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Innovation activities in the service sector across EU states: Similarities or differences?

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Abstract: Until 2005, service sector innovation had been a far less popular area of scholarly interest than studies on the industrial sector, the publication in 2005 of the methodological guidelines known as the Oslo Manual, in which it was noted that in addition to technological advancements in the economy, non-technological innovations might also be pursued in economic practice. Since then, although the popularity and dynamics of dedicated research have successively increased, this field of inquiry has not yet been sufficiently explored. Therefore, the aim of this study was to identify and assess the degree of homogeneity among EU countries in terms of innovation activity in the service sector. The hypothesis adopted for this study stated that there are countries within the EU that can be divided into clusters with respect to service sector innovation activity. Bearing in mind the objective and seeking to verify the hypothesis, this research used a critical review of literature, indicator-oriented analysis as well as quantitative statistical methods, among others, while relying on the most up-to-date data from the Eurostat database on innovation activity (as of 5.07.2022). The objective was accomplished using fifteen indicators which describe the effects of innovation activity, which were classified into four groups: innovation activity, types of implemented innovations, types of product innovation, and types of business process innovation. The research proceeded in three stages: identification of groups (clusters) in the area of the surveyed European countries which demonstrated the homogeneity of analysed indicators using Ward's agglomerative clustering method; identification of significant differences between the defined groups for each indicator carried out, using Student's t-test; an assessment of the degree of homogeneity in the scope of the surveyed EU countries with respect to innovation activity in the service sector by means of the methods outlined above.

On the basis of the conducted investigations and the adopted methodology, it may be concluded, first, that the service sectors of the surveyed EU countries can be divided into three homogeneous groups in terms of innovation activity. Second, the similarity within each group was confirmed by Levene's test, the results of which demonstrated homogeneity of variance for thirteen out of the fifteen analysed indicators. Thirdly, statistical analysis of the findings made it possible to identify significant

differences between the defined groups of countries, with the exception of country clusters I and II with respect to three product innovation indicators, as well as country groups II and III relative to three business process innovation indicators, where no significant differences occurred. The conclusions from the study warrant confirmation of the baseline hypothesis, which assumed that the surveyed EU countries could be divided into clusters in terms of service sector innovation activity.

The research and the analyses indicated that a homogeneous division of the surveyed EU countries into individual groups in terms of innovative activities in the service sector might offer a point of departure for further, in-depth analysis of the issues addressed in the study. Some of the compelling directions for future investigations include the determination of homogeneity and differences across the industries of the sector in question, as well as the creation of a ranking of countries in line with the analysed indicators. Approaching the issue in this manner will enable a detailed assessment of the innovation activity in the service sector and its internal structures, as well as provide grounds for validating the cluster division presented in this paper.

Keywords: innovation activity, similarities and differences, service sector, EU countries, cluster analysis

1. Introduction

The competitiveness of the global knowledge-based national economy (KBE) depends on numerous variables, including intellectual capital, skill, knowledge, experience, and social innovativeness, with substantial emphasis placed on the development of innovation capacity (Arefieva et al., 2018, p. 1). For this reason, competitiveness in the 21st century is largely determined by innovation, which becomes crucial in long-term economic performance. Innovation, on the other hand, is a manifestation of innovativeness construed as the capacity and motivation of businesses to introduce new product solutions in the market as well as to open new markets. In the subject literature, they are regarded as an excellent solution to many of the problems that modern enterprises face. In addition to providing a competitive advantage, they contribute to the survival of a business in the market (Carayannis & Grigoroudis, 2014, p. 200; Wang & Ahmed, 2004, pp. 303-313; Sobolewski & Wściubiak, 2017, p. 445, Witell et al., 2017, pp. 296-297). For many years, innovativeness and innovations have been regarded as an excellent pathway to higher competitiveness and, consequently, economic growth for individual countries (Alan & Köker, 2021, p. 228; Berdar & Yevtushevska, 2020, p. 26). This is also confirmed by Batóg (2008, pp. 136-137), who noted that the rate of global economic growth depends on the pace of innovation processes taking place in those countries which qualify as technological leaders.

Innovativeness appears to be one of the key characteristics of both the modern economy and the actors within it. It is in this domain that national economies compete with one another in the 21st century, as evidenced, for example, by the efforts of EU countries to achieve a level of economic and innovative development on a par with China, Japan and the USA; the policies and actions of EU countries are invariably geared towards such goals. Achieving that level crucially depends on the economic sectors, which, according to the paradigm proposed by C. Clark, A. Fisher and J. Fourastie (Wyszkowska-Kuna, 2016, p 28-29) include agriculture, industry and services. Such divergence generates an epistemological barrier which hampers an understanding of the development of modern economies which take advantage of the achievements of the technological and digital revolution, resulting in a gradual rejection of the aforementioned paradigm (Castells, 2007, p. 207-208). The interplay between the service sector and socio-economic development is particularly robust, having become even more intense in recent years as a result of globalisation, regionalisation, the spread of KBE and supranational expansion, which assumes the form of transnational corporations, for instance. The significant role of the service sector in national economies is also reflected in higher indicator values. In EU countries, for example, services generate 71% of added value and provide employment to 68% of those employed (Eurostat, 2022, p. 1).

Consequently, this study couples innovation and the service sector as unpopular research areas, whose synergy represents an even less orthodox current of inquiry in economics. As widely observed in the literature (Gonzalez-Lafaysse & Lapassouse-Madrid, 2016, pp. 560-583; Marcon et al., 2017, pp. 83-97; Cheah et al., 2018, p. 6; Pantano et al., 2018, pp. 150-152; Bilińska-Reformat et al., 2019, p. 11; Horvat et al., 2019, pp. 20-32), innovation in the service sector is considered a key element in survival and economic development (Barska et al., 2017, pp. 57-59), while according to Lipieta & Pliś (2022, p. 18), it is closely linked to increasing diversity. In turn, the growth of the latter translates into actual improvement not only in the economic circumstances of a proportion of consumers but, above all, fosters innovativeness of the economic system (Lipieta & Malawski, 2018, pp. 23, 25, 26).

Given this theoretical underpinning, the study set out to identify and assess the degree of homogeneity of EU countries in terms of service sector innovation activity, with a view to validating the hypothesis that countries within the EU may be divided into clusters defined by service sector innovation activity.

2. Literature review

In times of digital revolution, dynamic globalisation and internationalisation, a paramount role is played by a continuous improvement and implementation of innovative solutions at the level of company, region and country, which promote sustainable development and competitive advantage in the long term (Gołębiowski et al., 2019, p. 23; Mallinguh & Zoltan, 2020, pp. 168, 173-175; Bowonder et al., 2010, p. 19). Dynamic development in innovation motivates companies to intensify innovation activities to establish and maintain competitive advantage as well as ensure success (Berdar & Yevtushevska, 2020, p. 30). Putting new solutions into practice largely depends on the degree of innovation activity, which has become a vital factor in the sustainable development of European economies and remains unsolved from the viewpoint of a systemic multilevel approach based on the engagement of a knowledge economy (Arefieva et al., 2018, p. 2; Marin-Garcia et al. 2021, p. 1092). The innovations implemented as part of innovation activity should replace the already existing solutions, while Schumpeter observed that ‘old’ technologies need not have exhausted their capacity to satisfy needs and make money. Therefore, he suggested that businesses should launch new services that cater to the tastes of consumers even better, whereas the old ones will simultaneously and gradually become less significant and register decreasing sales. Schumpeter referred to this phenomenon as “creative destruction” (Osiadacz, 2012, pp. 39-40), which enables a smooth transition of obsolescent solutions into new ones. Such a transformation involves five changes (Rubalcaba, 2011, pp. 7-8):

- launching new products,
- introduction of new production methods,
- opening new markets,
- establishing new sources of supply of raw materials or other commodities,
- creating new market structures within one’s scope of business.

According to the Oslo Manual, such changes brought about the emergence of four (product innovation, process innovation, organizational innovation, and marketing innovation) and, subsequently, two types of innovation in current realities. The most recent 2018 edition identified two categories of innovation (the classification adopted in this study), the first of which is product innovation, i.e. new or significantly improved products/services that differ substantially from their predecessors (OECD, 2018, pp. 79-80). The second type of innovation involves changes in the business process with respect to six business functions (OECD, 2018, pp. 82-83):

- production of products and/or services,
- distribution and logistics,
- marketing and sales,

- information and communication systems,
- administration and management,
- product and business process development.

Innovations classified according to current or previous approaches remain an interesting area of inquiry due to their multidisciplinary nature. For this reason, they are studied by researchers in many fields, including politicians, lawyers, and economists, as well as theorists and practitioners in management and applied sciences. Innovation is the yield of creative and planned activities of both technological and non-technological domains, spanning organization, process, operations, finance and marketing.

Undoubtedly, innovation results from the application and development of novel ideas, which then require successive implementation of an established strategy aimed at achieving a permanent innovative capacity (innovative competence), referred to as innovativeness (Dos-Santos, 2021, p. 248). Essentially, this consists in a selective search for and implementation of new solutions or concepts which differ radically from those already in place as part of a competition to increase market shares between economic actors (Jasiński, 2021, p. 113; Tidd and Bessant, 2015). It follows from the diversified and heterogeneous notions of innovation in the Polish studies that it may be defined as a disposition (innovative motivation) and an ability to continuously search for, implement and disseminate innovation, which derives from creative processes, i.e. "the application of the creative effect in practice" (Matusiak, 2010; Brzeziński, 2009; Pomykalski, 2001). However, in international literature, innovation tends to be closely linked with competitiveness, for instance, Anning-Dorson and Nyamekye (2020, pp. 605, 609, 617) confirmed that a company's innovativeness can create a form of competitive advantage, and this capacity for innovation will have the greatest effect if it initially seeks to create flexibility at the company level, which, in turn, will turn into competitive advantage. According to Shoham et al. (2017, pp. 165-182), it may be understood as a measurable quantity and characteristic serving to gauge or state the degree of capability of a given company or organization. The measurable facet of innovativeness is reflected in the varied indicators employed at different levels, from macroeconomics through mesoeconomics to microeconomics. However, it has still not been possible to develop a universal benchmark of innovativeness (Jasiński, 2021, p. 114). At the sectoral level, the appropriate analytical metrics include those which directly describe the innovation activity of businesses. Such data may be used in research to test and estimate the level or degree of similarity between sectors in particular countries. As noted in the literature, studies on innovativeness focus primarily on ranking companies, industries, or countries in terms of their innovative activities (Bielińska-Dusza & Hamerska, 2021, p. 61), whereas categorising the studied entities into clusters with homogeneous, similar parameters is a far less popular approach. Nonetheless, it could lay the groundwork for further work, resulting in better exploration of the studied issues. For this reason, the next part of this study is concerned precisely with aspects relating to the identification of structures which demonstrate internal homogeneity as well as external differences.

3. Methodological assumptions

From the standpoint of long-standing research into innovation, 2005 proved a watershed when the third (penultimate) edition of the Oslo Manual was published. It expanded the innovation measurement system in three respects, two of which had a particular impact on the directions of later studies and provided an incentive for this one. First of all, the document recognised the important role of innovation not only in the industrial or high-tech sectors but also in the services sector where the scale of research and development (R&D) activity is lower. The second change which prompted changes in future research approaches was that the definition of innovation was broadened from its original form, referring to technological innovation (product and process

innovation), to include two additional types: organizational innovation and marketing innovation, together constituting the so-called non-technological, i.e. 'soft' innovation (OECD, 2005, p. 13). According to the literature, these are considered complementary and supplementary to product innovation (Battisti & Stoneman 2021, p. 4; Teece, 1986, p. 285). For example, new goods can yield better results and achieve greater success when launched in combination with marketing innovation (Bartoloni & Baussola, 2015, pp. 5-6, 10, 34).

The modified methodology of interpreting innovation and the above theoretical considerations informed the research objective of this study, i.e. to identify and assess the degree of homogeneity among EU countries in terms of innovation activity in the service sector. The overall objective was elaborated into specific objectives formulated in the following questions:

1. Have (internally) uniform[1] groups[2] of countries been defined in terms of service sector innovation activity, and which EU countries do they compris?
2. Have significant differences been observed between the identified groups of countries with respect to the analysed indicators of service sector innovation activity?

With the main objective and its explanatory specific objectives in mind, the hypothesis stating that countries within the EU may be divided into clusters in terms of innovation activity in the service sector was then tested in the course of the research.

In order to accomplish the objective and test the hypothesis, the following methods were used: critical literature analysis, the indicator method and quantitative statistical methods. The first served mainly to systematise previous findings relating to innovation, as well as define the knowledge gap with respect to innovative activities in the service sector. The indicator method was used to determine the innovation status of individual EU countries in that particular economic sector, relying on the most up-to-date surveys on innovation activity from the Eurostat database (Community Innovation Survey – CIS2018), concerning the period 2016-2018 (as of 5.07.2022). The analysis encompassed all the EU countries (for which secondary indicator data were available in the Eurostat database, i.e. fourteen countries) examined in light of fifteen indicators that characterised the outcomes of innovation activities undertaken by service companies. Therefore, whenever the study mentions the analysis of services in a methodological and empirical context, the service sector refers to the fourteen countries. Enterprises operating in the service sector of EU countries, in line with the methodology used by Eurostat, were the subject of research, whereas the aforementioned indicators were its object. For analytical purposes, the indicators were classified into four groups: innovation activity, types of innovations introduced, types of product innovations, types of business process innovations. The measures were calculated on the basis of variables, all of which were nominal qualitative data (Table 1).

Most indicators were directly associated with one of the two types of innovation, as defined in the 2018 Oslo Manual: either product innovation, which included goods and services and their significant improvements, or business process innovation¸ which integrates innovations defined in 2005 as process, organizational and marketing innovations (OECD, 2018, p. 23). In the 2018 methodology, business process innovation may stem from six "core business functions", the first of which is defined as the "production of goods and services" and constitutes the core function of a business involving, e.g. engineering, technical research, supporting basic production processes. Thus approached, the function meets the conditions of process innovation. The remaining five functions were considered complementary to the "production of goods and services" as they have been assigned the role of supporting production and supplying goods and services to the market (Chrobocińska et al., 2021, pp. 58-59).

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1 Further on, the term 'homogeneous' is used interchangeably.

2 Further on, the terms 'cluster' and 'concentration' are used as synonymous alternatives.

Table 1. Summary and characteristics of the indicators analysed in the work

Group of indicators which describe…	Type of indicator *(expressed in % of surveyed service enterprises)*	Variables which describe indicator – *number of enterprises which introduced…*
innovation activity	innovation activity efficiency index – IAEI	at least one innovation or conducted an innovation project
	innovative efficiency index – IEI	at least one innovation
types of innovations – *innovation activity index in the area of…*	product innovations	product innovations
	business process innovations	business process innovations
product innovations – *innovation activity index in the area of product innovations…*	in the form of goods – GIEI	product innovations in the form of goods
	in the form of services – SIEI	product innovations in the form of services
	that were new from the market perspective– MNIEI	product innovations that were new from the market perspective
	that were new only from the perspective of a given company – FNIEI	product innovations that were new only from the perspective of a given company
business process innovations – *innovation activity index in the area of business process innovations relating to…*	new or improved methods for producing goods or providing services – MPGS	business process innovations relating to new or improved methods for producing goods or providing services
	logistics – LI	business process innovations relating to logistic
	new business practices for organizing procedures or external relations – BPER	business process innovations relating to new business practices for organizing procedures or external relations
	new methods of organizing work responsibility, decision making or human resource management – OWHR	business process innovations relating to new methods of organizing work responsibility, decision making or human resource management
	new or improved methods for information processing or communication – IPC	business process innovations relating to new or improved methods for information processing or communication
	new methods for accounting or other administrative operations – AAO	business process innovations relating to new methods for accounting or other administrative operations
	new marketing methods for promotion, packaging, pricing, product placement or after-sales services – MM	business process innovations relating to new marketing methods for promotion, packaging, pricing, product placement or after-sales services

Source: own elaboration.

Quantitative statistical methods were used to accomplish the research objectives. They included Ward's agglomerative clustering method and other statistical tests to assess both potential homogeneities within the identified clusters as well as the differences between them.

The research procedure to accomplish the main objective and test the hypothesis consisted of three stages. The first involved the identification of clusters of EU countries which showed homogeneity in terms of the analysed indicators and relied on the agglomerative clustering method. The first stage was implemented using the agglomeration method of grouping objects, which is used both for quantitative and qualitative data (Augustyńska & Kozerska, 2008, p. 204), as practiced in many empirical works, for example by Bal-Domańska (2018, pp. 133-152), Miłek (2018, pp. 487-507), Dubiec (2020, pp. 87-108), Bluszcz & Manowska (2021, pp. 1-18) or Bielińska-Dusza & Hamerska (2021, pp. 53-98). In terms of the agglomeration method, it was initially presumed that each object (country) constitutes a separate group. In the next step, the most similar objects were successively combined into increasingly larger clusters until a single group containing similar elements was obtained (Migut, 2012, pp. 57-60).

In cluster analysis, there are a number of methods which serve to combine clusters as well as determine the distance between the objects under study (single linkage, complete linkage, centre of gravity of clusters, etc.). At the outset, it was necessary to create a distance matrix between the studied objects, whereby Euclidean distance determining the actual geometric distance in a multidimensional space, was used as the distance measure (Suchecki & Lewandowska-Gwarda, 2010, p. 60):

$$d_{ij} = \sqrt{\sum_{k=1}^{m}\left(z_{ik} - z_{jk}\right)^2}, \quad (1)$$

where d_{ij} – distance between the two studied objects *i* and *j*; z_{ik}, z_{jk} – values of the normalised *k*-th variable for objects *i* and *j*; m – number of classified characteristics.

In addition, Ward's method was used since it is widely considered the most effective and it is often employed in economic research because it reproduces the actual structure of data in the most efficient manner (Steinley & Brusco, 2007, pp. 110, 119; Korzeniewski, 2012, p. 17). As part of this method, one seeks to group objects by virtue of minimum intraclass variance by consolidating such clusters, which results in the minimised sum of squares of the distances from the centre of gravity of the new cluster they form (Łukiewska, 2019, p. 125). The values of the transformation parameters for Ward's method were cited by Grabiński et al. (1982, p. 146):

$$\alpha = \frac{m_i + m_s}{m_i + m_t + m_s}, \quad (2)$$

$$\beta = \frac{m_i + m_t}{m_i + m_t + m_s}, \quad (3)$$

$$\gamma = \frac{i}{m_i + m_t + m_s}, \quad (4)$$

where m_i, m_t, m_s – number of elements in groups G_i, G_s, G_t.

Countries grouped as described above yielded a dendrogram (hierarchical tree), which offered a graphical interpretation of the computed results. In this study, four distinct dendrograms were generated for each group of indicators. Agglomeration plots were used to accurately establish the number of country clusters in which linkage distances that determined the successively emerging groups were illustrated. Based on these, it was possible to split the hierarchical tree at the sites of relatively large changes in the increments of agglomeration distances as classes were being merged across different levels of consolidation. The analyses and the actions performed in the course of the first stage made it possible to accomplish the first specific objective.

The second-stage analysis aimed to assess the level of homogeneity within the identified clusters of states and to identify potential differences between them. The research procedures in this stage provided an answer to the second research question concerning the existence of significant differences between country clusters. Firstly, an analysis of variance was performed; Levene's test (the most potent test for assessing homogeneity of variance) was used to test the assumptions of the Student's t-test for homogeneity of variance. Where it showed statistical significance at $p < 0.05$, the statistical null hypothesis was rejected, and it was inferred that the cluster was heterogeneous. In a situation where $p \geq 0.05$, there were no grounds for rejecting the null hypothesis, and the assumption of homogeneity of variance within a given group of countries could be considered satisfied. Secondly, the normal distribution of the dependent variable was verified on the basis of categorised normal plots. The steps outlined were necessary to apply the Student's t-test for uncorrelated (independent) variables:

$$t = \frac{m_1 - m_2}{\sqrt{\frac{s_1^2(n_1-1)+s_1^2(n_2-1)}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}, \quad (5)$$

where m_i, s_i, n_i – mean, standard deviation and *i*-th sample size, respectively. The t-statistic has a Student's t distribution with $n_1 + n_2 - 2$ degrees of freedom.

Student's t-test was used to test the null hypothesis presuming that there are no statistically significant differences between the identified country clusters in terms of the mean values of the analysed indicators.

The final stage of the research consisted in the assessment of the degree of homogeneity among the EU countries with regard to service sector innovation activity, drawing on the methods applied in the

earlier stages. This part of the study also applied the analysis of intraclass mean for indicators, on the basis of which it was possible to establish a hierarchy of identified country clusters from the best to the worst.

All statistical analyses and computations in the study were performed using Statistica 13 software, with a significance level of p=0.05 adopted for testing. It should be noted that in order to keep the study as concise as possible and simultaneously maintain the most comprehensive approach to the discussed issues, the results in tables below (showing the outcomes of the applied statistical tests) describe only the first group of the discussed indicators. In the remaining cases, the findings are presented as cluster visualisations in hierarchical trees and intraclass means, while the results of statistical tests are provided only in descriptive form.

4. Results

4.1. Innovation activity in the service sector in the EU countries

As noted in the section devoted to methodology, the analysed indicators of innovation activity were divided into four groups. First, EU countries were examined in terms of similarities in innovation activity using the following:

- enterprise innovative efficiency index (IEI) – enterprises which introduce at least one innovation expressed as a percentage of surveyed service enterprises,
- innovation activity efficiency index (IAEI) – enterprises which introduced at least one innovation or conducted an innovation project expressed as a percentage of surveyed service enterprises.

A cluster analysis using Ward's method and Euclidean distance yielded innovation activity indicators in the form of a dendrogram. Based on the agglomeration plot, a cut-off point was established for a linkage distance of 3. As a result, three groups of countries which showed similar values of service sector innovation activity indicators were defined (Figure 1), all of which comprised a very similar number of countries.

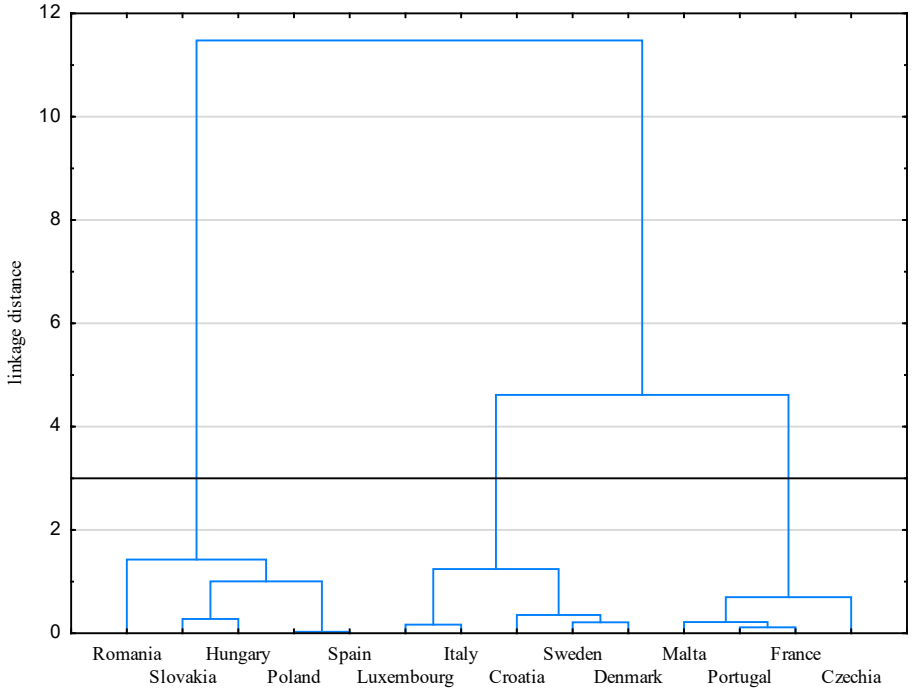

Fig. 1. Typology of EU countries by service sector innovation activity in 2016-2018

Source: own elaboration based on Eurostat data [inn_cis11_inact], last access: 7.07.2022.

Five countries were classified into the first cluster: Sweden, Denmark, Croatia, Italy and Luxembourg. This group had the highest level of innovation in terms of the relevant indicators. In these countries, the share of actively innovative businesses (except for Luxembourg) and innovative entities (except for Luxembourg and Italy) exceeded 51% and was the highest among the countries studied. The second cluster included four countries, namely Czechia, France, Portugal and Malta, where the analysed indicators were at an average level, whereas Hungary, Slovakia, Spain, Poland and Romania were classified into the third cluster with a shared trait of a low or very low degree of innovation activity as measured by the analysed indicators. For IAEI, it was no higher than 29% and did not exceed 26% for IEI, i.e. was twice less than the most innovation-active service sectors of the EU countries. Seven countries ranked below the EU average for IAEI and six countries for IEI (38.1% and 36.1%, respectively). A common feature for all countries surveyed was a higher level of innovation activity index relative to the innovation index, as evidenced, e.g., by intraclass means (Table 2). This is due to the fact that, in accordance with the Oslo Manual methodology, IAEI includes enterprises which have introduced at least one innovation, as well as those where an innovation project was being implemented (discontinued, abandoned etc.). Only companies with at least one innovation implemented were taken into consideration in the IEI.

Table 2. Intraclass means of innovation activity indicators in the EU services sector in 2016-2018 (data in % of companies surveyed)

Cluster number	Countries in the cluster	Mean indicator value	
		Innovation-active enterprises	Innovative enterprises
I	Sweden, Denmark, Croatia, Italy, Luxembourg	53.1	50.9
II	Czechia, France, Portugal, Malta	39.4	37.4
III	Hungary, Slovakia, Spain, Poland, Romania	22.1	20.2
I, II and III	all studied countries	38.1	36.1

Source: elaborated based on own computations and Eurostat data [inn_cis11_inact], last access: 7.07.2022.

In order to confirm that groups are internally homogenous, an analysis of variance was carried out using Levene's test (Table 3). Consequently, with a probability of p = 0.347 (innovation activity) and p = 0.498 (enterprise innovativeness), there were no grounds to reject the null hypothesis which presumed homogeneity within the identified clusters.

Table 3. Levene's test of homogeneity of variance at significance level p = 0.05

Variable	SS effect	df effect	MS effect	SS error	df error	MS error	F	p
Innovation-active enterprises	14.553	2	7.276	68.682	11	6.244	1.165	0.347
Innovative enterprises	8.010	2	4.005	59.274	11	5.389	0.743	0.498

Source: own elaboration based on Statistica 13 software and Eurostat data [inn_cis11_inact], last access: 7.07.2022.

The analysis of Levene's test results was an element in Student's t-test conducted for independent samples. In addition, it confirmed that the division of countries made using Ward's agglomeration with Euclidean distance was correct. With the assumptions of Student's t-test met, it was possible to identify significant differences between the defined clusters. The study identified relations occurring in all possible cluster configurations (i.e. I-II, I-III, II-III). For example, in the case of differences between clusters I and II, the null hypothesis presuming no significant differences was rejected at a significance level of 0.0004 (innovation activity) and 0.0009 (innovativeness of enterprises) (Table 4). Thus, it may be concluded that the mean indicators for the first and second clusters were significantly different from each other. Similar conclusions may also be drawn for the other cluster configurations, where significant differences between the groups were observed as well. The remaining results which illustrate these relationships are not presented for the sake of conciseness.

Table 4. Student's t-test results – innovation activity indicators

Variable	Mean in group I	Mean in group II	t	df	p	Standard deviation in group I	Standard deviation in group II
Innovation-active enterprises	53.1200	39.4000	6.4225	7	0.0004	3.3350	2.9721
Innovative enterprises	50.9200	37.4250	5.4615	7	0.0009	4.3182	2.6069

Source: own elaboration based on Statistica 13 and Eurostat data [inn_cis11_inact], last access: 7.07.2022.

Given these analyses, it may be unequivocally stated that the three-cluster division of countries in terms of innovation activity of the service sector enabled the identification of groups whose internal structures are strongly homogenous, but which remain significantly different from each other at the same time.

Comparing the above results with the latest Summary Innovation Index (SII) report from 2021, one can see considerable analogies, as the first cluster includes countries whose SII was relatively highest among EU countries. For example, Sweden and Denmark were classified as innovation leaders in 2021 (with indices of 0.731 and 0.689, respectively) in the group which achieved the highest innovativeness, while Luxembourg was ranked as a strong innovator (0.638). The SII values were lower than the EU average (0.526) only for Italy and Croatia, at 0.505 and 0.366, respectively. High innovation activity indicators in the service sectors of these countries may suggest that they are among the better developed in the EU in a particular respect. However, it was observed that this does not clearly significantly translate into the SII.

4.2. Type of innovation introduced in the service sector in the EU countries

Similarities between the service sectors of the EU countries in terms of the type of innovations implemented were carried out using indicators expressed in percentages of service firms surveyed:

- enterprises which introduced product innovations,
- enterprises which introduced business process innovations.

Based on the agglomeration plot, a cut-off point was established for a linkage distance equal to 3. As a result, it was possible to identify three groups of countries with similar indicator values (Figure 2).

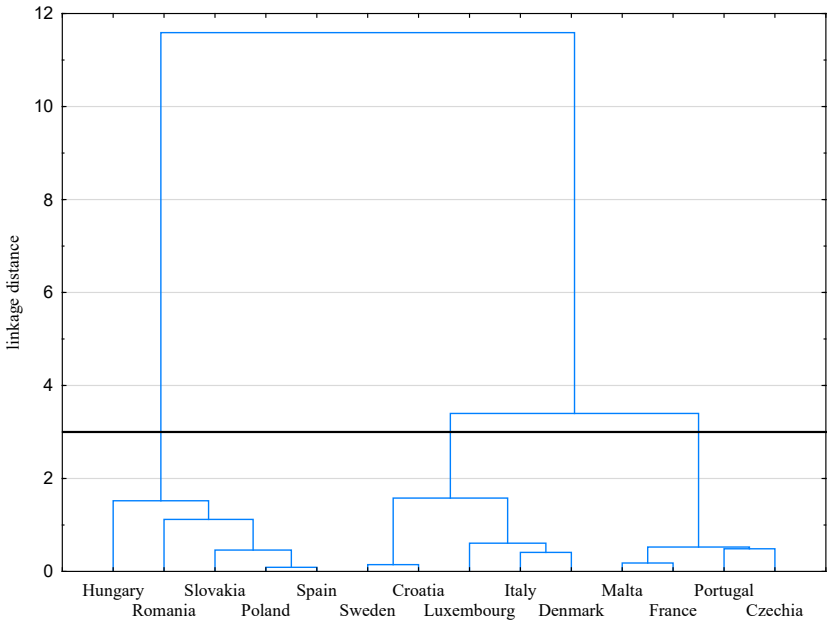

Fig. 2. Typology of the EU countries by types of innovations introduced in the services sector in 2016-2018

Source: own elaboration based on Eurostat data [inn_cis11_prod], last access: 7.07.2022.

Using Statistica 13 software, each cluster of countries was assigned a number. The first cluster included: Hungary, Slovakia, Poland, Spain and Romania, i.e. countries for which the values of the indicators in question were lowest. The second cluster consisted of countries with the highest scores for implemented innovations: Denmark, Croatia, Sweden, Italy and Luxembourg. The third group comprised four countries with average indicator levels, i.e. Czechia, Malta, Portugal and France.

The dendrogram demonstrates that the division into potentially homogeneous clusters follows the same pattern as in the case of the innovation activity indicators analysed previously, i.e. the same countries form similar groups. In addition, indicator values determined on the basis of the intraclass mean indicated that in each country, regardless of the cluster to which it belonged, there was a definite predominance of companies which introduced business process innovations over product innovations, with respective averages of 31.4% and 22.6% of the surveyed entities (Table 5). Such results are reported in the literature. For instance, Gallouj (2002, p. 128), Miles (2011, p. 293), Barska et al. (2017, p. 59) and Węgrzyn (2014, p. 235) observed that business process innovations (including process, marketing and organizational) are naturally more important for the development of innovation in service companies than product innovations. The aforementioned forms of business innovation play not only an ancillary but also a complementary function since, as follows from Naidoo (2010, p. 1316), performing technological development alone might interrupt the creation of successful innovation, thus indicating the necessity of marketing innovation. In practice, an innovative approach to services is important both in its design and creation, in interacting with the intended recipient of the innovation, and in the ability to establish and maintain a high quality relationship with the latter. For this reason, the role of process, marketing and organizational innovation in service entities is far more prominent than, for example in industrial enterprises.

The analysis of indicators in individual countries demonstrated a variation in the hierarchy of countries within each group with regard to the above indicators. In Denmark, for example, the proportion of companies actively involved in product innovation was 46.5 % (first place), whereas, in terms of business process innovation, the country ranked third with a 30.8 % share. Despite the differences occurring in the classification of individual countries, Levene's test unequivocally confirmed that the identified groups were homogenous, with probability $p = 0.292$ in product innovation and $p = 0.625$ in business process innovation. However, the analysis of the Student's t-test, explicitly showed that the differences between the mean values of the indicators in individual groups of countries were statistically significant, with $p = 0.05$ as the significance level. This proved true in the country cluster comparisons in all possible configurations, i.e. I with II, I with III and II with III.

Table 5. Intraclass innovation activity indicator means for types of innovations introduced in the EU services sector in 2016-2018 (data in % of enterprises surveyed)

Cluster number	Countries in the cluster	Mean indicator value	
		Business process innovation	Product innovation
II	Denmark, Croatia, Sweden, Italy, Luxembourg	43.9	32.4
III	Czechia, Malta, Portugal, France	33.9	24.4
I	Hungary, Slovakia, Poland, Spain, Romania	16.9	11.5
I, II and III	all studied countries	31.4	22.6

Source: elaborated from own computations and Eurostat data [inn_cis11_prod], last access: 7.07.2022.

Analyses with respect to the relevant indicators enabled clusters of countries to be definitively delineated; the clusters were both internally similar and significantly different from one another. It is worth noting, however, that the classification provided by these indicators was not as clear-cut as in the case of innovation activity. Certain countries performed better in comparison with the rest of the EU as far as product innovation was concerned, but fared much worse than, e.g. Denmark, in terms of business processes. The discrepancies in the values of individual indicators for the studied countries

would only become apparent if research were conducted in a manner enabling classification and prioritisation of the countries in question. Investigations thus oriented could be an extremely valuable supplement, broadening the scope of this inquiry.

4.3. Types of product innovations introduced in the EU services sector and their degree of novelty

The third group of indicators involved a more comprehensive conceptualisation of elements addressed in the previous part; namely, detailed types of product innovations were presumed considering their form and degree of novelty. The subsequent analysis targeted the following indicator expressed in percentages of the surveyed service enterprises:

- enterprises which introduced product innovations in the form of goods – GIEI,
- enterprises which introduced product innovations in the form of services – SIEI,
- enterprises which introduced product innovations that were new from the market perspective – MNIEI ,
- enterprises which introduced product innovations that were new only from the perspective of a given company – FNIEI.

The above indicators were examined according to the previously described methodology with a view to finding similarities and differences. First, cluster analysis was performed using Ward's method with Euclidean distance, and the results were presented on a hierarchical tree. In this case, based on the agglomeration plot, the cut-off point was set at the linkage distance level of 4. Hence, three clusters were identified to which the studied countries were assigned (Figure 3).

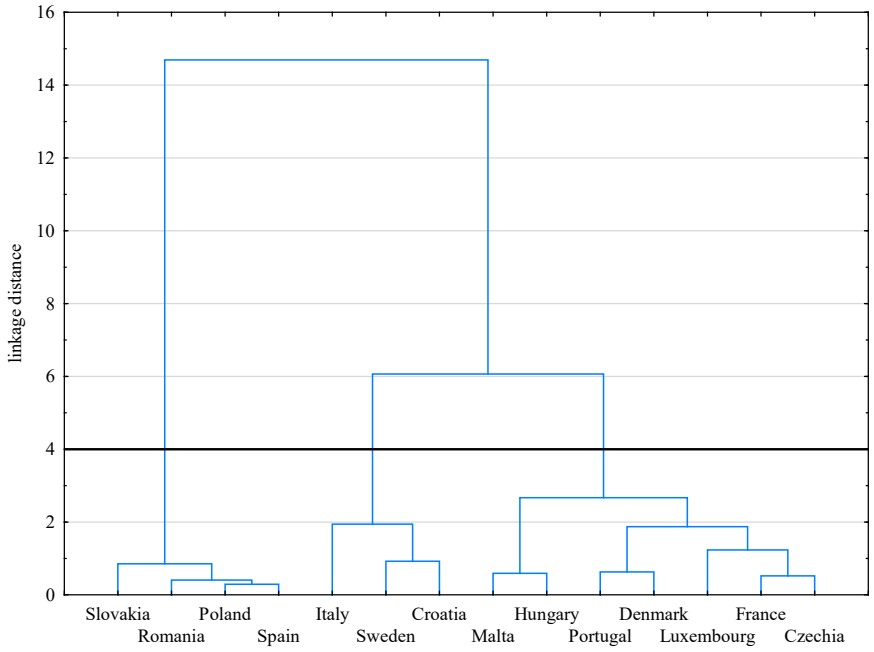

Fig. 3. Typology of the EU countries by type of product innovation in 2016-2018

Source: own elaboration based on Eurostat data [inn_cis11_prodn], last access: 7.07.2022.

It follows from computations using Statistica 13 that the first group includes Portugal, Denmark, Luxembourg, France, Czechia, Malta and Hungary. The degree of product innovation indicators in these countries reached an average level. Intraclass means ranged between 19.5% for innovations in the form of services and 9.7% for innovations that were innovations from the standpoint of the enterprise

itself (Table 6). Cluster II (Croatia, Sweden, Italy) was generally characterised by the highest ratios (except for market-recognised novelties). Firstly, this resulted from the highest activity of these countries in introducing product innovations – whether as goods or services – and, secondly, from the decisive dominance in implementing novelties within the enterprise (22.4%). The latter, however, was not fully indicative of a thriving innovation in the sectors of these countries, as this level of novelty of introduced innovations is the lowest possible. Compared to previous classifications, Denmark and Luxembourg were missing from group II, which may have been due to the low score for innovations introduced at the company level, where they ranked fifth and eighth, respectively. At the same time, these countries surpassed all others in terms of new innovations from the market standpoint, which positively attested to the innovation situation of the service enterprises operating there, as this is a desirable relation between innovation novelty scales. The last cluster consisted of four countries, namely Slovakia, Romania, Poland and Spain, whose indicator values were the lowest.

Table 6. Intraclass indicator means for product innovation introduced in the EU services sector in 2016-2018 (data in % of companies surveyed)

Cluster number	Countries in the cluster	Mean indicator value			
		SIEI	GIEI	MNIEI	FNIEI
II	Croatia, Sweden, Italy	24.4	18.9	11.5	22.4
I	Portugal, Denmark, Luxembourg, France, Czechia, Malta, Hungary	19.5	15.3	14.5	9.7
III	Slovakia, Romania, Poland, Spain	7.0	5.4	4.0	5.1
I, II and III	all studied countries	17.0	13.2	10.9	11.1

Source: elaborated based on own computations and Eurostat data [inn_cis11_prodn], last access: 7.07.2022.

In each country group, the predominance of companies which implemented product innovations in the form of services was evident, which is not surprising and should be attributed to the primary type of activities in this sector of the economy. In addition, it should be noted that more companies in clusters II and III introduced novelty product innovations on a company rather than on a market scale. The opposite proportion was observed in cluster I, in Denmark, Luxembourg, as well as other countries, i.e. Czechia, Malta or Hungary. In cluster I, companies which implemented innovations that were new on the market scale (14.5%) were clearly more numerous than enterprises with company innovation (9.7%); as already observed, this is a positive indication of the degree of innovation of the products they launched. Novel market-wide innovations are more likely to diffuse, while their originators tend to display higher innovativeness than, e.g. businesses whose solutions are unique.

Analysis of variance using Levene's test demonstrated that each group of countries is homogeneous with regard to all product innovation indicators (SIEI: $p = 0.343$; MNIEI: $p = 0.152$; FNIEI: $p = 0.061$), with the exception of GIEI ($p = 0.404$). In this case, there were no grounds for rejecting the null hypothesis regarding the presence of homogeneity of countries within clusters. Student's t-statistic was not as clear-cut as in the previously discussed composite indices. Significant differences between the means were determined between groups I and III, II and III. However, this was not observed between clusters I and II for the SIEI ($p = 0.080$), GIEI ($p = 0.114$) and MNIEI ($p = 0.231$) indicators. The differences between the two were not statistically significant, as the null hypothesis concerning no significant difference was accepted, which may indicate that there was little variation in the mean values of the aforementioned indicators between clusters I and II.

The research procedure applied to product innovation indicators generally supplied evidence of homogeneity of the identified clusters and simultaneously significant differences between them. This was the case in all cluster configurations, apart from the cited exceptions, which nonetheless did not affect the final conclusion of internal homogeneity and external differentiation between countries.

4.4. Types of business process innovation introduced in the service sector of the EU countries

The last category of metrics in which similarities and differences were identified involved business process innovations, whereby they derived directly from the functions of such processes. Accordingly, and in conjunction with the OECD (2018, pp. 82-83), the analysis targeted seven indicators expressed in percentages of the service enterprises surveyed and described "enterprises which, during the period under review, introduced business process innovations relating to...":

- new or improved methods for producing goods or providing services – MPGS,
- logistics – LI,
- new business practices for organizing procedures or external relations – BPER,
- new methods of organizing work responsibility, decision making or human resource management – OWHR,
- new or improved methods for information processing or communication – IPC,
- new methods for accounting or other administrative operations – AAO,
- new marketing methods for promotion, packaging, pricing, product placement or after-sales services – MM.

According to research concerned with the above indicators, the cut-off point on the agglomeration plot was ascertained at the level of 4. As a result, three clusters comprising countries which proved similar in terms of specific business process functions were identified (Figure 4).

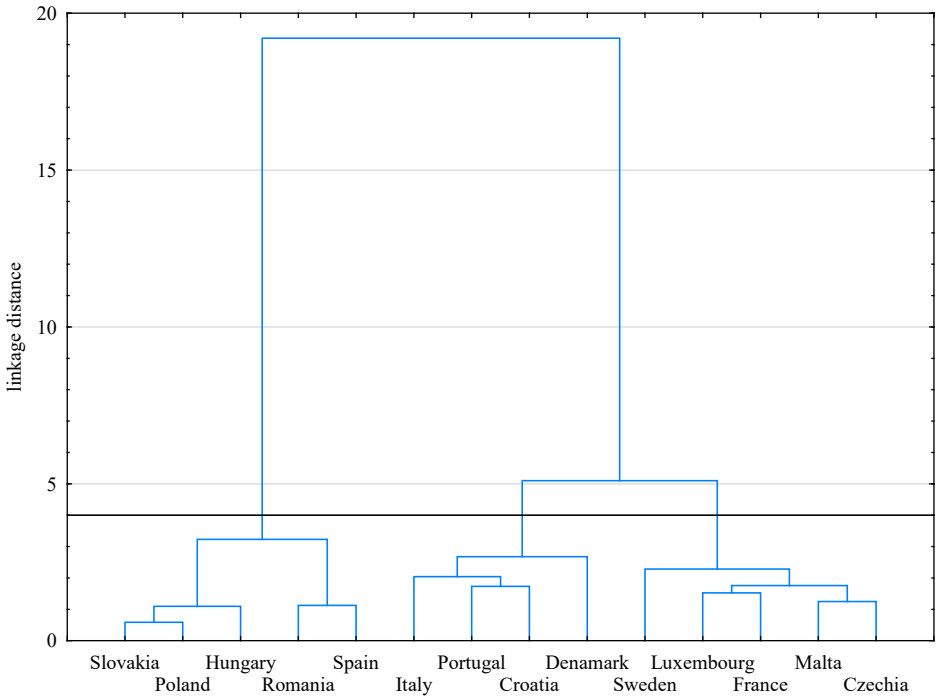

Fig. 4. Typology of the EU countries by type of business process innovation in 2016-20182016-2018

Source: own elaboration based on Eurostat data [inn_cis11_spec], last access: 7.07.2022.

Cluster II with the highest indicator values also included Portugal, which so far has been classified into average-scoring groups; here, it was placed in the cluster of countries with the highest results. Group II also included Croatia, Denmark and Italy, which displayed the highest business process innovation activity. Intraclass mean values were highest in this cluster, ranging from 16.3% to 28.2% (Table 7). Admittedly, countries in this cluster had a number of indicators lower than those in cluster III (average metrics), but this was offset by the value of the remaining indicators. In Italy, for instance, only 12.3%

of companies introduced innovative methods of producing goods and providing services, i.e. 5.1% lower than Sweden (cluster III). For other indicators, the advantage of the service sector in Italy was already considerably greater; for example, companies introducing innovations in business practices and external networking account for as much as 11.3% more than in Sweden.

Table 7. Intraclass indicator means for business process innovation introduced in the EU services sector in 2016-2018 (data in % of surveyed companies)

Cluster number	Countries in the cluster	Mean indicator value						
		MPGS	LI	BPER	OWHR	IPC	AAO	MM
II	Croatia, Portugal, Denmark, Italy	16.3	17.5	20.2	21.0	28.2	19.6	19.6
III	Sweden, Luxembourg, France, Malta, Czechia	14.9	10.9	12.7	18.3	20.6	15.9	16.9
I	Hungary, Slovakia, Poland, Spain, Romania	6.8	5.7	6.5	7.5	9.8	7.1	7.4
I, II and III	all studied countries	12.4	10.9	12.7	15.2	18.9	13.8	14.2

Source: elaborated based on own computations and Eurostat data [inn_cis11_spec], last access: 7.07.2022.

In the countries classified in cluster II, the highest proportion of service companies (28.2%) introduced innovations in communication and information systems (ICT) and in new or improved methods of information processing or communication (IPC). In general, this was the dominant form of innovation in all identified clusters of countries, opted for by 20.6% of surveyed companies in cluster III and 9.8% in cluster I.

Another identified cluster (III) consisted of five countries: Sweden, Luxembourg, France, Malta and Czechia, in which an average level of the examined indicators was observed. In this cluster, companies which introduced innovations in IPC (20.6%) clearly predominated; also, the value of MPGS (14.9%) was close to that noted in group II (16.3%).

The last, weakest cluster in terms of business process innovation (cluster I) comprised five countries as well, specifically Hungary, Slovakia, Poland, Spain, and Romania. In all analyses conducted so far – except for types of product innovation (where Hungary was classified into the average-scoring cluster) – these countries showed the lowest innovativeness and were considered similar. Their ranking was the only element which varied due to the values of particular metrics. No intraclass mean of any indicator exceeded the value of 10%, indicating relatively low innovation activity in business process innovation.

An analysis of the means showed that, in general, service companies active in logistics-related functions (LI) had the lowest share in business process innovation. This was evident in clusters I and III, in which the intraclass means were 5.7% and 10.9%, respectively,, yet the companies which introduced improved and new production methods in the studied period were the fewest in cluster II (16.3%).

Variance analysis conducted by means of Levene's test for the described indicators demonstrated homogeneity for six of the latter. Of the examined variables, LI was the only exception for which the null hypothesis of homogeneity within clusters was rejected with a significance level $p = 0.026$. Student's t-statistic also confirmed the existence of significant differences between the mean indicator values in the relations between clusters I and II, as well as between I and III. A comparison of clusters II and III did not produce such unambiguous results. No statistically significant differences were observed in three out of the seven analysed metrics, specifically in LI, OWHR and MM, whose probability values reached $p = 0.113$, $p = 0319$ and $p = 0.414$, respectively.

In light of the presented data and following statistical computations, it may be legitimately stated that the country clusters identified with respect to business process innovation indicators were internally homogeneous, as well as significantly different from one another in view of the internal mean value. The metrics which failed to meet the assumptions of statistical tests constituted a negligible proportion of the comprehensive analysis and had no bearing on the overall conclusions drawn from it.

5. Conclusions

The research material and the application of a specific research methodology resulted in confirmation of the research hypothesis, declaring that countries within the EU can be divided into clusters in terms of service sector innovation activity. The analyses conducted and the data from the Eurostat database led to several important conclusions regarding the service sector in the surveyed countries and enabled the initial goals to be attained. The first objective concerned the possibility of creating homogeneous clusters of the studied countries in terms of innovation activity in the sector to identify those countries that formed particular groups. Cluster analysis using Ward's method and Levene's test of homogeneity made it possible to formulate the first conclusion. It was found that, with respect to service sector innovation activity, the examined EU countries aggregated into clusters. For innovation activity and types of innovation, the indicator-driven composition of the clusters was the same, whereby the cluster with the highest indicator values included Sweden, Denmark, Croatia, Italy and Luxembourg. The group of countries with average innovativeness consisted of Czechia, France, Portugal and Malta, whereas the lowest indicator scores were observed for Hungary, Slovakia, Spain, Poland and Romania. The latter cluster was the least diverse, as these countries made up the cluster with the lowest intraclass means for each indicator set. By way of exception, Hungary was classified into the average innovation level cluster only with respect to product innovation type. In the course of the conducted research, a relationship was observed between the amount of expenditure on innovative activity per service entity and its level in some of these countries. Such a situation occurred in Romania, Hungary, Slovakia, and Poland, where the lowest values of the indicators and, at the same time, the lowest values of expenditures for innovative activities were identified. In the case of the cluster of the best countries, the above-mentioned relationship between inputs and the studied indicators was also noted in the Danish service sector, where expenditure on innovation activities per company was the second highest after France (Decyk, 2023, p. 11-12, 20).

Italy and Croatia always qualified in the group of countries with the highest indicator values. Sweden was also classified into the superior cluster in view of product innovation indicators. Denmark and Portugal were included in that group (together with Italy and Croatia), having scored high for business process innovation. Moreover, Luxembourg also met the requirements of the cluster, though only with regard to innovation activity and the types of innovations introduced.

The studied groups of countries proved to have homogeneous and strong internal structures within the identified clusters of countries by means of Levene's test. Such homogeneity was not observed in only two out of the 15 studied indicators (13.33% of the analysed metrics), specifically in terms of product innovation in the form of goods and business process innovation in the domain of logistics. On these grounds, therefore, one may generally draw another conclusion: that the applied methodology, involving Ward's method with Euclidean distance, agglomeration plots and dendrogrammatic cluster visualisation, made it possible to identify clusters of the EU countries surveyed which were homogeneous in terms of innovation activity in the services sector.

The second specific objective was to test statistically significant differences between the defined clusters of countries. In the course of research, and having applied Student's t-test, it was determined that such differences do occur between the defined clusters of countries. There were only six out of the 51 instances (11.76%) in which the variation between clusters was not statistically significant. This applied to the groups which qualified as top and average in view of the analysed indicators, whilst where product innovation (GIEI, SIEI, MNIEI) was concerned, this situation was observed with clusters I and II. For indicators describing types of business process innovation (MPGS, OWHR and MM), no significant differences were identified between clusters II and III. Given the results of statistical analyses in this respect, it may be generally concluded that statistically significant differences were in evidence between individual clusters of countries in terms of mean values of the examined indicators.

The findings and conclusions of this study show that the adopted research objective, i.e. to identify and assess the degree of homogeneity of the EU countries in terms of service sector innovation activity,

has been accomplished. The exploratory bias of the analyses and the nature of the data yielded information on the service sectors in the surveyed EU countries, which displayed similar levels of innovation activity in light of the indicator sets used in this assessment. Considering the fact that sustainable development is a major theme in the literature, this study appears to have highly valuable practical implications, suggesting directions of collaboration among suitable EU partners in terms of innovation activities in the service sector. In order to ensure sustainable development in Europe, countries from the clusters typified by the lowest level of innovation activity should engage in cooperation with those considered the best in this respect, such as Croatia, Italy or even Denmark and Sweden. Another advantageous option would be to emulate good practices employed by, e.g. Spanish, Romanian, Hungarian or Polish service companies in their innovation activities so as to gradually improve the degree of innovation, compete better in the international arena and become equal to the best.

In the context of the issues raised in the study, certain research limitations should be noted related to the lack of completeness and accessibility to a wide and also highly specific database on innovative activities carried out in other EU countries. However, one should pay attention to the fact that the presented research results are undoubtedly a strong foundation for further in-depth analysis on many levels of the discussed issues of innovation in the service sector. For instance, an attempt to examine the homogeneity and differences of EU countries with regard to particular industries in accordance with the cluster pattern identified here, could supply much more details and represent an extremely valuable addition to this study. Moreover, this research could be elaborated on by comparing the degree of clustering of EU countries over time (at intervals). Third, prospective research may seek to identify and describe the underlying causes of the division of the EU countries into the clusters determined in this study. Preliminarily, it may be assumed that the differences and similarities between the countries are due to, e.g. different levels of expenditure on innovation activities, specific knowledge of products and services, and the varied availability of relevant ICT tools. Yet another compelling avenue for future research may be to develop a hierarchy of countries relative to various parameters of innovation activity in the service sector and to subsequently verify whether this hierarchy reflects the clusters identified in this study.

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