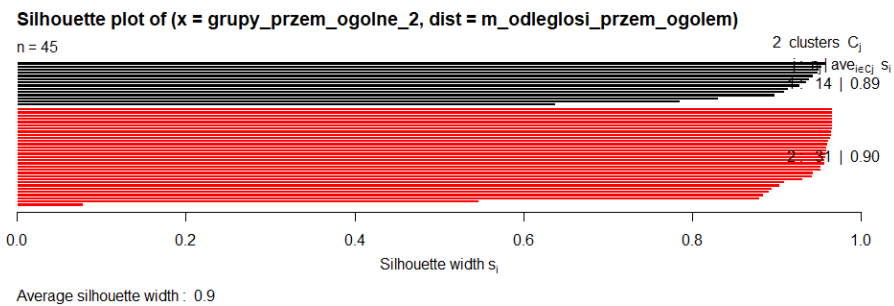
For the cluster analysis, Ward's algorithm was used with the Cosine distance. The dendrogram obtained as a result is presented in Figure 8.

The next step in the analysis was to determine the appropriate number of clusters. The silhouette index was used to assess the quality of the division. As the results in Table 10 show, the best quality was found in the division of the surveyed population into two clusters. The silhouette index was 0.90, which means that a strong structure has been found.

**Table 10.** The silhouette index for the similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products or business processes

	2 groups	3 groups	4 groups	5 groups	6 groups
The silhouette index	0.9011347	0.8372588	0.7213203	0.7645575	0.7034355

Figure 9 shows the calculated coefficient for all objects and values aggregated for every cluster. As the results show, all three clusters are of high quality.



**Figure 9.** The silhouette index for three clusters of similar NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products or business processes

Table 11 presents NACE divisions divided into two clusters. The first cluster contains 14 NACE divisions, where it can be observed that the share of industrial enterprises introducing new or improved business processes is much higher in each NACE divisions than the share of industrial enterprises introducing new or improved products. The second cluster contains 32 NACE divisions, where it can be observed that the share of enterprises introducing new or improved business processes and products is at a similar level within each NACE division.

**Table 11.** Similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products or business processes

Cluster	NACE divisions
1	<p>Mining of coal and lignite, Mining support service activities, Manufacture of tobacco products, Electricity, gas, steam and air conditioning supply, Water collection, treatment and supply, Sewerage, Waste collection, treatment and disposal activities; materials recovery, Mining and quarrying over 249 employed persons, Electricity, gas, steam and air conditioning supply 10–49 employed persons, Electricity, gas, steam and air conditioning supply 50–249 employed persons, Electricity, gas, steam and air conditioning supply over 249 employed persons, Water supply; sewerage, waste management and remediation activities 10–49 employed persons, Water supply; sewerage, waste management and remediation activities 50–249 employed persons, Water supply; sewerage, waste management and remediation</p>
2	<p>Mining of metal ores, Other mining and quarrying, Manufacture of food products, Manufacture of beverages, Manufacture of textiles, Manufacture of wearing apparel, Manufacture of leather and related products, Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, Manufacture of paper and paper products, Printing and reproduction of recorded media, Manufacture of coke and refined petroleum products, Manufacture of chemicals and chemical products, Manufacture of basic pharmaceutical products and pharmaceutical preparations, Manufacture of rubber and plastic products, Manufacture of other non-metallic mineral products, Manufacture of basic metals, Manufacture of fabricated metal products, except machinery and equipment, Manufacture of computer, electronic and optical products, Manufacture of electrical equipment, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and semi-trailers, Manufacture of other transport equipment, Manufacture of furniture, Other manufacturing, Repair and installation of machinery, Remediation activities and other waste management services, Mining and quarrying 10–49 employed persons, Mining and quarrying 50–249 employed persons, Manufacturing 10–49 employed persons, Manufacturing 50–249 employed persons, Manufacturing over 249 employed persons</p>

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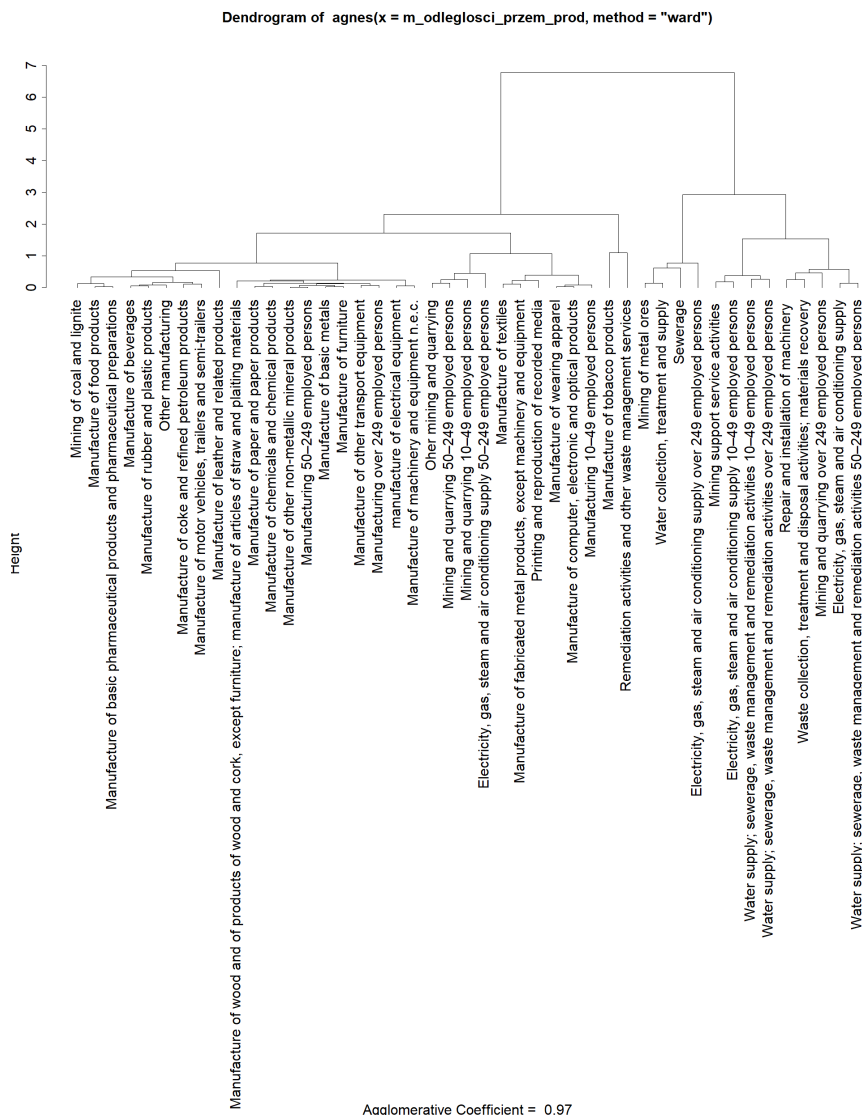
## **Innovation activity of industrial enterprises that introduced new or improved products**

The cluster analysis of NACE divisions similar to each other in terms of the share of industrial enterprises that introduced new or improved products was the main goal of this stage of the analysis. The following variables were included in the analysis:

- 1) Share of enterprises that introduced new or improved goods.
- 2) Share of enterprises that introduced new or improved services.
- 3) Share of enterprises that introduced new or improved goods or services new to the market.
- 4) Share of enterprises that introduced new or improved goods or services new only to the enterprise.

For the cluster analysis, Ward's algorithm was used with the Cosine distance. The dendrogram obtained as a result is presented in Figure 10.





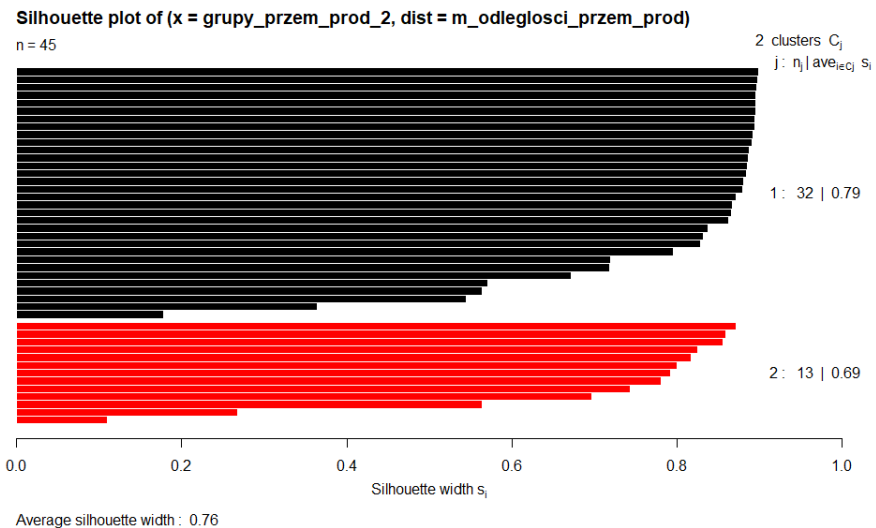
**Figure 10.** The similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products

The next step in the analysis was to determine the appropriate number of clusters. The silhouette index was used to assess the quality of the division. As the results in Table 12 show, the best quality was found in the division of the surveyed population into two clusters. The silhouette index was 0.76.

**Table 12.** The silhouette index for the similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products

	2 groups	3 groups	4 groups	5 groups	6 groups
The silhouette index	0.7628942	0.6287666	0.6333996	0.4387073	0.3772319

Figure 11 shows the calculated coefficients for all objects and values aggregated for every cluster. As the results show, one of the clusters is of high quality and the second one presents a reasonable structure.



**Figure 11.** The silhouette index for two clusters of similar NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products

According to the results, Table 13 shows the grouping of NACE divisions divided into two clusters. Based on the tables published by the Polish Central Statistical Office (GUS, 2020), it can be indicated that the first cluster is characterized by a high share of enterprises that introduce new and improved goods. In the case of the second cluster, the share of industrial enterprises that introduced new or improved goods is higher than the share of industrial enterprises that introduced new or improved services.

**Table 13.** Similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products

Cluster	NACE divisions
1	<p>Mining of coal and lignite, Other mining and quarrying, Manufacture of food products, Manufacture of beverages, Manufacture of tobacco products, Manufacture of textiles, Manufacture of wearing apparel, Manufacture of leather and related products, Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, Manufacture of paper and paper products, Printing and reproduction of recorded media, Manufacture of coke and refined petroleum products, Manufacture of chemicals and chemical products, Manufacture of basic pharmaceutical products and pharmaceutical preparations, Manufacture of rubber and plastic products, Manufacture of other non-metallic mineral products, Manufacture of basic metals, Manufacture of fabricated metal products, except machinery and equipment, Manufacture of computer, electronic and optical products, Manufacture of electrical equipment, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and semi-trailers, Manufacture of other transport equipment, Manufacture of furniture, Other manufacturing, Remediation activities and other waste management services, Mining and quarrying 10–49 employed persons, Mining and quarrying 50–249 employed persons, Manufacturing 10–49 employed persons, Manufacturing 50–249 employed persons, Manufacturing over 249 employed persons, Electricity, gas, steam and air conditioning supply 50–249 employed persons</p>
2	<p>Mining of metal ores, Mining support service activities, Repair and installation of machinery, Electricity, gas, steam and air conditioning supply, Water collection, treatment and supply, Sewerage, Waste collection, treatment and disposal activities; materials recovery, Mining and quarrying over 249 employed persons, Electricity, gas, steam and air conditioning supply 10–49 employed persons, Electricity, gas, steam and air conditioning supply over 249 employed persons, Water supply; sewerage, waste management and remediation activities 10–49 employed persons, Water supply; sewerage, waste management and remediation activities 50–249 employed persons, Water supply; sewerage, waste management and remediation activities over 249 employed persons</p>

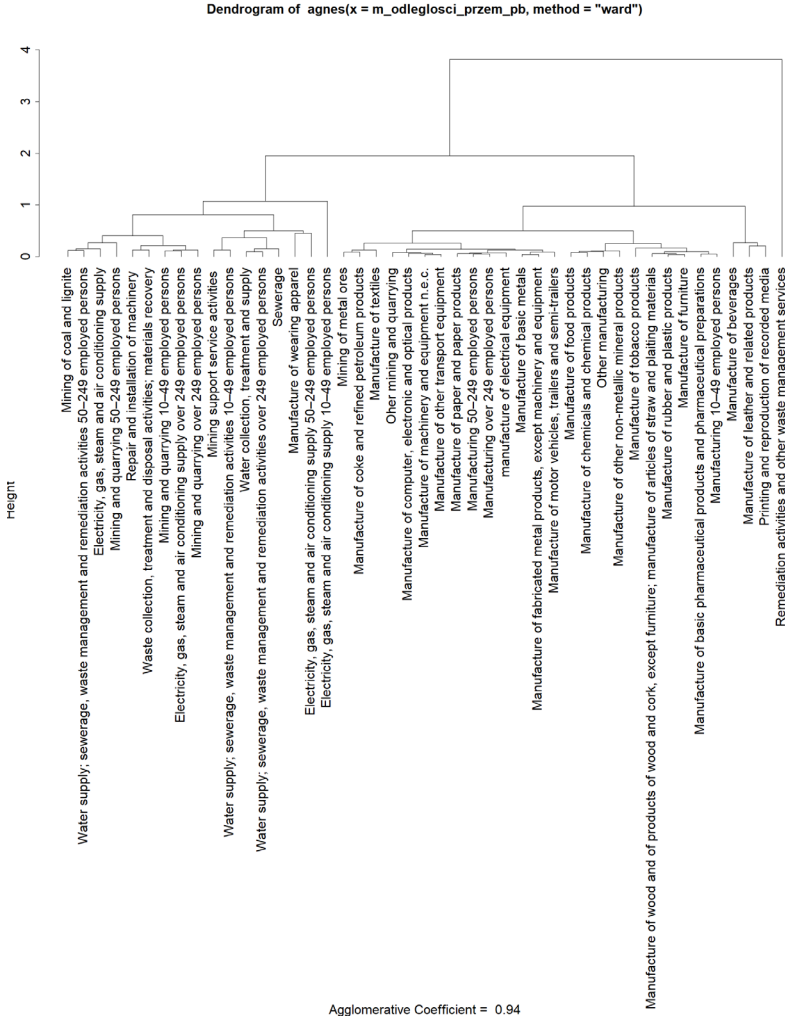
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## **Innovation activity of industrial enterprises that introduced new or improved business processes**

The cluster analysis of NACE divisions similar to each other in terms of the share of industrial enterprises that introduced new or improved business processes was the main goal of this stage of the analysis. The analysis included variables related to the share of industrial enterprises that introduced new or improved methods for:

- 1) Producing goods or providing services (including methods for developing goods or services).
- 2) Logistics, delivery or distribution.
- 3) Information processing or communication.
- 4) Accounting or other administrative operations.
- 5) Business practices for organizing procedures or external relations.
- 6) Organizing work responsibility, decision making or human resource management.
- 7) Marketing methods for promotion, packaging, pricing, product placement or after sales services.

For the cluster analysis, Ward's algorithm was used with the Cosine distance. The dendrogram obtained as a result is presented in Figure 12.



**Figure 12.** The similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new improved business processes

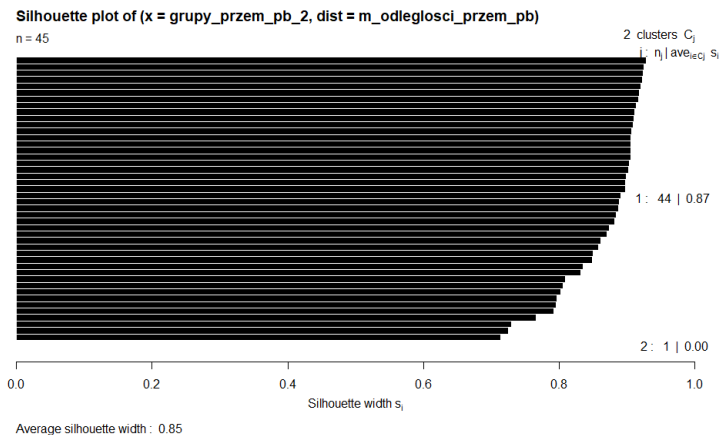
The next step in the analysis was to determine the appropriate number of clusters. The silhouette index was used to assess the quality of the division. As the results in Table 14 show, the best quality was found in the division of the surveyed population into two clusters.

**Table 14.** The silhouette index for the similarity of NACE divisions with respect to the total share of industrial enterprises that introduced new or improved business processes

	2 groups	3 groups	4 groups	5 groups	6 groups
The silhouette index	0.847214	0.5345078	0.4789247	0.360337	0.3084363

Figure 13 shows the calculated coefficients for all objects and values aggregated for every cluster. The surveyed group was divided into two clusters. One of them is a one-element group and it concerns the NACE division:

*Remediation activities and other waste management services.* This is the only one of the analyzed NACE divisions that is characterized by the lack of introduced innovative methods for producing goods or providing services, logistics, delivery or distribution of logistics methods, accounting or other administrative operations, business practices for organizing procedures or external relations, marketing methods for promotion, packaging, pricing, product placement or after sales services. It is also characterized by a very low share of industrial enterprises that introduced new or improved innovation methods for information processing or communication (1.9%) and organizing work responsibility, decision making or human resource management (3.7%).



**Figure 13.** The silhouette index for two clusters of similar NACE divisions with respect to the total share of industrial enterprises that introduced new or improved business processes

## Similarity of classifications

The last stage of analysis was to measure the similarity between two data classifications using the Rand index. The results of this stage of analysis, for clustering NACE divisions with respect to the total share of enterprises that introduced new or improved products or business processes and separately for new or improved products and new or improved business processes, are shown for service enterprises in Table 15 and industrial enterprises in Table 16. The analysis of similarity took into account the division into two and three clusters in each case.

**Table 15.** Similarity of clustering NACE divisions with respect to the share of service enterprises: in innovation activity (product innovations or business processes innovations) that introduced new or improved products (product innovations) or business processes (business processes innovations)

	Product innovations or business processes innovations 2 clusters	Product innovations or business processes innovations 3 clusters	Product innovations 2 clusters	Product innovations 3 clusters	Business processes innovations 2 clusters	Business processes innovations 3 clusters
Product innovations or business processes innovations 2 clusters	1	0.6458333	0.5909091	0.4772727	0.6212121	0.655303
Product innovations or business processes innovations 3 clusters	0.6458333	1	0.5056818	0.5662879	0.782197	0.8162879
Product innovations 2 clusters	0.5909091	0.5056818	1	0.6780303	0.5909091	0.5871212
Product innovations 3 clusters	0.4772727	0.5662879	0.6780303	1	0.5568182	0.5833333
Business processes innovations 2 clusters	0.6212121	0.782197	0.5909091	0.5568182	1	0.9431818
Business processes innovations 3 clusters	0.655303	0.8162879	0.5871212	0.5833333	0.9431818	1

**Table 16.** Similarity of clustering NACE divisions with respect to the share of industrial enterprises: in innovation activity (product innovations or business processes innovations) that introduced new or improved products (product innovations) or business processes (business processes innovations)

	Product innovations or business processes innovations 2 clusters	Product innovations or business processes innovations 3 clusters	Product innovations 2 clusters	Product innovations 3 clusters	Business processes innovations 2 clusters	Business processes innovations 3 clusters
Product innovations or business processes innovations 2 clusters	1	0.9505051	0.7979798	0.7838384	0.5454545	0.7727273
Product innovations or business processes innovations 3 clusters	0.9505051	1	0.7828283	0.7929293	0.4959596	0.7373737
Product innovations 2 clusters	0.7979798	0.7828283	1	0.9636364	0.5616162	0.7383838
Product innovations 3 clusters	0.7838384	0.7929293	0.9636364	1	0.5252525	0.7202020
Business processes innovations 2 clusters	0.5454545	0.4959596	0.5616162	0.5252525	1	0.5363636
Business processes innovations 3 clusters	0.7727273	0.7373737	0.7383838	0.7202020	0.5363636	1

In the case of service enterprises, the highest values of the coefficients occurred for the division into two and three clusters according to the share of enterprises that introduced new or improved business process. The Rand index in this case was 0.9431818. As for industrial enterprises, the highest value of the index concerned the division of the NACE divisions into two and three clusters, taking into account enterprises that introduced new or improved products. In this case, the Rand index was 0.9636364.

## CONCLUSIONS

The aim of this paper was to divide industries, classified according to NACE (the Statistical Classification of Economic Activities in the European Community) divisions, into groups that will be homogeneous in terms of the share of innovative enterprises. Based on the analyses carried out, the following conclusions can be drawn:

- 1) In the case of service enterprises, the best quality of the division was achieved when NACE divisions were separated into three clusters with



- respect to the total share of service enterprises that introduced new or improved products or business processes.
- 2) In the case of service enterprises, the best quality of the division was achieved when NACE divisions were separated into two clusters with respect to service enterprises that introduced new or improved products and with respect to the total share of service enterprises that introduced new or improved business processes.
  - 3) The similarity of separating NACE divisions into two clusters, with respect to the share of service enterprises that introduced new or improved products (product innovations) or business processes (business processes innovations) is on average level. The Rand index in this case was 0.5909091.
  - 4) In the case of industrial enterprises, the best quality of the division was achieved when NACE divisions were separated into two clusters.
  - 5) The best quality of division was obtained in the case of separating NACE divisions with respect to the total share of industrial enterprises that introduced new or improved products or business processes. The silhouette index was 0.9011347.
  - 6) The NACE divisions of Remediation activities and other waste management services are significantly different from the rest in terms of introducing new or improved business processes and are characterized by a very low share of enterprises introducing this kind of innovation.

Within the total share of service enterprises that introduced new, improved products or business processes, three clusters have been observed. The highest share in introducing product and business innovations concerns NACE divisions such as: *Insurance, reinsurance and pension funding, except compulsory social security; Financial and insurance activities; Publishing activities; Programming and broadcasting activities; Telecommunications; Computer programming, consultancy, and related activities; Information service activities; Financial service activities, except insurance and pension funding; Activities auxiliary to financial services and insurance activities; Scientific research and development; Information and communication; and Professional, scientific and technical activity.*

The second cluster is the smallest and contains only 5 NACE divisions: *Land transport and transport via pipelines; Warehousing and support activities for transportation; Motion picture, video and television program production; Sound recording and music publishing activities; and Transporting and storage.* This cluster has been presented by enterprises whose share in introducing new or improved products is rather low.

The third cluster contains 11 NACE divisions, where the share of enterprises introducing product innovations is rather on average level, with

the three clusters of the lowest share being: *Whole trade, except of motor vehicles and motorcycles; Postal and courier activities and Whole trade and retail trade, repair of motor vehicles including motorcycles*. These industries have been presented by *Water transport; Air transport; Architectural and engineering activities, technical testing and analysis; Advertising and market research; Transporting and storage over 249 employed persons; and Professional, scientific and technical activity*.

Consequently, the analysis of the similarities in NACE divisions in terms of the share of innovative industrial enterprises has shown only two similar clusters.

The first cluster contains: *Mining of coal and lignite; Mining support service activities, Manufacture of tobacco products; Electricity, gas, steam and air conditioning supply, Water collection, treatment and supply; Sewerage; Waste collection, treatment and disposal activities; Materials recovery; Mining and quarrying over 249 employed persons; and Water supply, sewerage, waste management, and remediation activities*.

Whereas the second cluster contains: *Manufacture of: computer, electronic, optical products and electrical equipment; Manufacture of motor vehicles and other transport equipment; Repair and installation of machinery; Manufacture of: food products, textiles, leather, wood and of products of wood, articles of straw and plaiting materials, paper and paper products, rubber and plastic products; Printing and reproduction of recorded media; Manufacture of chemicals and pharmaceutical; Manufacture of basic metals and other non-metallic mineral products; Manufacture of fabricated metal products; Remediation activities and other waste management services; Mining of metal ores; and Manufacture of coke and refined petroleum products*.

Although the research procedure showed which enterprises belong to the groups of NACE divisions, it does not give us sufficient grounds to infer causality. It can be assumed that the similarity of a group may be a consequence of the amount of financial outlays, knowledge of products and services, use and level of support with IT tools, or extensive inter-organizational cooperation.

Besides, divisions grouped into similar clusters may constitute a starting point for further in-depth analysis. However, some limitations of the conducted research should be pointed out. Firstly, the analysis carried out was based on data from a report published in January 2020 by the Polish Central Statistical Office and it concerns the innovative activity of enterprises in the years 2016–2018. Secondly, in the next stages of the research, it is crucial to verify whether, in previous years, NACE divisions were grouped into similar clusters. Lastly, an interesting direction of future research would be to try to create a ranking of industries in terms of the share of innovative

enterprises introducing new or improved products or business processes and to check whether it reflects clusters of homogeneous industries.

## Acknowledgment

The data used in the analysis come from a report published in January 2020 by the Polish Central Statistical Office – Innovative activity of enterprises in the years 2016–2018 (GUS, 2020). The research has been carried out as part of a research initiative financed by the Ministry of Science and Higher Education within “Regional Initiative of Excellence” Programme for 2019–2022. Project no.: 021/RID/2018/19. Total financing: 11,897,131.40 PLN.

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### Abstrakt

**Cel:** Innowacyjność przedsiębiorstw uzależniona jest od wielu zmiennych, w tym od decyzji w zakresie innowacji, posiadanych zasobów i kompetencji, jak i sektora działalności. Powinna być rozpatrywana w wymiarze strategicznym, zarówno na poziomie innowacyjności strategicznej przedsiębiorstwa oraz ogólnej strategii. Innowacyjność strategiczna będąca długookresowym procesem uwzględniającym wzajemne przenikanie się różnych rodzajów innowacji wraz z myśleniem strategicznym może być skutecznym narzędziem uzyskiwania wysokiej efektywności działania oraz utrzymania przewagi konkurencyjnej na rynku. Analiza literatury przedmiotu, jak również obserwacje, wskazują, że nawet w obrębie jednej branży występują zróżnicowania pod tym względem. Celem autorów było dokonanie podziału branż klasyfikowanych według podziałów PKD na jednorodne grupy pod względem innowacyjności przedsiębiorstw w danej branży. **Metodyka:** W części empirycznej przedstawiono wyniki badań własnych metodą analizy skupień, natomiast wszystkie obliczenia wykonano w programie R. **Wyniki:** Na podstawie tych wyników można stwierdzić, że branże można pogrupować w jednorodne klastry pod względem udziału innowacyjnych przedsiębiorstw. Wyniki przeprowadzonych badań wykazały, że klastry wyliczane na podstawie udziału firm innowacyjnych, które wprowadziły nowe lub ulepszone produkty oraz klastry notowane na podstawie udziału firm innowacyjnych, które wprowadziły nowe lub ulepszone procesy biznesowe, są bardzo zbliżone. **Implikacje dla teorii i praktyki:** Wartością dodaną rozważań przedstawionych w artykule jest możliwość uzyskania dodatkowych informacji o jednorodności działalności innowacyjnej tych przedsiębiorstw w poszczególnych działach PKD. Wyniki te można wykorzystać do dalszej pogłębionej analizy poszczególnych grup. **Oryginalność i wartość:** Możemy odnaleźć wiele pozycji skupiających się na problemie innowacyjności poszczególnych przedsiębiorstw, sektorów, branż, regionów. Brak jest natomiast opracowania prezentującego podobieństwo branż i podział na jednorodne grupy pod względem udziału innowacyjnych przedsiębiorstw. Luka ta, stała się inspiracją do badań, co pozwoliło zweryfikować problem naukowy.

**Słowa kluczowe:** strategia, strategia innowacji, sektor, klasyfikacja PKD, analiza skupień, podobieństwo

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### **Conflicts of interest**

The authors declare no conflict of interest.

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