Benchmarking of Clusters in Poland

2024 Edition

General Report

European Funds
for Smart Economy

Fundusze Europejskie dla Nowoczesnej Gospodarki

Rzeczpospolita Polska

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PARP Grupa PFR

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Authoring team

dr Katarzyna Amador Dziedzic
Krzysztof Krystowski
dr Dominika Kuberska
dr hab. Marta Mackiewicz
Magdalena Marciniak-Piotrowska
dr Maciej Piotrowski
dr Rafał Sieradzki
Anna Sokołowska
dorota Thlon
dr Michał Thlon

Reviewer

dr hab. Arkadiusz Michał Kowalski, prof. SGH

Support on the Part of the Polish Agency for Enterprise Development

Monika Antonowicz

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Implementation

Innoreg Sp. z o.o.
ul. Kukuczki 124
35-330 Rzeszów, Poland
NIP 8133700870, REGON 360676879
WWW: www.innoreg.pl
E-mail: biuro@innoreg.pl
Tel: +48 790 694 624

Polish Clusters Association
ul. Kaprys 4A
01-448 Warszawa, Poland
NIP 5223002197, REGON 146405672
WWW: www.klastrypolskie.pl
E-mail: poczta@klastrypolskie.pl
Tel: +48 533 911 904

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1. Introduction

This publication has been prepared as part of the seventh edition of the study titled **"Benchmarking of Clusters in Poland – 2024 Edition"**, undertaken to deepen the understanding of the condition and current stage of development of clusters in Poland. The study was conducted on behalf of the **Polish Agency for Enterprise Development (PARP)**.

Benchmarking is a method for identifying exemplary practices adopted by organisations – both in the private and public sectors – by comparing them with other organisations that serve as reference points. The primary aim of the study was to identify and present the best patterns and good practices observed among the clusters under review, as well as to formulate recommendations regarding desirable directions for their development. These recommendations are addressed to cluster coordinators and other actors forming the cluster ecosystem in Poland, including institutions responsible for shaping national cluster policy. This report constitutes an important contribution to diagnosing the ecosystem and provides a basis for strengthening various aspects of cluster functioning in Poland. The study covered 42 clusters in Poland (listed alphabetically):

- Association of West Pomeranian Chemical Cluster „Green Chemistry"
- Aviation Valley Association
- Baltic Sea & Space Cluster
- Bydgoszcz Industrial Cluster Tool Valley
- Bydgoszcz IT Cluster
- Circular Economy and Recycling Cluster (Waste Management and Recycling Cluster)
- Cluster of Innovative Technologies in Manufacturing CINNOMATECH
- Cluster Polish Nature
- Digital Creative Cluster
- East Automotive Alliance
- Eastern Metalworking Cluster
- Eastern Poland Medical Cluster
- EVOLUMA Industrial Cluster
- Food Cluster of Southern Wielkopolska Association in Kalisz
- ICT Cluster Association West Pomerania
- INTERIZON Pomeranian ICT Cluster
- LifeScience Kraków Cluster
- Lodz ICT Cluster
- LODZistics – Logistics Business Network of Central Poland
- Lower Silesian Automotive Cluster
- Lower Silesian Education Cluster
- Lublin Enterprise Cluster

- Lubuski Metal Cluster
- Mazovia Cluster ICT
- MedSilesia Cluster – the Silesian Network of Medical Devices
- METALIKA Cluster for Industry
- Microelectronics, Electronics and Photonics Cluster (microEPC)
- North – South Logistics and Transport Cluster
- NUTRIBIOMED Cluster
- POLIGEN Plastic Processing Cluster
- Polish Automotive Group Cluster
- Polish Cluster of Composite Technologies
- Polish Construction Cluster
- Polish Cybersecurity Cluster #CyberMadeInPoland
- Radom Metal Cluster
- Silesia Automotive & Advanced Manufacturing
- Silesian Aviation Cluster
- Subcarpathian Tastes Cluster
- Sustainable Infrastructure Cluster
- The Cluster of Tourist Brands of Eastern Poland
- Leszno Printing and Advertising Cluster
- Waste-Cluster

It is noteworthy that the Polish Agency for Enterprise Development was among the first institutions to promote the concept of clustering in Poland and to provide direct support for cluster development. This activity, which began in 2005, lays a solid foundation for PARP's active role in shaping and implementing the key directions of the national cluster policy.

2. Summary

The cluster benchmarking study continues the research series initiated by PARP in 2010. Previous editions took place in 2010, 2012, 2014, 2018, 2021, and 2022. The current 2024 edition report presents the results of a study covering 42 selected clusters in Poland and 733 of their members.

The report summarises the key findings on the state of cluster development during the study period, i.e. 2022–2023, and includes an analysis of good practices as well as recommendations aimed at various stakeholder groups – both cluster coordinators and organisations within the cluster environment, as well as national and regional public administration bodies responsible for shaping cluster policy in Poland. The following section presents selected results of the study.

1. The benchmarking analysis was carried out across five main areas. The research findings in these areas were as follows:
    a. **Cluster resources** – the median value of 0.21 indicates a moderate level of resource development across the surveyed clusters, while the benchmark value of 0.79 reflects the presence of a few highly developed organisations setting the standard. Within the sample, no single cluster consistently achieved high results across most sub-indicators. Among the sub-areas, human resources recorded the highest median value (0.22), whereas infrastructure and financial resources reached the maximum benchmark value (1.00). The low median for infrastructure resources (0.14) shows that at least half of the clusters have limited research, production, or IT infrastructure, or lack such facilities altogether. A similar situation was observed for financial resources, where the median was even lower (0.11), indicating limited financial stability and restricted or no access to financial instruments in at least half of the clusters. The best performance was observed in large clusters with 150 or more members, those holding the National Key Cluster (KKK) status, operating since at least 2009, and having a formally adopted and regularly updated strategy. From a sectoral perspective, there is no clearly defined group of leaders, although clusters representing education and consultancy, food, and tourism sectors achieved relatively weaker results.
    b. **Cluster processes** – the median value remains quite high at 0.44, with a relatively high benchmark of 0.80. The clusters display a fairly balanced level of performance, similar to the previous edition of the study. At least half of the clusters can be rated as good or very good in this area. The best-performing subareas are cluster digitalisation (median 0.78) and management processes (0.65), while the weakest are market activity and marketing activity (0.28).

Besides very large clusters established no later than 2009, large clusters and those founded between 2010 and 2014 also achieve good results. The lowest ratings are observed in education and consulting, food, and tourism clusters.

c. **Cluster results** – the median value of 0.13, combined with a very high benchmark score of 0.90, indicates a significant disparity between the top-performing clusters and the rest of the group. This suggests that about half of the clusters exhibit little or no activity in developing cooperation, innovation, or skills within their networks. Only one cluster can be clearly identified as a leader in this area. Among the sub-areas, skills development achieved the highest median score (0.30), while innovation development within clusters was rated the lowest (0.11). The best and most consistent results were recorded by large and very large clusters. From a sectoral perspective, the strongest group includes clusters operating in chemicals, construction, and the circular economy, whereas the weakest results were observed among clusters from the education and consultancy, food, and tourism sectors.
d. **Impact on the environment** – the median value is moderate (0.30), with a very high benchmark (0.92). The large gap between the median and the benchmark shows significant variation in the development levels of clusters in this area. One cluster stands out as a clear leader. The best-performing subareas are influence on shaping the external environment (median 0.42) and impact on the natural environment (0.38), while the weakest are specialisation and advanced technologies (0.25). From a sectoral perspective, the leading clusters are those representing the chemical industry, construction, circular economy, and the metal, machinery, and materials industry. The least developed group includes clusters active in education and consulting, food, and tourism.
e. **Cluster internationalisation** – the median value is relatively low (0.28), with a fairly high benchmark (0.83). The substantial gap between the median and the benchmark indicates notable variation in development levels. At least half of the clusters achieve very low results in this area. Three clusters can be identified as leaders. The best-performing subarea is exports and pro-export activities (median 0.28), while the weakest is internationalisation potential (0.23). In internationalisation, clusters established between 2003 and 2009 perform slightly better than those founded after 2010. Once again, the poorest outcomes are observed among clusters from education and consulting, food, and tourism.

2. Next, results and conclusions for each of the previously described areas are presented, developed based on partial indicators expressed in actual values.
    a. **Cluster resources.** Compared with the previous benchmarking edition, there has been a slight decline in the number of people employed to manage clusters (1–2 people declared by 11 out of 44 clusters, with an average of 5.2). Among cluster members, 54.4% believe this number is sufficient, while 16.4% hold the opposite view. Academic staff are actively engaged in cluster activities, with a median of 9 researchers collaborating (only three clusters reported no such cooperation). Research infrastructure is provided by 22 clusters (with an average area of 3,700 m² across the entire sample), and 14 clusters reported investments in such infrastructure in 2022–2023. Production infrastructure is available in 18 clusters (average area 49,500 m²), with only 13 clusters investing in this area. Clusters actively use IT platforms, mainly for communication (88%) and as knowledge repositories (57%). Cluster budgets for 2022–2023 varied widely, with an average of PLN 4.1 million and a median of PLN 847,200. Eighteen clusters managed budgets exceeding PLN 1 million, while 11 did not reach PLN 100,000, which represents an improvement compared to the previous survey. Public funding remains one of the main sources of financing (28 clusters declared receipt, with an average value of PLN 5.6 million and a median of PLN 335,600). Providing access to financial instruments plays a minor role in cluster activities; the most common are loan funds and venture capital, each available in 21% of clusters.
    b. **Cluster processes.** Around 69% of clusters have a written and regularly updated strategy, often developed with the active involvement of members (confirmed by 49% of surveyed representatives). Most clusters (93%) have conducted member needs or satisfaction surveys, although only 52% do so regularly. Regular meetings remain a key element of cluster activity, with an average of 24 meetings held annually across the surveyed organisations, showing a slight increase compared to the previous benchmarking edition. Many clusters support various stages of the value chain, particularly marketing and sales (76%) and product and service development or planning (62%). In marketing, common initiatives include creating a cluster logo and brand, as well as engaging in advertising and public relations activities. A total of 33 clusters participated in trade fairs, exhibitions, and other national events to promote their members. In terms of innovation, coordinators actively facilitate access to innovation support services, such as specialised training (86%), innovation consulting (76%), technology audits (60%), and technology trend monitoring (57%). Furthermore, 81% of clusters reported having an institution supporting technology transfer,

while 37% confirmed involvement in knowledge and technology acquisition. Regarding digitalisation, the most widely used tools include IT systems for customer relationship management (CRM), resource management, and document management (each used by 93% of clusters). Among the 13 technologies related to Industry 4.0, the most frequently implemented are IT systems in general (100%), cybersecurity solutions (90%), and digital platforms (86%), indicating an improvement compared to the previous edition of the study.

c. **Cluster results.** This area included, among others, the development of cooperation within clusters. Assessed aspects included joint projects, creating joint offers, and securing joint orders. In 30 clusters, joint projects co-financed with public funds were implemented, a slight decrease from 32 clusters in the previous survey. About 17% of cluster members participated in such projects. The average value of these projects was nearly PLN 27 million, with a median of PLN 700,000. Regarding sales, joint production or service provision was reported in 22 clusters, involving an average of 7 members. Coordinators can also play a role in securing orders; this occurred in 16 clusters. Many of these projects concerned innovation implementation and R&D, reported by 19 clusters with an average of 4 such projects each. These activities contributed significantly to product innovations (22 clusters with implementations), process innovations (17 clusters), and technology transfers (15 clusters). This indicates a deterioration compared with the previous survey. In total, 242 product innovations and 176 process innovations were reported, representing a more than 50% decline compared with the previous edition. Coordinators also support competence development through training, workshops, courses, conferences, seminars, and postgraduate studies (only three clusters did not report such activity). Participation in these initiatives was declared by 60% of members, a rate comparable to the previous edition.

d. **Impact on the environment.** In this area, one of the main aspects assessed was cooperation with the broader environment. A total of 28 clusters reported active agreements with public authorities, with a similar number reporting agreements with business environment institutions and with R&D and education institutions. Clusters most often receive support from public authorities in the form of promotion (57%), financial support (45%), training/educational support (33%), and organisational support (33%). Regarding R&D and education institutions, cooperation most often involves individual researchers (81%). Other forms include joint project implementation (64%) and educational activities (60%). Clusters reported delivering 1,642 internships and 460 student placements – a relatively high result, with more internships and fewer placements than in the previous edition. Representatives of 32 clusters also participate in various advisory or consultative bodies. Many clusters undertake activities with positive societal impacts (e.g. CSR initiatives, support for education, co-organisation of social events, or direct support for local NGOs); such activities were reported by 62% of clusters. Another dimension of environmental impact is activity aimed at improving the natural environment. The most common actions are implementing the circular economy concept (69%), R&D in low-emission technologies (57%), and production/distribution of renewable energy (57%). Finally, specialisation and advanced technologies were assessed. On average, 64.8% of cluster enterprises operate within the National Smart Specialisation (KIS) most relevant to their cluster, while 61% are active within their Regional Smart Specialisation (RIS). A smaller share (33%) operate in the area of Key Enabling Technologies (KET), regarded as fundamental for the EU's future development.

e. **Cluster internationalisation.** Internationalisation is considered a crucial aspect of cluster activities, where initiatives can greatly enhance the situation of cluster members. Thirty-four clusters provided support services in this area, with an average of 5.1 services each. However, only about 22% of members utilised these services. Most clusters (30) maintain at least one foreign-language version of their website, leaving 12 that should consider creating at least an English version. Thirty-one clusters reported having signed cooperation agreements with international partners, averaging 6 per cluster. Slightly more than half of the clusters (23) participated in international projects with foreign partners – a notable decline from the previous edition. The average value of these projects was PLN 9.8 million per cluster, compared to a benchmark of PLN 86 million, highlighting considerable variation in project sizes. Twenty-nine clusters organised international events. Twenty clusters noted members with foreign capital, averaging 11 foreign entities per cluster, mainly in ICT and automotive sectors. Clusters also actively facilitate attendance at international trade fairs, exhibitions, and other events. In total, 29 clusters engaged in such activities, involving 753 members. Additionally, 25 clusters organised inbound missions for visiting foreign clusters.

3. At the level of both research areas and sub-areas, as well as for individual indicators, the advantage was most often held by large or very large clusters with the status of National Key Cluster, established before 2010 or between 2010–2015, and with a written strategy that is regularly updated.
4. In some sub-areas, exceptions to this general rule can be observed, usually of a sectoral nature. For example, ICT clusters gained an advantage in digitalisation, while clusters in

the chemical industry, construction, and the circular economy performed better in external impact.

5. **The number of cluster members** was positively correlated with the average benchmark value. This results from the fact that some indicators measured absolute quantities such as cluster budgets, employment in member organisations, or the number of events organised. Larger clusters thus had an automatic advantage over smaller ones. The exceptions were indicators based on percentages (e.g. the share of members operating in high-tech sectors[1]). Nevertheless, the relationship between membership size and benchmark score is clear – the greater the number of members, the higher the average benchmark score.
6. A vital part of the benchmarking study is analysing the opinions of cluster members. In this edition, a record number of 733 entities participated, representing all 42 analysed clusters. The following section presents selected survey results, focusing on key aspects of participation in a cluster. The complete set of results is included in the discussion of individual sub-areas and the statistical Annexes.

    a. **Perceived benefits of cluster participation.** The survey results show that involvement in cluster structures is generally viewed positively, although some areas still need improvement. More than half of respondents reported tangible benefits from membership (55.3% – significant benefits, 21.8% – minor benefits), while only a small percentage (2.2%) said they receive no benefits. This marks a decline compared to the previous edition of the study, when about 70% of members reported significant benefits. About three-quarters of cluster members rated the coordinators' activities highly for supporting various elements of shared value chains. Regarding market-related activities, the most positively assessed area was integration and relationship-building within the cluster, which received 77 high ratings from members.

    b. **Effects of cluster participation**. The most commonly reported effects of participation include the development of business networks (69.6%) and improved cooperation (64.2%), confirming that clusters play an important integrative role and support new business and research relationships. A significant proportion of respondents also highlighted joint marketing efforts and increased opportunities for product distribution (49.7%) as key outcomes. For 42.5% of cluster members, participation led to access to both material and non-material resources, while 36.9% reported a rise in the number of innovations introduced. Nearly half of the respondents (48.5%) stated that their involvement

[1] For clarity in the following analysis and charts, whenever the report mentions high and medium-high technologies, this should also include knowledge-intensive services.

in a cluster enabled them to gain new clients and enter new markets, which emphasises the contribution of cluster cooperation to business growth and competitiveness.

c. **Innovation activity**. The study indicates a moderate level of engagement in innovation and R&D projects: only 40% of cluster members participated in cluster-led projects, and of these, 49.7% were innovation or R&D initiatives. The proportion of companies implementing innovations due to their cluster participation remains relatively low – 25.5% introduced product innovations and 29.8% adopted process innovations, while 44.7% reported no innovation activity at all. However, there is a rising interest in innovation- and development-oriented services, especially training (46% have already participated, with a further 47.5% intending to do so), as well as technological consulting and support for digital and green transformation. These findings emphasise the need to further broaden the range of services that enhance innovation capacity and promote the modernisation of enterprises within clusters.
d. **Internationalisation**. Cluster members express a strong demand for increased support in internationalisation. While 30.9% of respondents have utilised the services offered, as many as 69.1% reported that such services were either unavailable or that they chose not to use them. Participation in clusters has nonetheless facilitated international engagement, with approximately 37% of members establishing business relationships with foreign partners. Looking ahead, members place particular importance on activities such as participation in international trade fairs (average score: 4.8) and foreign business missions (4.7), as well as initiating international projects (4.6) – all rated on a five-point scale where 1 indicates no interest and 5 a strong willingness to engage. From the members' perspective, the key development priorities are integration and relationship building, cooperation with external partners, marketing activity, and skills development (each rated at 4.6). These findings demonstrate that members value the potential of clusters as platforms for collaboration and internationalisation but expect a more comprehensive and better-tailored range of services to support their technological progress and market expansion.

7. An important part of the study is the analysis of **inter-cluster cooperation** in Poland, developed as an additional element of the benchmarking project at the contractor's initiative and not included in the Terms of Reference. The purpose of this analysis was to demonstrate the role of cooperation between clusters in the context of increasingly complex value chains. The findings indicate that, beyond their role as local innovation hubs, clusters are becoming part of broader national networks. Cooperation between clusters, both within specific sectors and across industries, helps to combine

complementary competences, develop joint R&D projects, achieve scale effects, and strengthen economic resilience. Benchmarking results reveal that 62% of the surveyed clusters maintain active cooperation agreements, although these are mainly bilateral and limited in scope. Examples of more advanced collaboration include the Forum of Polish Automotive Clusters, the Council of Medical Clusters, and the Polish Construction Cluster's partnerships with ICT, circular economy, and composite material clusters. Clusters are also active in public policy initiatives such as Sectoral Skills Councils, regional Smart Specialisation Strategies (RIS3), and Entrepreneurial Discovery Processes (EDP). The results confirm the growing strategic maturity of Polish clusters and their increasing understanding of the importance of network-based collaboration, although there remains room to deepen such cooperation. The main challenges continue to be financial stability and the absence of national instruments supporting long-term partnerships.

8. The chapter analysing **cluster resilience** illustrates how clusters enhance the ability of enterprises to survive and adapt amid economic, technological, and geopolitical uncertainties. The analysis identifies several key factors that foster resilience: strong cooperation and trust among members, effective exchange of information and innovation, diversification of funding sources, and the adoption of development strategies that incorporate digital and green transformations. The vast majority of surveyed clusters (34 out of 42) reported an increase in membership, demonstrating their stability and attractiveness during periods of economic turbulence. Simultaneously, the analysis highlights areas for improvement – about 31% of clusters do not have regularly updated development strategies, while the low median values for financial (0.11) and infrastructure resources (0.14) confirm limited capacity to sustain operational continuity in the long term. A relatively low level of internationalisation and a limited number of agreements with R&D institutions also restrict access to diverse sources of knowledge and support. On a positive note, there is a rising number of initiatives aimed at strengthening resilience, such as Resilience 2030, implemented by the Silesia Automotive & Advanced Manufacturing cluster. As clusters continue to expand their critical mass – measured by the number of members and employment levels – and further develop organisational maturity and risk management practices, they possess the potential to become one of the key pillars of economic resilience in the years ahead.
9. **Strengths and weaknesses of clusters.** The assessment of clusters' strengths and weaknesses was based on the median score values obtained by the clusters in individual sub-areas. Elements where the median score for the group of clusters exceeded 0.30 were identified as strengths, while those with a median not exceeding 0.20 were considered weaknesses. Analysis of the results shows that the number of strengths

surpasses the weaknesses, which are mainly related to resources, collaboration development, and innovation within clusters.

Table 1. Strengths and weaknesses of the clusters studied (median values in brackets)

Strengths of clusters	Weaknesses of clusters
Digitalisation of the cluster (0.78)	Development of cooperation in the cluster (0.15)
Managerial processes (0.65)	Infrastructural resources (0.14)
Influence on shaping external conditions (0.42)	Financial resources (0.11)
Impact on the natural environment (0.38)	Development of innovation in the cluster (0.11)
Collaboration in the cluster (0.35)	
Innovation activity (0.34)	
Development of competences in the cluster (0.30)	

Source: own elaboration based on the cluster coordinators' survey (N = 42).

10. The study identified over forty good practices implemented by domestic clusters and about a dozen in the case of international structures. According to the methodology, 13 domestic and 3 international good practices were selected and described in detail. For each practice, a key area was indicated, along with other related areas. It is worth emphasising that most of the good practices are interdisciplinary, affecting various dimensions of cluster activities (e.g. cooperation with the external environment, intra-cluster collaboration, or innovation-related activity).
11. The report concludes with a set of recommendations directed at various stakeholders within the cluster ecosystem, including national and regional authorities, cluster coordinators, business support institutions, universities, and innovation centres. These recommendations were developed based on benchmarking results, qualitative analyses, and the identification of good practices from both Poland and abroad, considering current trends in EU and national policies. Their main aim is to outline actions that will strengthen the potential of Polish clusters, improve their resilience, and boost their contribution to achieving green and digital transformation goals. The proposed measures are organised thematically across areas such as cluster policy and financing, cluster development, cooperation and knowledge exchange, R&D and innovation activities, incubation, digitalisation, artificial intelligence, green transformation, internationalisation, and the development of skills and human capital.

3. Methodological introduction

3.1. Research methodology

Benchmarking is a method used to identify exemplary organisational practices in both the private and public sectors by comparing them with other organisations serving as reference points. The main aim of the study is to identify and showcase the best patterns and good practices observed among the clusters examined, as well as to formulate recommendations for desirable directions for cluster development, directed among others to cluster organisers and institutions responsible for shaping cluster policy in Poland. This, in turn, provides a foundation for enhancing various aspects of cluster functioning in Poland.

The core assumption behind the cluster benchmarking concept was to conduct a relatively comprehensive and cross-sectional analysis of clusters. Therefore, the logic and structure of the entire study were based on two essential elements:

- **Cluster characteristics** – a set of key cluster attributes used, among other purposes, to perform cross-sectional analyses within the benchmarking framework (e.g. comparing clusters by age, size, location, or sectoral specialisation). The areas of cluster characteristics identified in the study include: their formalisation, size, geographical concentration, and sectoral concentration and specialisation. (including classification according to PKD[2], KIS[3] and RIS[4]);
- **Cluster benchmarking** – A comparison of the development stages of clusters across various functional areas, accompanied by the presentation of good practices implemented by clusters. Within the chosen methodology, the analysis was segmented into five main benchmarking areas and 19 detailed sub-areas.

In the seventh edition of the benchmarking study, **42 clusters from across Poland took part**. The project was conducted from January to November 2025, and the reported data covered cluster activities during 2022–2023. As part of the project:

- **A desk research analysis** was conducted, involving the compilation and synthesis of secondary data from reports, academic publications, studies by national and EU institutions, and online sources (including cluster websites). This analysis played a key role in chapters addressing, among others, cluster resilience, inter-cluster cooperation, and the review of good practices in cluster functioning.
- **Data were collected from 42 cluster coordinators** participating in the benchmarking. The survey was conducted using the CAWI method (Computer-Assisted Web Interview),

[2] Polish Classification of Activities (equivalent to NACE Rev. 2).

[3] National Smart Specialisations.

[4] Regional Smart Specialisations.

with telephone contact in some cases to resolve inconsistencies or gather missing information. The research questionnaire was aligned with the assumptions and structure outlined in the project’s Terms of Reference (OPZ). Using the same set of indicators as in the previous edition ensured full comparability of results at the level of detailed indicators, thereby enabling the analysis of changes over time across different areas of cluster functioning.

- **A survey of 733 cluster members** participating in the study was conducted using CAWI and, complementarily, CATI (Computer-Assisted Telephone Interview). For each cluster, at least five questionnaires were collected (a complete set of results is presented in the statistical annex in Appendix 12.3).
- Based on data gathered from desk research and in-depth individual interviews, **good practices of thirteen Polish clusters and three foreign clusters were developed** (described in Chapter 8).
- **A general report** and **42 individual reports** (one for each participating cluster) were prepared.
- As an additional component of the study specified in the bid, 42 accessibility audits of cluster websites were conducted. The audits evaluated the websites' compliance with selected criteria from WCAG 2.1 (Web Content Accessibility Guidelines 2.1). Since this component did not directly follow from the Terms of Reference (OPZ), a consolidated summary of the audit results is provided in Appendix 11.2 of the general report.

The opinions of cluster members were used to evaluate the perceived benefits and satisfaction related to cluster membership, and served to confirm and validate the data obtained from the cluster coordinators’ survey. The data collected during interviews with cluster coordinators were verified by the researchers and supplemented with information gathered through desk research.

In total, **90 indicators** relating to cluster functioning were analysed, forming the basis for assessing the state and level of cluster development in Poland for the period covered by the study (a complete set of partial indicator values is presented in the statistical annex in Appendix 12.1). The set of examined areas and sub-areas is presented in the table below.

Table 2. Overview of the benchmarking areas and sub-areas along with the number of indicators

Benchmarking area	Benchmarking sub-area	Number of indicators
I. Cluster resources	I.1. Human resources	4
	I.2. Infrastructure resources	6
	I.3. Financial resources	4
II. Cluster processes	II.1. Management processes	5
	II.2. Cluster communication	2
	II.3. Market activity	5
	II.4. Marketing activity	5
	II.5. Innovation activity	5
	II.6. Cluster digitalisation	2
III. Cluster results	III.1. Development of collaboration in the cluster	10
	III.2. Development of innovation in the cluster	7
	III.3. Development of competences in the cluster	3
IV. Cluster impact on the environment	IV.1. Cooperation with the external environment	8
	IV.2. Influence on shaping external conditions	3
	IV.3. Impact on the natural environment	1
	IV.4. Specialisation and advanced technologies	4
V. Cluster internationalisation	V.1. Internationalisation potential	3
	V.2. International activities	6
	V.3. Export and export-oriented activities	7

Source: Cluster benchmarking methodology – 2024 edition.

The data needed to estimate the values of 88 indicators were collected through a survey conducted among cluster coordinators. The estimation of 2 indicators was based on the

Contractor's desk research (the number of language versions of the cluster's website and the number of search engine results for the phrase "cluster name").

Within the benchmarking exercise, a series of analyses was carried out, taking into account the levels of **partial indicators** and **synthetic indicators** (at the sub-area, area, and overall levels). At the data analysis stage, the partial indicators were **normalised** using the min–max method[5], enabling their aggregation to the aforementioned levels. The aggregation of partial indicators was carried out in multiple stages, following the methodology outlined in the Tor. In the first stage, the normalised values of the partial indicators were averaged within each sub-area, creating the so-called sub-synthetic indicators. In the subsequent stage, the mean values of the sub-synthetic indicators were calculated, producing synthetic indicators for the five main benchmarking areas. Lastly, the arithmetic mean of these synthetic indicators determined each cluster's overall benchmarking result.

The analysis of the resulting partial, sub-synthetic, and synthetic indicators used the following measures:

- **Mean** – the arithmetic average of indicator values within a given area;
- **Median** – divides clusters into two equal groups in terms of size (lower-performing and higher-performing for a given area);
- **Benchmark** – the value of the indicator for the best-performing cluster in a given area.

Within these indicators, various combinations of values may occur. Of particular interest for analysing cluster-related phenomena are:

- **Low median value** (close to 0) – at least half of the clusters achieved very weak results compared with the others;
- **High benchmark value** (close to 1) – one or a small group of clusters achieved a very high position, clearly outperforming the rest;
- **Median close to half of the benchmark value** – the level of cluster development across a given area or sub-area is relatively evenly distributed (there is neither a clear group of leaders nor a group of very weak clusters).

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[5] The purpose of normalisation is to obtain variables with a standardised range of variation, traditionally defined by the difference between their maximum and minimum values. However, it should be noted that the study includes several indicators where the benchmark (the highest recorded value) is an extreme value. Such extreme values can substantially inflate the mean and cause a concentration of unitised variables in the lower range of 0–0.1. This results in a dominant single cluster or a few clusters, while decreasing differences within the remaining groups (weak, average, strong). Since most variable distributions are skewed towards the lower end of the scale, extreme values were trimmed using the first and third quartiles (Q1 and Q3) and the interquartile range (IQR). In this approach, the maximum value (upper cut-off) is set at Q3 + 1.5 IQR. Although the value 1.5 IQR is considered conventional, it remains widely used in statistical and econometric literature..

The study included analyses of the entire population of clusters as well as for specific groups. The report presents analyses across the following cross-sections:

- **Cluster status:** either holding the status of Key National Cluster (Krajowy Klaster Kluczowy, KKK), planning to apply for the status, or not holding the status with no plans to apply.
- **Cluster size:** small clusters (20–49 members), medium clusters (50–79 members), large clusters (80–149 members) and very large clusters (150 members or more).
- **Cluster age**: mature clusters (established before 2010), clusters established between 2010–2014, and clusters established between 2015–2020.
- **Existence of a cluster strategy:** no documented cluster strategy; a documented strategy exists but is not kept up to date; a documented strategy exists and is regularly reviewed.
- **Sector:** the clusters studied were divided into six sectors:
    - Biotechnology and medicine;
    - Chemical industry, construction and circular economy;
    - Education and consulting, food, tourism;
    - ICT (information technology, electronics, digital technologies, cybersecurity);
    - Automotive, aerospace, transport;
    - Metal, machinery and materials industry.

Finally, it is important to note that directly comparing the current benchmarking results with the previous edition is not entirely possible because of the different composition of clusters included (32 out of 42 clusters in the present edition also participated in the previous one).

3.2. Cluster selection

The criteria listed below were used when choosing clusters for the study:

- The cluster must have a legal form and be actively operating for at least three years;
- The cluster must possess an appropriate critical mass (minimum 20 cluster members);
- The cluster must have a defined organisational structure (formalised cooperation between its constituent entities);
- The cluster demonstrated a geographical concentration of most of its members, meaning that more than half of the cluster members were located no more than 200 km from the cluster coordinator’s registered office;
- The sample included clusters representing different sectors of the economy.

Efforts were also made to ensure that the sample included clusters from each voivodeship (based on the location of the coordinator’s registered office); however, this was not possible in the case of the Opolskie, Świętokrzyskie, and Warmińsko-Mazurskie Voivodeships due to the absence of structures meeting the qualifying criteria. A similar situation occurred in the previous edition of the study.

To summarise the recruitment process: from a consolidated database of approximately 70 active clusters[6], some were excluded for failing to meet the above criteria or for a lack of demonstrable activity. From the final list of approximately 60 clusters meeting the requirements, 42 clusters participated in the study, reflecting characteristics of the cluster landscape in Poland. The study included both clusters holding the status of Key National Cluster (17 as of July 2025) and those without this status (25). The surveyed clusters varied in terms of years of operation, critical mass and sectoral specialisation. The table below summarises the characteristics of the entities taking part in the benchmarking exercise.

Table 3. Characteristics of clusters participating in the benchmarking

No.	Cluster name	Established year	Members	Dominant sector (by NACE section)	Coordinator headquarters (region)
1.	Association of West Pomeranian Chemical Cluster “ Green Chemistry”	2007	231	20 – Manufacture of chemicals and chemical products	West Pomeranian
2.	Aviation Valley Association	2003	195	30 – Manufacture of other transport equipment	Subcarpathian
3.	Baltic Sea & Space Cluster	2009	48	50 – Water transport	Pomeranian
4.	Bydgoszcz Industrial Cluster Tool Valley	2006	144	22 – Manufacture of rubber and plastic products	Kuyavian-Pomeranian
5.	Bydgoszcz IT Cluster	2013	40	62 – Computer programming, consultancy and related activities	Kuyavian-Pomeranian
6.	Circular Economy and Recycling Cluster (Waste Management and Recycling Cluster)	2012	154	38 – Materials recovery	Mazovian
7.	Cluster of Innovative Technologies in Manufacturing CINNOMATECH	2012	128	28 – Manufacture of machinery and equipment n.e.c.	Lower Silesian
8.	Cluster Polish Nature	2016	137	01 – Crop and animal production, hunting and related service activities	Mazowieckie
9.	Digital Creative Cluster	2007	54	66 – Activities auxiliary to financial services and insurance activities	Mazowieckie

[6] The consolidated database was created on the basis of data from previous editions of the benchmarking study and other sources of information on clusters (e.g. regional cluster databases). It is worth noting that in the previous edition of the study the initial list comprised approximately 200 clusters, while active status was confirmed for around 80 of them. The database was supplemented with relatively new clusters, although most of these were not eligible to participate in the study due to not meeting the criterion concerning the cluster’s date of establishment.

No.	Cluster name	Established year	Members	Dominant sector (by NACE section)	Coordinator headquarters (region)
10.	East Automotive Alliance	2015	38	29 – Manufacture of motor vehicles, trailers and semi-trailers (excluding motorcycles)	Podkarpackie
11.	Eastern Metalworking Cluster	2009	78	25 – Manufacture of fabricated metal products, except machinery and equipment	Lublin Region
12.	Eastern Poland Medical Cluster	2008	67	86 – Human health activities	Podlaskie
13.	EVOLUMA Industrial Cluster	2007	166	94 – Activities of membership organisations	Podlaskie
14.	Food Cluster of Southern Wielkopolska Association in Kalisz	2009	56	10 – Manufacture of food products	Greater Poland
15.	ICT Cluster Association West Pomerania	2011	78	62 – Computer programming, consultancy and related activities	West Pomeranian
16.	INTERIZON Pomeranian ICT Cluster	2009	102	62 – Computer programming, consultancy and related activities	Pomeranian
17.	Leszno Printing and Advertising Cluster	2007	20	18 – Printing and reproduction of recorded media	Greater Poland
18.	LifeScience Kraków Cluster	2006	152	86 – Human health activities	Małopolskie
19.	Lodz ICT Cluster	2012	49	62 – Computer programming, consultancy and related activities	Łódź Region
20.	LODZistics – Logistics Business Network of Central Poland	2016	40	52 – Warehousing and support activities for transportation	Łódź Region
21.	Lower Silesian Automotive Cluster	2014	60	29 – Manufacture of motor vehicles, trailers and semi-trailers (excluding motorcycles)	Lower Silesian
22.	Lower Silesian Education Cluster	2015	225	85 – Education	Lower Silesian
23.	Lublin Enterprise Cluster	2008	25	41 – Construction of buildings	Lublin Region
24.	Lubuski Metal Cluster	2008	67	28 – Manufacture of machinery and equipment n.e.c.	Lubuskie
25.	Mazovia Cluster ICT	2007	457	62 – Computer programming, consultancy and related activities	Mazowieckie
26.	MedSilesia Cluster – the Silesian Network of Medical Devices	2007	125	32 – Other manufacturing	Silesian
27.	METALIKA Cluster for Industry	2011	51	25 – Manufacture of fabricated metal products, except machinery and equipment	West Pomeranian

No.	Cluster name	Established year	Members	Dominant sector (by NACE section)	Coordinator headquarters (region)
28.	Microelectronics, Electronics and Photonics Cluster (microEPC)	2023	74	26 – Manufacture of computer, electronic and optical products	Mazowieckie
29.	North – South Logistics and Transport Cluster	2012	202	52 – Warehousing and support activities for transportation	Pomeranian
30.	NUTRIBIOMED Cluster	2007	148	74 – Other professional, scientific and technical activities	Lower Silesian
31.	POLIGEN Plastic Processing Cluster	2011	37	22 – Manufacture of rubber and plastic products	Podkarpackie
32.	Polish Automotive Group Cluster	2016	95	29 – Manufacture of motor vehicles, trailers and semi-trailers (excluding motorcycles)	Podkarpackie
33.	Polish Cluster of Composite Technologies	2017	123	22 – Manufacture of rubber and plastic products	Małopolskie
34.	Polish Construction Cluster	2011	501	41 – Construction of buildings	Podlaskie
35.	Polish Cybersecurity Cluster #CyberMadeInPoland	2020	57	62 – Computer programming, consultancy and related activities	Małopolskie
36.	Radom Metal Cluster	2011	42	25 – Manufacture of fabricated metal products, except machinery and equipment	Mazowieckie
37.	Silesia Automotive & Advanced Manufacturing	2011	215	29 – Manufacture of motor vehicles, trailers and semi-trailers (excluding motorcycles)	Silesian
38.	Silesian Aviation Cluster	2006	117	52 – Warehousing and support activities for transportation	Silesian
39.	Subcarpathian Tastes Cluster	2013	51	10 – Manufacture of food products	Podkarpackie
40.	Sustainable Infrastructure Cluster	2011	145	41 – Construction of buildings	Małopolskie
41.	The Cluster of Tourist Brands of Eastern Poland	2012	37	93 – Sports activities and amusement and recreation activities	Podlaskie
42.	Waste-Cluster	2012	111	06 – Extraction of crude petroleum and natural gas	Greater Poland

Source: own elaboration based on the cluster coordinators' survey (N = 42).

3.3. Sample characteristics

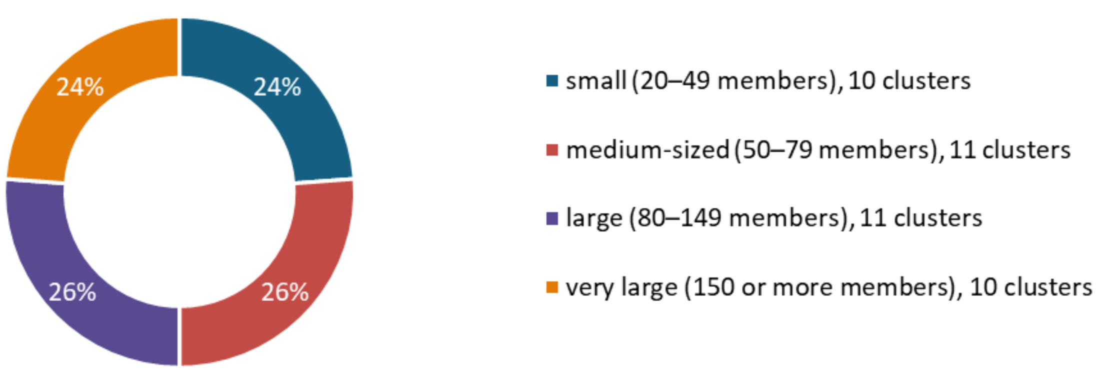
Considering the year of establishment, the study was dominated by clusters founded before 2010 (18 clusters) and during the period 2010–2014 (16 clusters). This timeframe coincided with the 2007–2014 EU financial perspective, during which instruments supporting the creation of clusters were available in Poland. Only eight clusters established between 2015 and 2020 participated in the study. At the recruitment stage, a group of about ten newly created clusters (established after 2020) was identified; however, most of them did not meet the criteria concerning years of operation and minimum membership, and therefore did not take part in the study.

Figure 1. Characteristics of clusters participating in the benchmarking – year of establishment

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Considering the number of members, the cluster population was divided into four size groups of similar scale: small clusters with 20–49 members (10 clusters), medium-sized clusters with 50–79 members (11), large clusters with 80–149 members (11), and very large clusters with 150 or more members. The average number of members across the surveyed clusters was 117.7, compared to 102.6 in the previous edition of the study.

Figure 2. Characteristics of clusters participating in the benchmarking – number of members



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The largest clusters by membership at the time of the study included the Polish Construction Cluster (501 members), the Mazovian ICT Cluster (457), and the West Pomeranian Chemical Cluster “Green Chemistry” Association (231). It is noteworthy that nearly all clusters in the “very large” category held the KKK status. Among clusters with more than 100 members, only the following did not hold this status.

- Lower Silesian Education Cluster (225 members);
- North-South Logistics and Transport Cluster (202 members);
- Polska Natura Cluster (137 members);
- Waste-Cluster (111 members).

It is worth noting that the above clusters operate within broadly defined service sectors. One might assume that it is relatively easier to establish a cluster with many members in the service domain, which, however, may not necessarily meet all the requirements for obtaining KKK status.

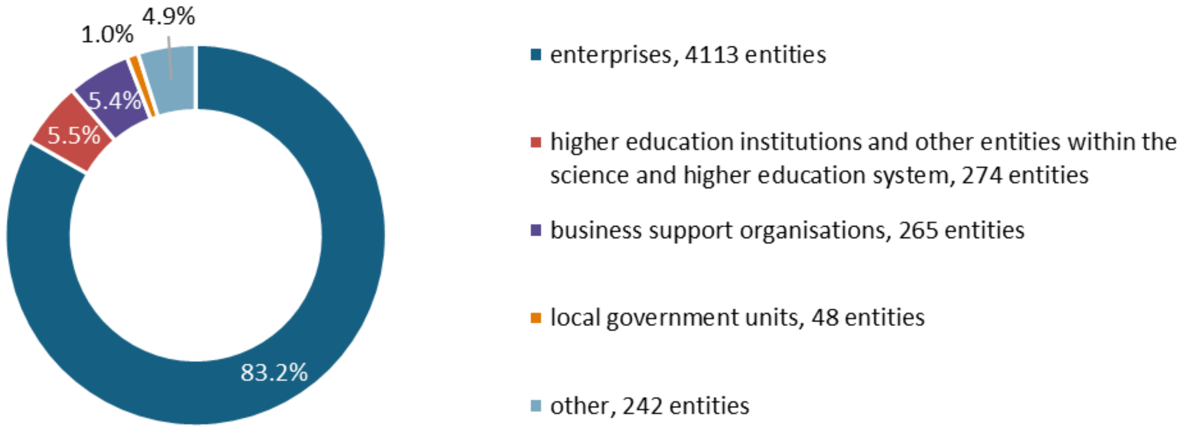
The total number of members across all surveyed clusters, based on declarations submitted, reached 4,942 at the end of the study period (a 17.4% increase compared to the previous edition). The number of unique entities was about 5% lower, as some belonged to more than one cluster. This was especially true for business support institutions, universities, and other entities within the higher education and science system.

During the benchmarking period (i.e., 2022–2023), an increase in membership was observed compared to the previous study period (2020–2021). Overall, the clusters participating in the benchmarking exercise reported admitting 969 new members. During the same period, resignations amounted to 312.

The composition of cluster membership was mainly made up of enterprises (83.2%), followed – at similar levels – by universities and other entities within the higher education and science system (5.5%), business support organisations (5.4%), and the category “other”, which includes educational institutions, healthcare organisations, NGO sector organisations, and individuals (4.9%). Local government units (LGUs) had a much smaller presence in clusters (1.0%).

Overall, the surveyed clusters included 4,113 enterprises (an increase of 579 compared to the 2022 edition), 274 universities and higher education and science entities (an increase of 37), 265 business support institutions (an increase of 83), and 48 local government units (an increase of 8).

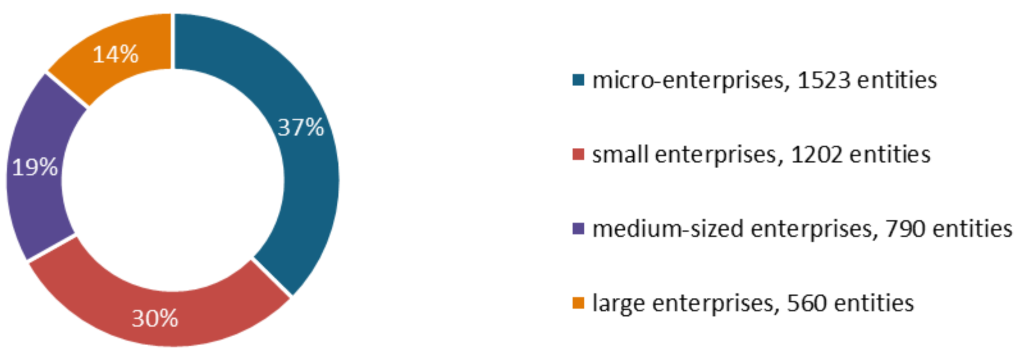
Figure 3. Characteristics of clusters participating in the benchmarking – types of entities



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The structure of enterprises in the surveyed clusters was also analysed based on their size. The largest group consisted of micro-enterprises (37%), followed by small enterprises (30%). No significant changes were observed in this respect compared to the previous edition of the study. It is worth noting the relatively high proportion of medium-sized and large enterprises (19% and 14% respectively). The participation of medium-sized and large entities in clusters was significantly higher than their share among all registered enterprises in the country[7].

Figure 4. Characteristics of clusters participating in the benchmarking – structure of members (enterprises)[8]



Source: own elaboration based on the cluster coordinators' survey (N = 42).

[7] According to Statistics Poland (GUS), as at the end of 2024, medium-sized enterprises accounted for 0.54% of all firms in the country, while large enterprises represented 0.08%.

[8] The total number of enterprises shown in the figure, broken down by size category, does not equal the overall number of enterprises, as detailed data in this regard were not obtained for one of the clusters.

Despite their relatively small numbers, business support institutions play a significant role within clusters (and this group experienced a notable increase in membership compared to the 2022 edition). They may perform various functions. In some clusters, they act as coordinators – especially regional development agencies and advisory institutions. Additionally, they can support multiple areas of cluster activity, particularly in education, technological consultancy, and project engineering, assisting with project implementation throughout the entire lifecycle, from securing funding and providing implementation support to financial and technical settlement.

Business support institutions represented in clusters may vary in their level of development and the quality of services provided. An important indicator of a strong position for a particular unit is its status as an accredited innovation centre (formerly granted by the Ministry of Economic Development and Technology), or its designation as a Digital Innovation Hub (DIH), a European Digital Innovation Hub (EDIH), or an EDIH candidate.

Innovation centres include entities involved in technology transfer, the provision of pro-innovation services, and cooperation with businesses. Their activities aim to support the development of innovation in both product and process aspects. The competition for the status of accredited innovation centre is announced by the minister responsible for the economy (according to the ministry's website, the next call is scheduled for September 2025).

Determining whether an accredited innovation centre exists within a cluster can be challenging. Innovation centres – especially regional development agencies – often have extensive organisational structures. Frequently, the cluster member is not the entire innovation centre but rather one of its organisational units or a subsidiary entity. Based on responses from cluster coordinators, 12 clusters were identified as including such entities (compared with 10 structures in the previous edition).

It is also worth noting that, until recently, having an accredited innovation centre among cluster members was one of the scored criteria in the substantive assessment phase of the call for KKK designation[9].

[9] According to the competition documents from the KKK call announced on 24 December 2024, https://www.gov.pl/web/rozwoj-technologia/6-runda-konkursowa [accessed: 09.09.2025].

Figure 5. Characteristics of clusters participating in the benchmarking – presence of an accredited innovation centre among members

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Members of clusters, often business support institutions, may also hold the status of Digital Innovation Hubs (DIH, EDIH, or EDIH candidate). Their role is to act as a bridge between entities that generate demand for digital transformation services – such as entrepreneurs and public administration bodies whose activities could benefit from digital transformation – and those providing supply, including providers of ready-to-deploy technologies, organisations delivering educational, training, and support services, and start-ups.

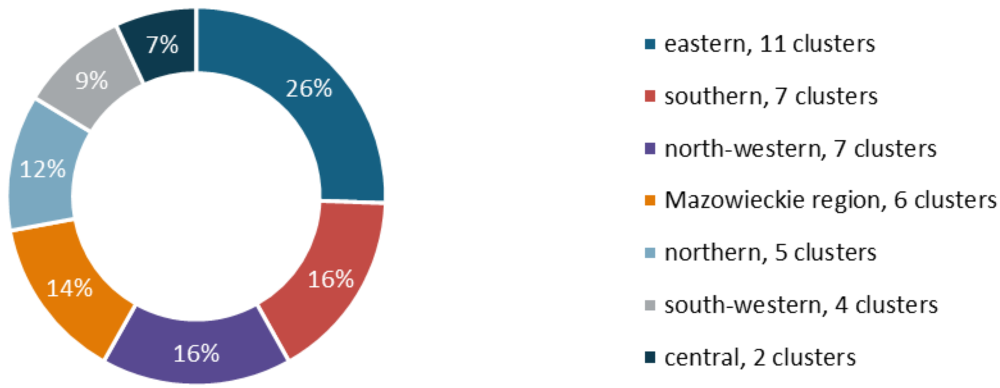
It is worth noting that the participation of organisations with DIH, EDIH, or EDIH candidate status among the members of clusters involved in the benchmarking exercise was relatively high (16 clusters confirmed the presence of such entities). This marks a notable increase compared with the previous edition of the study, in which only six clusters included such organisations.

Figure 6. Characteristics of clusters participating in the benchmarking – presence of at least one DIH, EDIH or EDIH candidate among members

Source: own elaboration based on the cluster coordinators' survey (N = 42).

A regional breakdown was also considered in the study. Among macro-regions, the Eastern macro-region was the most represented (11 clusters), followed by the Southern and North-Western macro-regions (7 clusters each)[10].

Figure 7. Characteristics of clusters participating in the benchmarking – location of the coordinator's office by macro-region

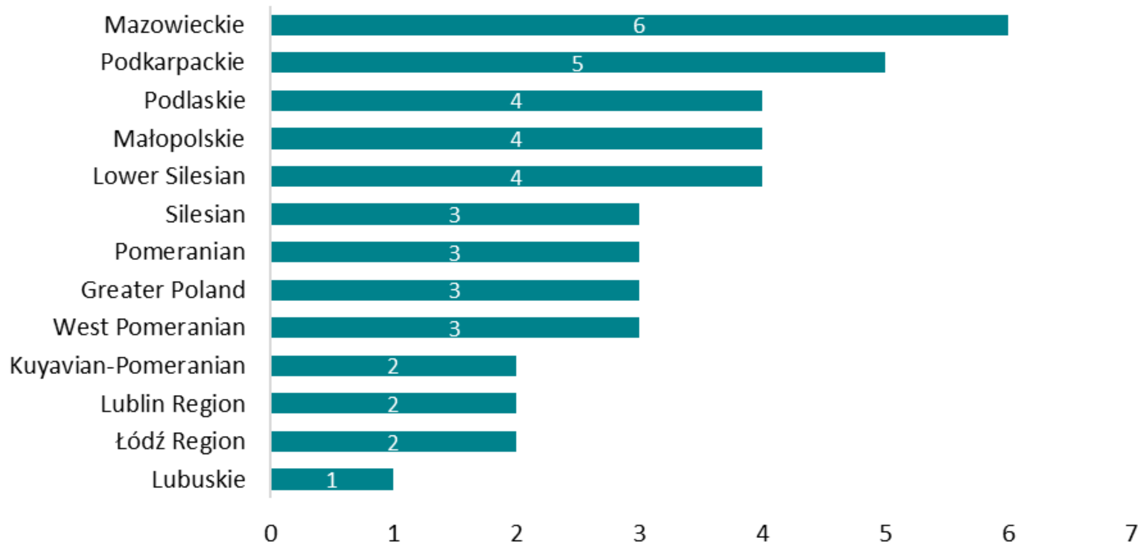


Source: own elaboration based on the cluster coordinators' survey (N = 42).

It is worth examining the geographical distribution of clusters by region. During the study, efforts were made to include clusters from all parts of Poland. However, some regions show low cluster activity; as a result, three regions were not represented in the benchmarking project (**Warmian-Masurian**, **Świętokrzyskie** and **Opole**). The most heavily represented regions were Mazovian (6 clusters), Subcarpathian (5 clusters), and Lower Silesian, Lesser Poland, and Podlaskie (4 clusters each).

[10] The division into macro-regions follows the NUTS 1 classification of regions used by Statistics Poland (GUS), https://stat.gov.pl/statystyka-regionalna/jednostki-terytorialne/klasyfikacja-nuts/klasyfikacja-nuts-w-polsce [accessed: 06.09.2025].

Figure 8. Characteristics of clusters participating in the benchmarking – location of the cluster coordinator's office by regions

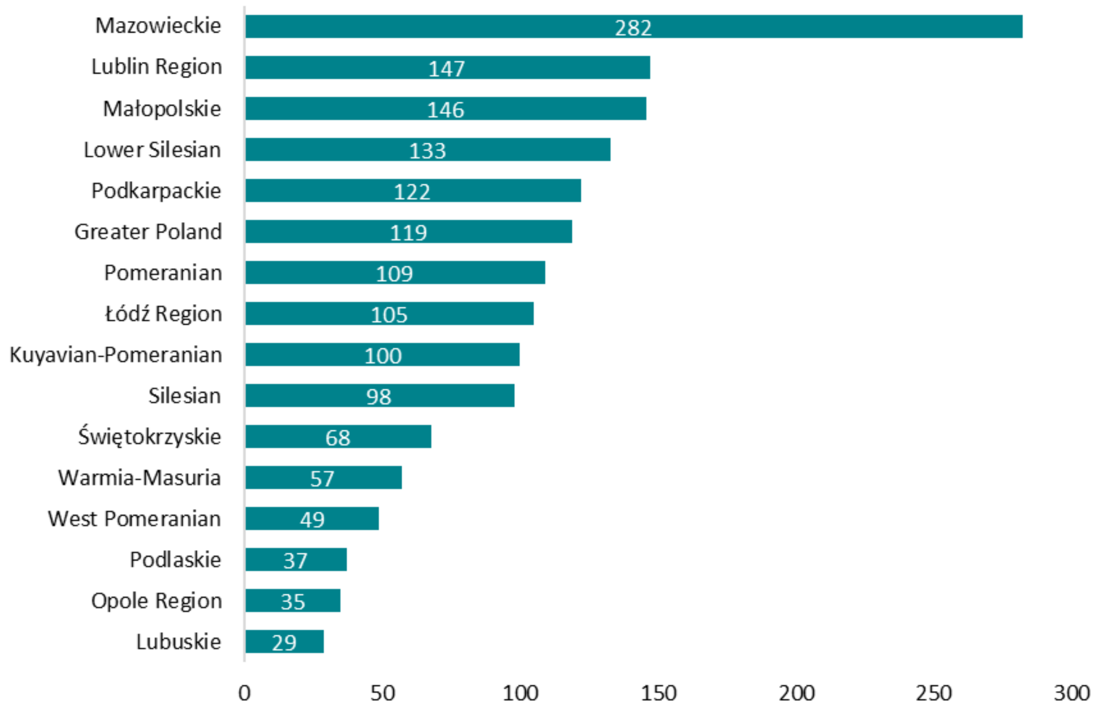


Source: own elaboration based on the cluster coordinators' survey (N = 42).

The surveyed clusters are characterised by a high degree of geographical concentration. On average, 66.3% of members are based in the region where the coordinator is located (with a median of 72.8%). Compared to the previous edition, a gradual dispersion of cluster members can be observed (although this remains moderate). Clusters with a relatively low level of concentration include those with a large or very large number of members (80 or more) as well as clusters with a narrow technological specialisation (e.g. photonics, composite technologies, cybersecurity, creative technologies, biotechnology). In the latter case, clusters bring together leading centres developing a given technology from across the country.

Among cluster members from outside the coordinator's region, the most represented are entities from Mazowieckie (282), followed by Lublin (147), Małopolska (146), and Lower Silesian regions (133). It is notable that the list also includes entities from Świętokrzyskie (68), Warmia-Masuria (57), and Opole regions (35), despite the lack of clusters from these areas in the benchmarking exercise. This suggests potential for developing cluster initiatives in these regions.

Figure 9. Characteristics of clusters participating in the benchmarking – number of members from a region other than the cluster coordinator's seat



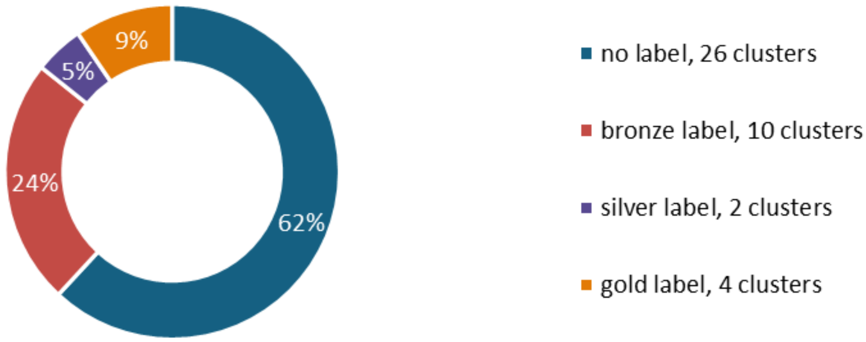
Source: own elaboration based on the cluster coordinators' survey (N = 42).

Only four clusters included foreign entities among their members, and their number was marginal compared to the total membership base. The countries represented among the foreign members of Polish clusters included, among others, Ireland, the United Kingdom, and Switzerland.

Fewer than half of the surveyed clusters (16) held a European Clusters Excellence Labelling Structure (EUCLES)[11] label during the study period. this figure closely resembles that recorded in the previous edition of the study. During the preparation of this report, these data were verified, revealing an unfavourable trend whereby clusters have been failing to renew their existing badges. Currently (as of September 2025), 33 clusters participating in the study do not hold a certificate; a further three hold the Bronze label, two hold the Silver label, and four hold the Gold label.

[11] The European Clusters Excellence Labelling Structure (EUCLES) — a private entity independent of the European Commission — has taken over responsibility for the cluster labelling system previously managed by the European Secretariat for Cluster Analysis (ESCA).

Figure 10. Characteristics of clusters participating in the benchmarking – possession of the EUCLES quality label during the study period



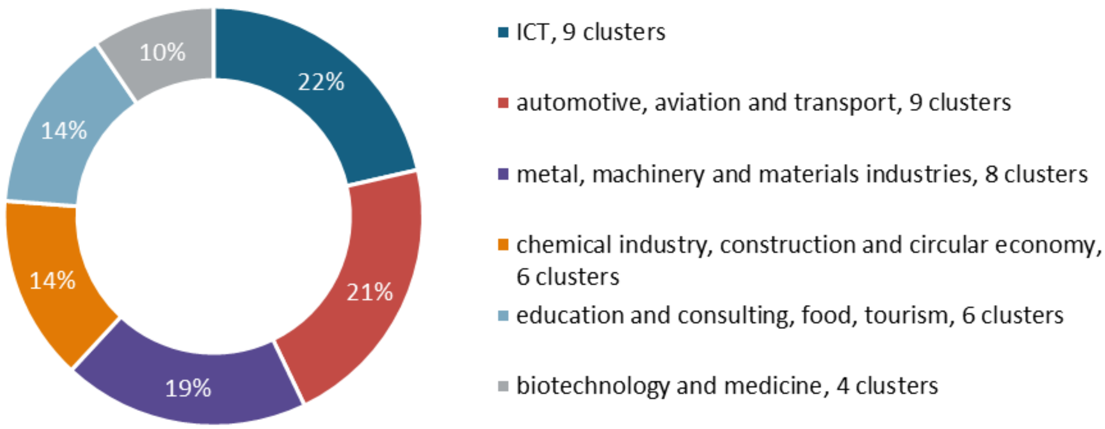
Source: own elaboration based on the cluster coordinators' survey (N = 42).

Considering the sectoral structure, the clusters were grouped into six categories. The most prominent were ICT clusters (9), which develop skills in digitalisation, cybersecurity, and Industry 4.0 technologies, supporting the modernisation of many other sectors. Equally numerous was the group of clusters working in the automotive, aviation, and transport sectors (9). The third largest group consisted of structures representing the metal, machinery, and materials industry (8). These sectors play a crucial role in the Polish economy, especially in terms of exports and integration into global value chains.

Fewer clusters were found in the chemical industry, construction, and the circular economy (6), which are significant for the green transition and implementing environmentally friendly solutions, as well as in education, consultancy, food, and tourism (6), which address local community needs and promote regional development. The smallest group consisted of clusters in biotechnology and medicine (4), which, despite their limited number, hold strategic importance for innovation and the advancement of technologies related to quality of life.

Overall, 42 clusters took part in the study, covering a broad range of sectors – from traditional industries to rapidly growing innovative fields. This varied composition reflects both Poland's economic specialisations and the increasing significance of emerging areas such as digitalisation, the bioeconomy, and the circular economy.

Figure 11. Sectoral specialisation of clusters participating in the benchmarking



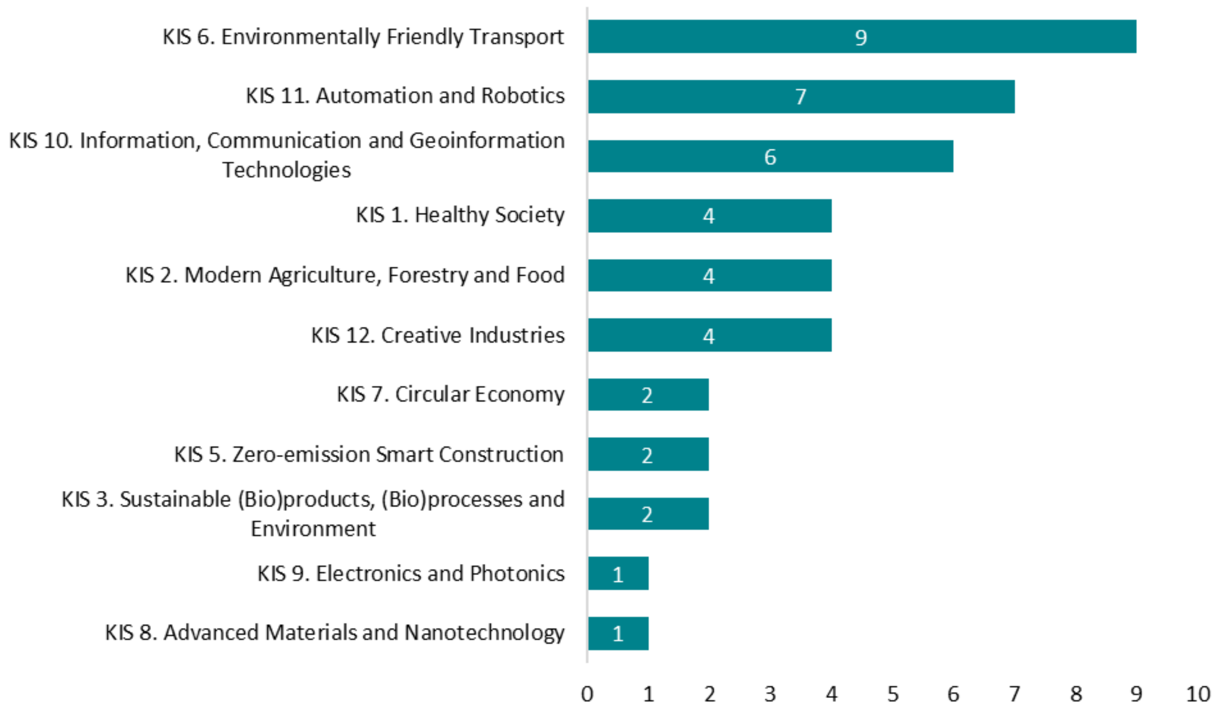
Source: own elaboration based on the cluster coordinators' survey (N = 42).

The clusters involved in the study also declared alignment with one or more National Smart Specialisations (KIS)[12]. The analysis was based on the list of 13 KIS in force since 13 February 2023[13]. Each of the surveyed clusters indicated at least one specialisation related to its area of activity. Among them, 15 clusters reported alignment with four or more KIS, which shows a broad thematic scope and operation across extensive value chains spanning multiple sectors of the economy.

[12] National Smart Specialisations (KIS) constitute a set of priority areas for economic and scientific development in Poland, aimed at increasing the added value of the economy and enhancing its competitiveness.
[13] https://www.gov.pl/web/rozwoj-technologia/krajowe-inteligentne-specjalizacje [accessed: 09.09.2025].

Considering the division into key KIS areas, the greatest number of clusters indicated environmentally friendly transport (9), followed by automation and robotics (7), and information, communication, and geoinformation technologies (6).

Figure 12. Number of clusters participating in the benchmarking – dominant National Smart Specialisation (KIS)



Source: own elaboration based on the cluster coordinators' survey (N = 42).

4. Study results

4.1. Overall results

In the first step, the results for all clusters were presented, both at the overall level and at the level of sub-areas, considering the breakdowns specified in the study methodology. The following subsections provide detailed results at the sub-area and partial indicator levels. The analysis started with a comparison of the synthetic indicator values across the five areas between the current benchmarking edition and the previous one from 2022. The comparison was carried out using normalised values and the following measures:

- **Benchmark** – the values achieved by the best-performing cluster in a given area;
- **Median** – the value dividing clusters into two equally sized groups (lower-performing and higher-performing clusters for the given area).

Comparisons of such values between the two editions of the study are subject to estimation limitations. A fully accurate comparative analysis would require assessing the same population of clusters using an identical set of indicators. Although the indicator set has not changed, a precise comparison is not possible due to alterations in the list of clusters included in the study. The analyses were conducted for groups of clusters distinguished according to the following criteria:

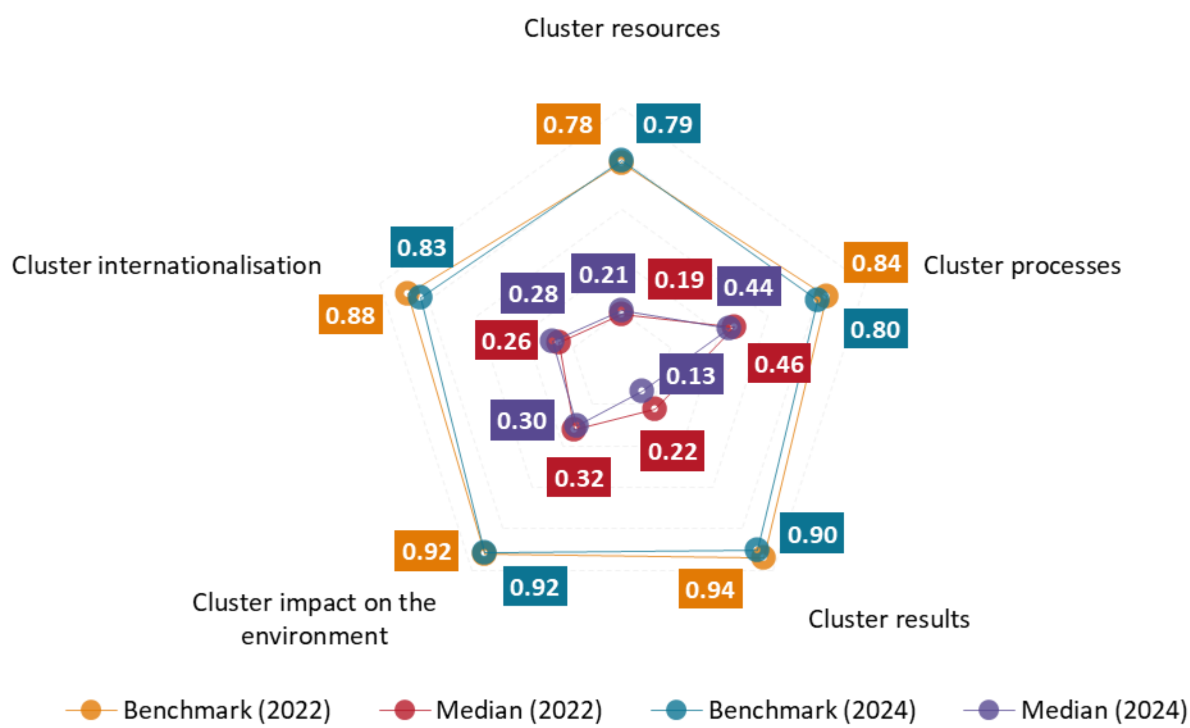
- **Cluster status:** holding the status of Key National Cluster (Krajowy Klaster Kluczowy), not holding the status but planning to apply, and not holding the status with no plans to apply.
- **Cluster size:** small clusters (20–49 members), medium clusters (50–79 members), large clusters (80–149 members) and very large clusters (150 members or more)[14].
- **Cluster age**: mature clusters (established before 2010), clusters established between 2010–2014 and clusters established between 2015–2020.
- **Existence of a cluster strategy:** no written cluster strategy; a written strategy exists but is not updated; a written strategy exists and is regularly updated.
- **Sector** according to the division into six groups:
  - Biotechnology and medicine;
  - Chemical industry, construction and circular economy;
  - Education and consulting, food, tourism;
  - ICT (information technology, electronics, digital technologies, cybersecurity);
  - Automotive, aerospace, transport;

[14] A revised cluster size taxonomy was applied compared with the previous edition. The change was introduced due to the significant growth in membership in the largest clusters, with the aim of maintaining a comparable number of clusters in each size category.

- Metal, machinery and materials industry.

The figure below compares medians and benchmarks from the previous and current editions of the benchmarking exercise, indicating that the highest recorded results have remained relatively stable. A slight decline was observed in cluster processes (from 0.84 to 0.80), cluster performance (from 0.94 to 0.90), and internationalisation (from 0.88 to 0.83). A marginal increase in cluster resources was observed (from 0.78 to 0.79). It is important to emphasise that the benchmarks were achieved by a single, top-performing cluster; therefore, the median better reflects the overall situation across the cluster population. Regarding the median, apart from a notable deterioration in cluster performance (from 0.22 to 0.13), no significant differences were recorded in the remaining areas. It is also worth noting that the areas which were relatively weak in the previous edition of the benchmarking – namely, cluster resources, cluster performance, and cluster internationalisation – have continued to be the weakest in the current study.

Figure 13. Median and benchmark values for the 2022 and 2024 editions



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The next phase of the analysis concentrates on the cross-sections described earlier. The initial comparison was made regarding possession of the National Key Cluster (KKK) status. It is notable that, in all cases, KKKs achieved stronger results – measured both by the median and the benchmark – than the other clusters. When analysing median values, the largest performance gap was in the areas of cluster resources and cluster outcomes, while the smallest differences appeared in cluster processes and the cluster's impact on the external environment.

The analysis of benchmark values shows that the sample includes clusters – without KKK status and without plans to apply – that nonetheless attain very high results in resource and process areas, demonstrating mature and effective organisational performance. Clusters without KKK status but planning to apply recorded slightly stronger results than clusters without such plans in processes, external impact, and internationalisation.

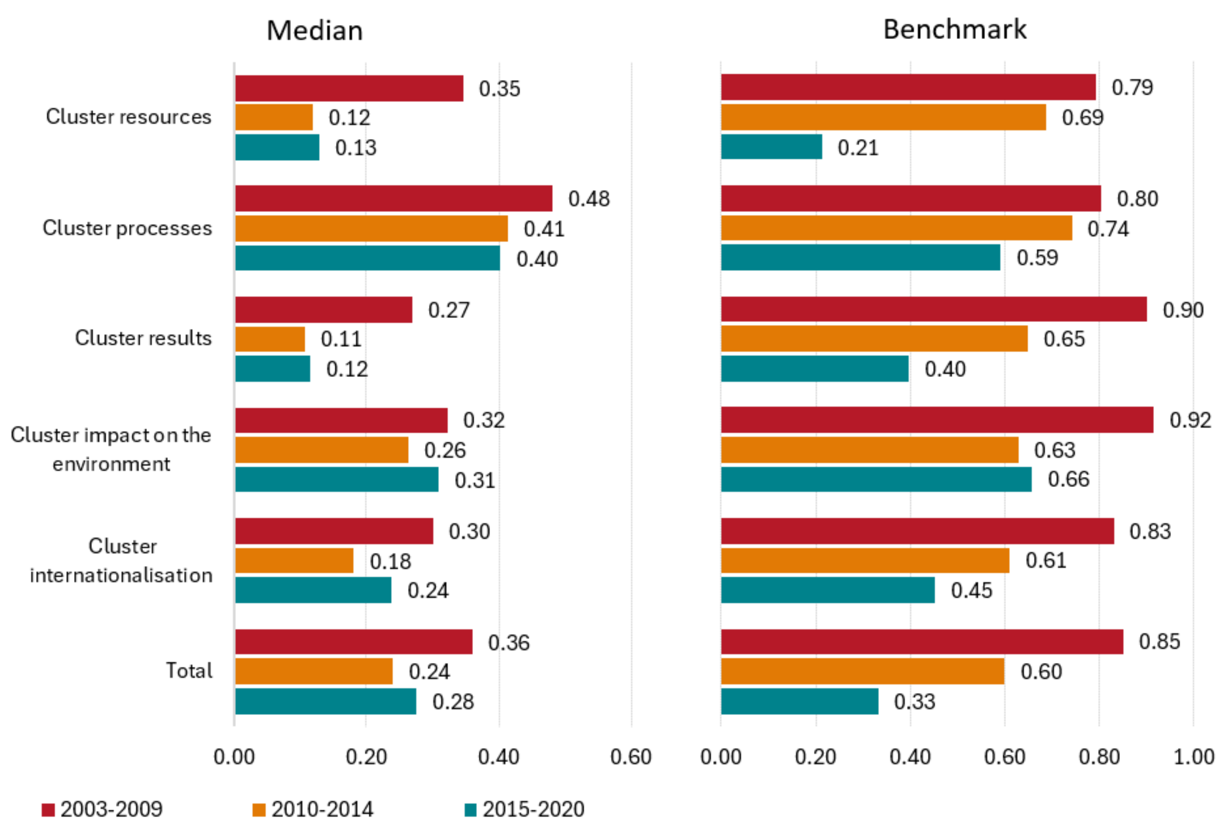
Figure 14. Median and synthetic benchmark values for Key National Clusters (KKK) and other clusters

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Another criterion of the analysis was the age of the clusters. A clear influence of the duration of cluster operation on performance across various areas can be observed. The largest differences were noted for the oldest clusters (established before 2010), which achieved significantly higher results than younger structures in most areas. This gap was particularly pronounced in the areas of cluster resources, cluster outcomes, and internationalisation.

When analysing median values, it is notable that there were no significant differences between clusters formed in 2010–2014 and those formed in 2015–2020. The relatively large gaps between the median and benchmark values highlight a strong asymmetry in the distribution of results – meaning that most clusters reach moderate or low levels of development, while only a small number approach the maximum. In other words, the typical cluster (represented by the median) performs considerably below the best-performing cluster in a given area.

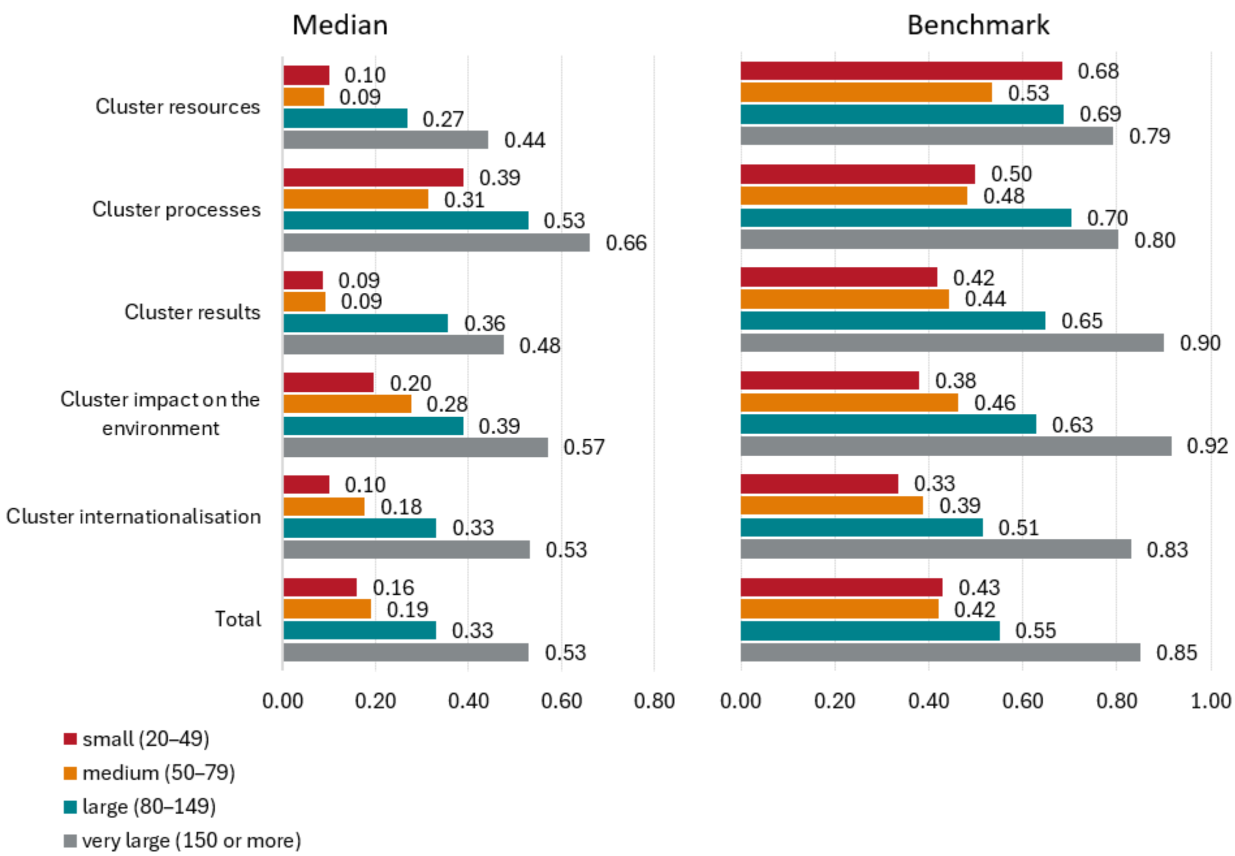
Figure 15. Median and synthetic benchmark values by cluster year of establishment



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The next phase of the analysis explored the link between the size of the cluster and the results from the benchmarking exercise. Clusters were categorised into four size groups (20–49, 50–79, 80–149, and 150 or more members). Clusters with smaller memberships performed notably worse in areas such as cluster resources, internationalisation, and overall results. Having more than 150 members consistently correlated with strong performance across all evaluated domains. Smaller structures did relatively well in cluster processes, which include indicators not directly tied to cluster size – such as the presence of a strategy and operational plans, collaboration along the value chain, or levels of digitalisation.

Figure 16. Median and synthetic benchmark values by areas and number of members



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The relationship between cluster size and performance was further analysed using a scatter plot that shows the connection between the number of members and the average value of synthetic indicators across all benchmarking areas (each point representing one cluster). A clear trend line appeared, defined by the following linear regression equation:

$y = 0.0012x + 0.1799$, where:

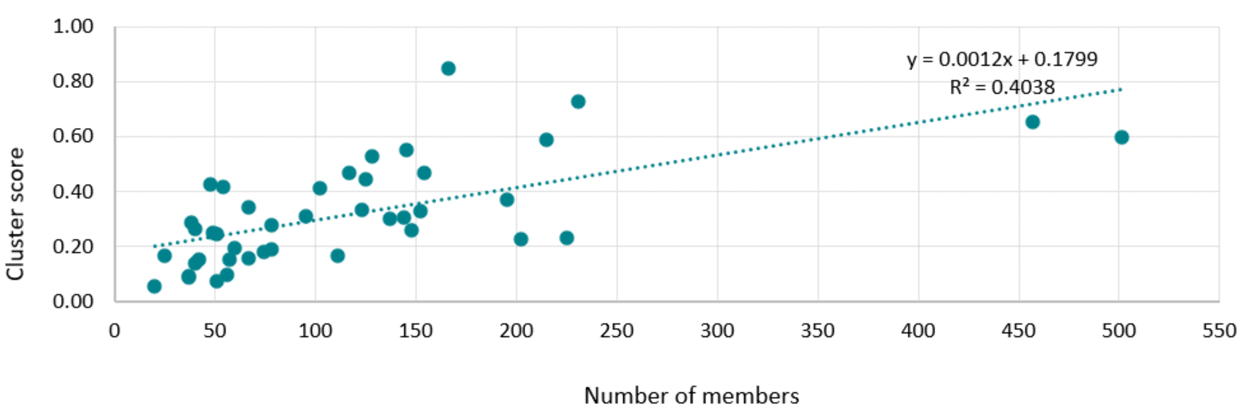
- x – the number of cluster members;
- y – the predicted average cluster score;
- 0.0012 – the regression slope coefficient, indicating the extent to which the cluster's score (y) increases when the number of members rises by one;
- 0.1799 – the intercept, representing the theoretical baseline score for a cluster with zero members.

A slope coefficient of 0.0012 indicates that an increase of 100 members results, on average, in an increase of approximately 0.12 points in the cluster's score. This supports a positive, though modest, relationship between cluster size and performance.

The coefficient of determination ($R^2 = 0.4038$) shows that approximately 40% of the variation in cluster scores can be explained by differences in the number of members, while the remaining 60% is due to other factors such as management quality, cooperation levels, and the effectiveness of the coordinator.

Compared with the previous edition of the benchmarking exercise, a slight decline in the slope coefficient – from 0.0015 to 0.0012 – was observed. This indicates a marginal weakening of the influence of member count on overall cluster performance. However, the change is not substantial enough to be considered a shift in the underlying trend; rather, it suggests a stabilisation of the relationship alongside a growing importance of other developmental drivers.

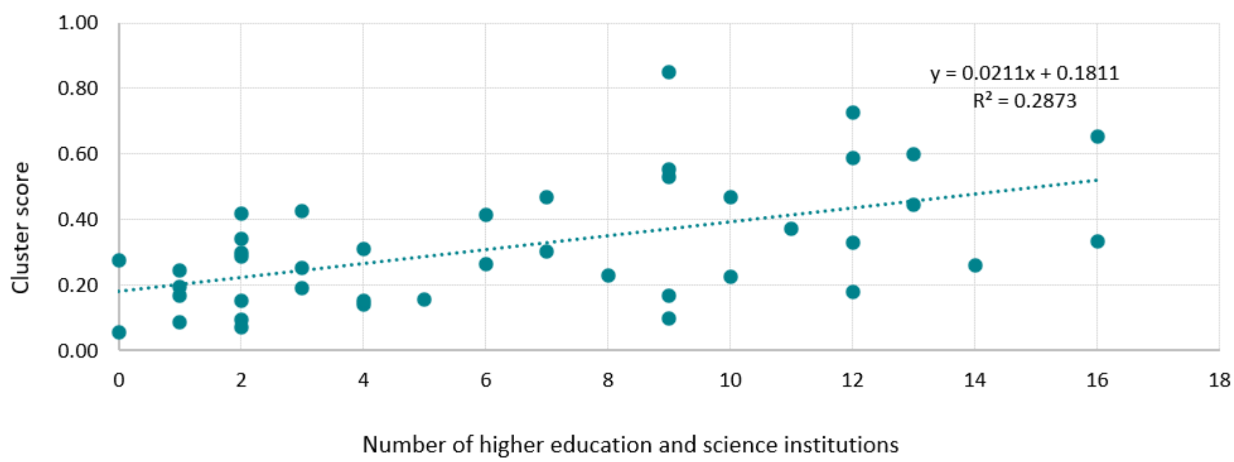
Figure 17. Relationship between the number of cluster members and overall cluster result



Source: own elaboration based on the cluster coordinators' survey (N = 42).

An important aspect of cluster operations is the inclusion of higher education and research institutions among their members. Consequently, an additional verification was undertaken to assess how the number of such entities within a cluster influences its overall score. The analysis reveals a weak positive correlation between the number of higher education and research institutions and the cluster's overall result. The coefficient of determination ($R^2 = 0.2873$) indicates that the number of scientific institutions accounts for only around 29% of the variability in cluster performance, confirming that this factor does not play a decisive role in shaping benchmarking outcomes. The figure demonstrates that clusters with the same number of scientific institutions can achieve very different results, suggesting differences in the quality and level of collaboration with the research sector. The study identified two clusters with no higher education or research institutions among their members (down from four in the previous edition), and two clusters with the highest number of such entities – 16 each.

Figure 18. Relationship between the number of research organisations in the cluster and overall cluster result



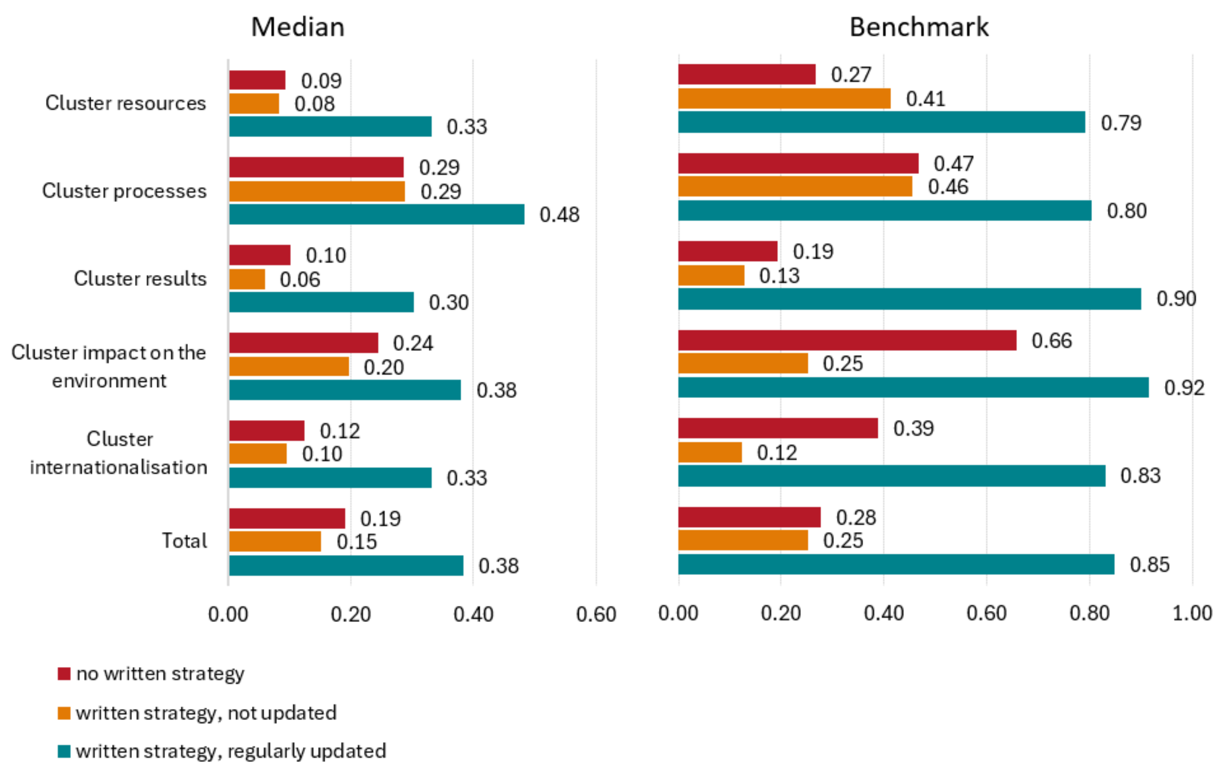
Source: own elaboration based on the cluster coordinators' survey (N = 42).

Another area of analysis was comparing cluster performance based on whether they had a strategic document in place and whether that document was regularly updated. Three groups were identified: clusters with a written strategy that is regularly updated (29 clusters), clusters with a written strategy that is not updated (5 clusters), and clusters lacking any written strategy (8 clusters).

The results shown below clearly demonstrate that clusters with an updated strategy attain significantly higher scores than the other groups. None of the clusters without a strategy – or with an outdated one – reached a high position in the benchmarking results, as indicated by the low benchmark values (the highest score among these clusters was 0.28). It is also worth noting that there was no significant difference between clusters without a strategy and those with an outdated one.

It is concerning that most clusters in this group (11 out of 13) were established before 2015. This suggests that, despite more than ten years of activity in many cases, they have failed to develop the foundations of effective strategic management or to implement operational documents that could support planning and monitoring of cluster development. The lack of such instruments results in weaker benchmarking outcomes and hampers their ability to systematically improve performance.

Figure 19. Median and synthetic benchmark values considering the possession and updating of a cluster strategy



Source: own elaboration based on the cluster coordinators' survey (N = 42).

4.2. Cluster resources

For the purposes of the study, “Cluster resources” were assessed across three sub-areas:

- **Human resources** – this sub-area examined employment across all cluster member entities, including the number of people working in cluster enterprises, the number of academic staff involved in cluster activities, and the size of the coordinator’s team assigned to cluster operations.
- **Infrastructure resources** – this sub-area assessed the availability and suitability of research, production, and IT infrastructure in relation to the needs of cluster members.
- **Financial resources** – this sub-area analysed the cluster’s budget, including self-financing and external financing, as well as the availability of financial instruments for cluster members.

In the Cluster resources area, the benchmark value reached 0.79, signalling that one of the clusters achieved very strong results in this domain. Meanwhile, the relatively low average (0.28) and median (0.21) values demonstrate that most clusters recorded results at a moderate or low level. Among the analysed sub-areas, Human resources received the highest assessment, with the highest median value (0.22). Conversely, the low median values for Infrastructure resources and Financial resources indicate limited activity among many clusters in these fields.

Table 4. Assessment for the area: cluster resources[15]

Sub-area	Mean	Median	Benchmark
Human resources	0.30	0.22	0.87
Infrastructure resources	0.28	0.14	1.00
Financial resources	0.26	0.11	1.00
Overall score for the area	0.28	0.21	0.79

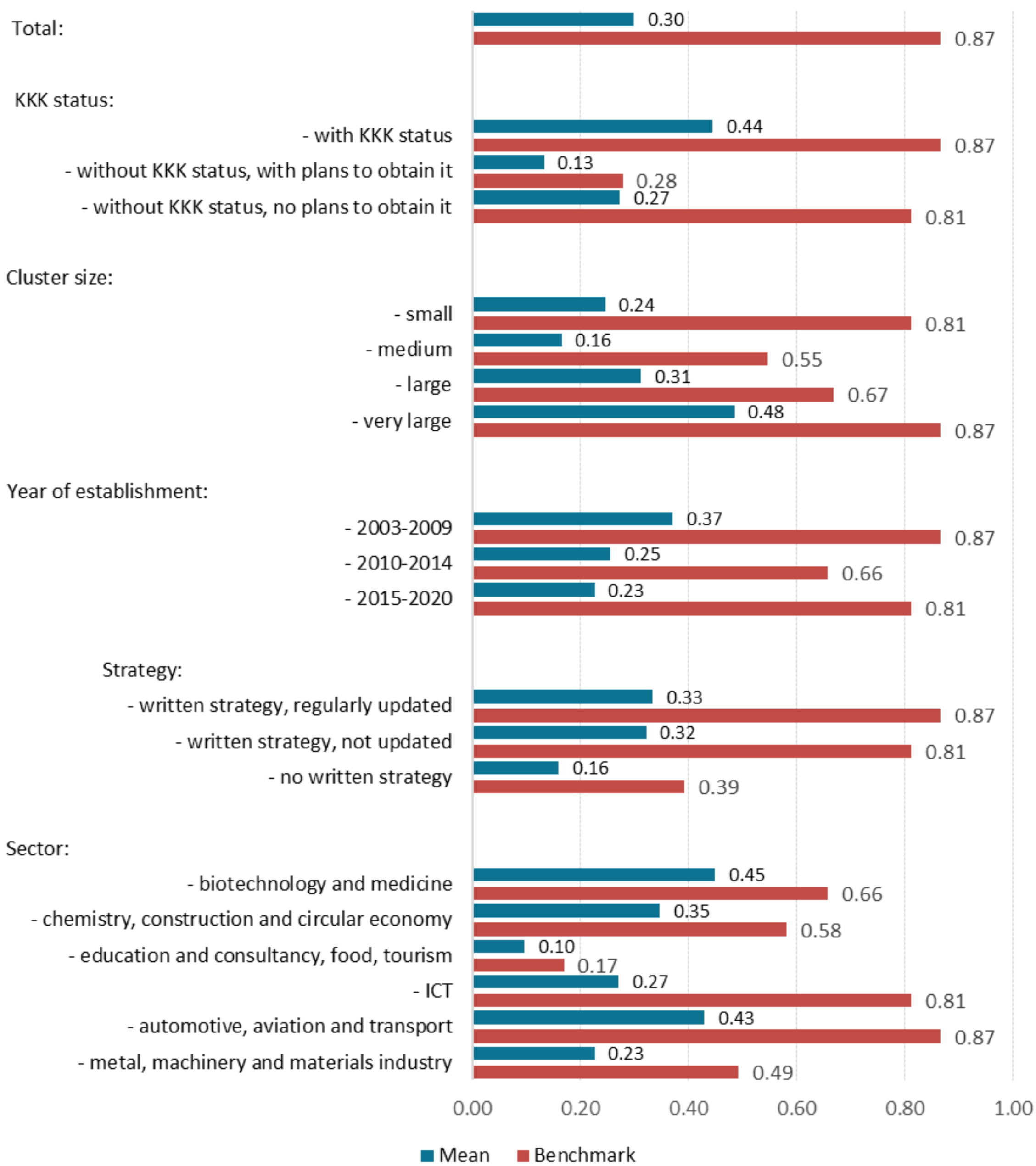
Source: own elaboration based on the cluster coordinators’ survey (N = 42).

[15] In this table, as well as in the subsequent tables for each benchmarking area, the values of the average, median and benchmark were calculated on the basis of results from all 42 clusters included in the study.

4.2.1. Human resources

For the "Human resources" sub-area, the average results of clusters were compared with benchmark values to highlight differences in their relative positions. The figure below shows the overall results and their distribution across the categories outlined in the study methodology.

Figure 20. Mean and benchmark for the sub-area: human resources



Source: own elaboration based on the cluster coordinators' survey (N = 42).

This section offers an analysis of cluster activity data for 2022–2023, supplemented by references to the findings of the previous benchmarking edition (2022 edition, data for 2020–2021) where notable trend shifts were observed. The interpretation also considers the broader context of cluster operations in Poland, including institutional changes and financing conditions. Results at the level of partial indicators[16]:

- **Total employment in cluster entities.** Total employment across all organisations within clusters increased substantially. In 2022–2023, the average number of employees was about 25.9 thousand per cluster (median 17.4 thousand), compared to an average of 18.0 thousand (median 13.2 thousand) two years earlier. The latest edition included several large clusters – one cluster reported 175 thousand employees (benchmark; previously 105.8 thousand). Meanwhile, very small organisations continue to operate. In 2022–2023, four clusters reported fewer than 1,000 employees across all member entities (previously only two clusters). These figures suggest a growing critical mass of the average cluster and increased differentiation – alongside a rising number of large clusters with extensive membership bases, there remains a group of small clusters with limited operational capacity scale.
- **Employment in cluster enterprises.** Most employment is concentrated in member enterprises. On average, approximately 79% of all cluster-level employees work in companies. In 2022–2023, the average number of employees in cluster enterprises reached 20.96 thousand (median 11.2 thousand), almost doubling the previous average of 11.8 thousand (median 7.5 thousand). This increase results from two factors: growth in the number of enterprises within clusters and rising employment within member firms. This phenomenon is further discussed in the conclusions in Chapter 9. The distribution of this indicator remains highly asymmetric. Four clusters recorded fewer than 1,000 employees among member firms (previously five clusters), while the largest cluster reported 175 thousand employees. A detailed analysis of employment structure in the smallest clusters reveals that other types of institutions (such as universities or local government units) can account for a significant share of employment. Conversely, the largest clusters, comprising many large manufacturing or industrial enterprises, report very high employment levels, which substantially raise the overall average for the entire group.
- **Academic staff involved in cluster activities.** Collaboration between clusters and the R&D sector also reveals increasing disparities. In 2022–2023, an average of 93 academic staff worked with a single cluster, whereas the median was only 9 individuals. In comparison, during 2020–2021, the average was just 22.3 (median 10). The notable rise in the average is primarily driven by exceptionally high involvement in one cluster (a

[16] The complete set of partial indicators for the "Human resources" sub-area is provided in Annex 12.1.1.

National Key Cluster), which collaborates with approximately 2,000 researchers. Meanwhile, many clusters continue to show limited links with the scientific community. Three clusters reported no academic staff involvement, and a further 14 reported fewer than five such staff (previously 3 clusters reported none and 12 reported up to five). This highlights ongoing challenges faced by many clusters in attracting and engaging research institutions, even though the most successful clusters have considerably strengthened their collaboration with science, likely aided by closer ties with universities and acquiring the National Key Cluster status.

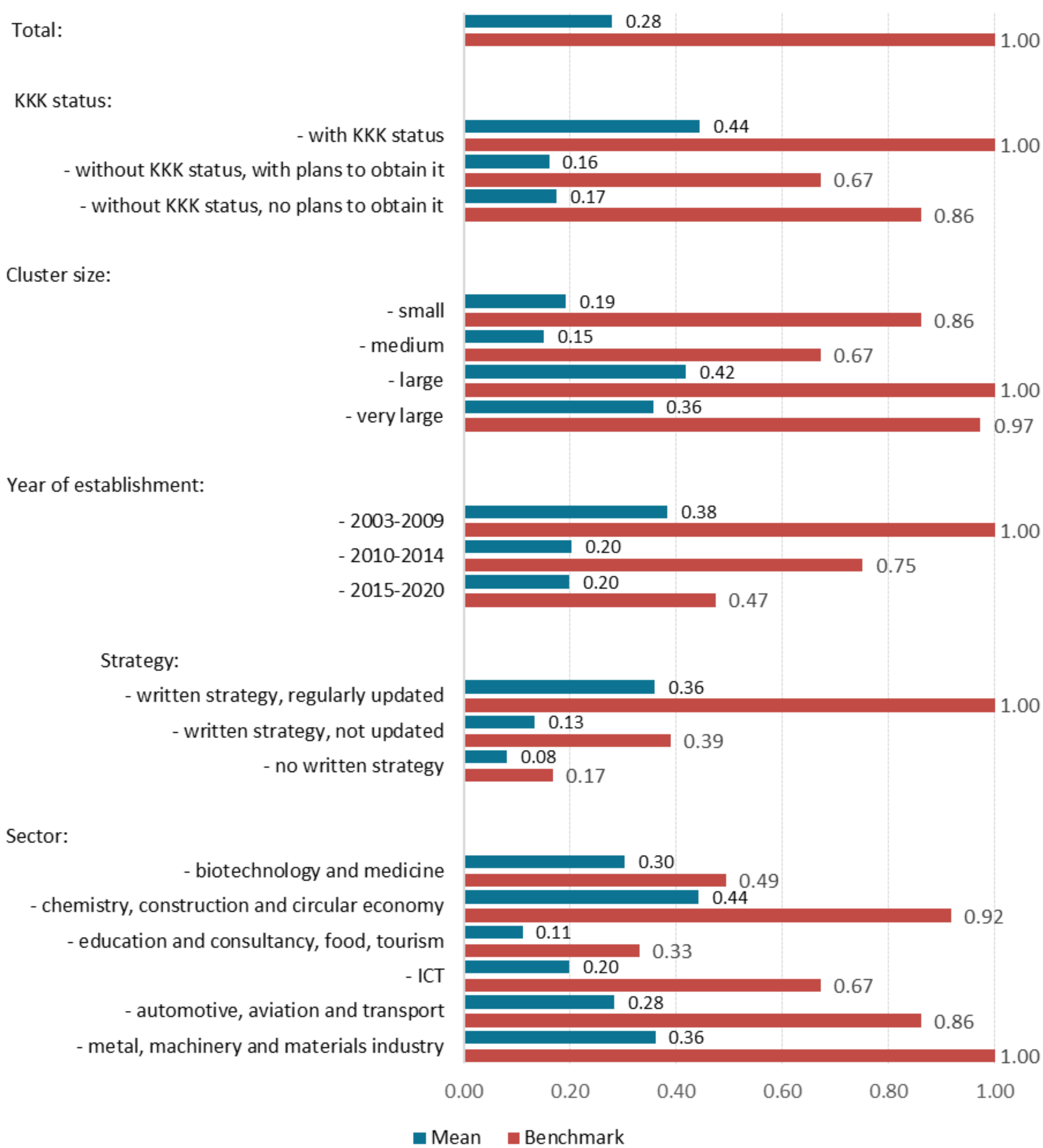
- **Cluster coordinator staff.** The size of teams responsible for cluster management has not improved; in fact, it has declined. In 2022–2023, cluster coordinators employed an average of 5.2 staff (median 3.5) for cluster operations, compared with an average of 6.1 (median 4.0) in 2020–2021. Many clusters continue to operate with very small teams – nine clusters function with only 1–2 staff members (similar to the previous edition), and two clusters reported no dedicated coordinator staff at all. Only four clusters have larger teams (≥10 staff, although none exceeds 16). This reflects the limited institutional capacity of most Polish clusters: despite growing membership and project portfolios, many still lack the ability to significantly expand their professional management teams. A minor positive sign is that the share of clusters managed by only 1–2 staff members did not increase (remaining at a similar level), which may indicate slight improvement in the weakest cases as a result of additional posts or volunteers involvement.
- **Cluster members' perspective**[17]. As part of the member survey, responses were gathered from 733 entities representing all clusters involved in the benchmarking exercise. Up to 79.5% of respondents limited their participation to basic membership, without delegating staff to cluster bodies, while only 20.5% reported active involvement through staff delegation to at least one specialised body. Regarding competence development, it is notable that nearly 60% of members stated that their staff attended training sessions, workshops, or courses organised by clusters in the past two years, confirming that clusters support skills development. Simultaneously, just over half of respondents (54.4%) considered the number of coordinator staff dedicated to cluster operations sufficient, whereas one in six indicated a shortage.

[17] The full set of results from the cluster member survey is provided in Annex 12.3.

4.2.2. Infrastructure resources

In the sub-area “Infrastructure resources”, a wide dispersion of results is observed – the average values for most groups are relatively low, while the benchmarks are high, indicating the presence of a small number of clearly outstanding clusters.

Figure 21. Mean and benchmark for the sub-area: infrastructure resources



Source: own elaboration based on the cluster coordinators’ survey (N = 42).

The "Infrastructure resources" sub-area shows that clusters in Poland operate with highly diverse infrastructure bases, and infrastructure development is concentrated among a small group of leaders. Research and production infrastructure is available only in a limited number of clusters, and investment in these areas is sporadic and concentrated in a few large projects. Most clusters do not expand their technical facilities, which limits their direct support for member firms' innovative or production-related activities. The strongest results relate to IT platforms, which are widely used for communication and knowledge exchange, although they are less likely to include more advanced functionalities. According to cluster members, communication tools are rated as the most effective, while technical infrastructure and financial instruments receive lower ratings. Results at the level of partial indicators:

- **Research infrastructure.** The availability of shared research infrastructure across clusters remains limited and uneven. Around half of the surveyed clusters (22) report possessing or providing access to R&D infrastructure for their members; however, the median available surface area has fallen to 25 m² (previously 77 m²). This means that more than half of all clusters either lack research infrastructure or have only symbolic resources (0–25 m²). The average value (approx. 3.69 thousand m² per cluster) remained similar to the previous edition (3.62 thousand m²), owing to the participation of several exceptionally well-equipped clusters. Two clusters declare extensive infrastructure, including one offering as much as 100,000 m² of research facilities (a benchmark in both editions). This distribution shows that, apart from a small number of leaders (often those hosting university laboratories or research centres), most Polish clusters do not provide substantial R&D infrastructure to their members.
- **Investment in R&D infrastructure.** In 2022–2023, investment in research infrastructure development decreased. Half of all surveyed clusters (21) have R&D infrastructure, but only 14 have made investments in this area over the last two years (compared with 16 in the previous edition). The median investment value remained zero, indicating that more than half of the clusters made no new investments. Average investment across all clusters amounted to PLN 6.27 million (compared with PLN 11.09 million previously). This decline is mainly due to the absence of projects as large as those in the previous period, when one cluster invested PLN 120 million in R&D infrastructure (benchmark). In 2022–2023, the largest investment reached PLN 60 million. It is worth noting that four clusters invested amounts of PLN 40 million or more, while the remaining clusters invested significantly smaller sums (ranging from several tens of thousands to a few million PLN). Overall, investment in research infrastructure is limited to a few well-funded clusters, while most do not undertake such investments (likely due to funding constraints or different strategic priorities).
- **Production infrastructure.** Even fewer clusters offer shared production infrastructure. More than half provide no production space at all (median of 0 m², both previously and

currently). The number of clusters with such infrastructure rose only slightly (from 16 to 17), mainly in production-oriented sectors; only a few clusters in other industries (e.g. one in the quality-of-life sector and two in ICT) declare such resources. The average reported production area rose sharply from 1.65 thousand m² to 49.5 thousand m². This dramatic increase results from the participation of a cluster providing access to 2 million m² of production halls and facilities (benchmark for 2022–2023). This cluster did not participate in the previous edition, when the maximum value was 38 thousand m². Excluding this case, a typical production cluster continues to have moderate resources (usually a few hundred to a few thousand m²), and the absence of production infrastructure remains the norm in more than 50% of clusters.

- **Investment in production infrastructure.** In 2022–2023, the share of clusters investing in production infrastructure increased, although the scale of investment remains highly varied. Currently, 17 clusters provide access to production infrastructure, and 13 investments have been declared in the last two years (compared with nine in the previous edition). The average investment has increased slightly (PLN 4.75 million per cluster, up from PLN 3.99 million previously), but the median remains zero, indicating no investment in more than half of the sample. Only three clusters invested amounts above PLN 10 million (down from five), while one cluster launched a project worth PLN 90 million (a new record, up from PLN 40 million previously). This suggests that although new investments have emerged (possibly linked to preparations for larger industrial undertakings), most clusters still do not invest significant resources in production infrastructure. Likely reasons include limited financial capacity or the fact that such investments are not essential for many service-oriented or software-focused clusters.
- **Functionality of cluster IT platforms.** The use of digital tools in clusters remains moderate. Most surveyed clusters have an IT platform offering around 2–3 functionalities (median of three in both 2020–2021 and 2022–2023). The most common modules include internal cluster communication (used by over 80% of clusters) and knowledge repositories or project collaboration tools (reported by 40–60% of clusters). The share of clusters using communication tools increased from 83% to 88%, and the use of knowledge repositories grew from 51% to 57%, possibly reflecting rising needs for information exchange and knowledge management amid the post-pandemic period. Slight increases were also seen in the use of e-learning tools (from 32% to 36%) and collaboration management tools (from 41% to 47%). Conversely, some functionalities became less popular – for instance, joint procurement platforms are now less common (down from 29% to 17%), likely due to decreased demand or challenges in their maintenance. The most advanced clusters expand their platforms with additional, customised modules – such as innovation and job exchanges, technology mapping, R&D project management, or integration with regional smart specialisations. In some cases,

the number of available functions exceeded the basic catalogue of five, thanks to these customised extensions (the previous benchmark was seven functions, now six). Overall, the level of cluster digitalisation has not seen significant change – IT platforms are mainly used for communication and knowledge exchange, while the full range of functionalities (e.g. e-services, joint procurement, advanced modules) remains underdeveloped common.

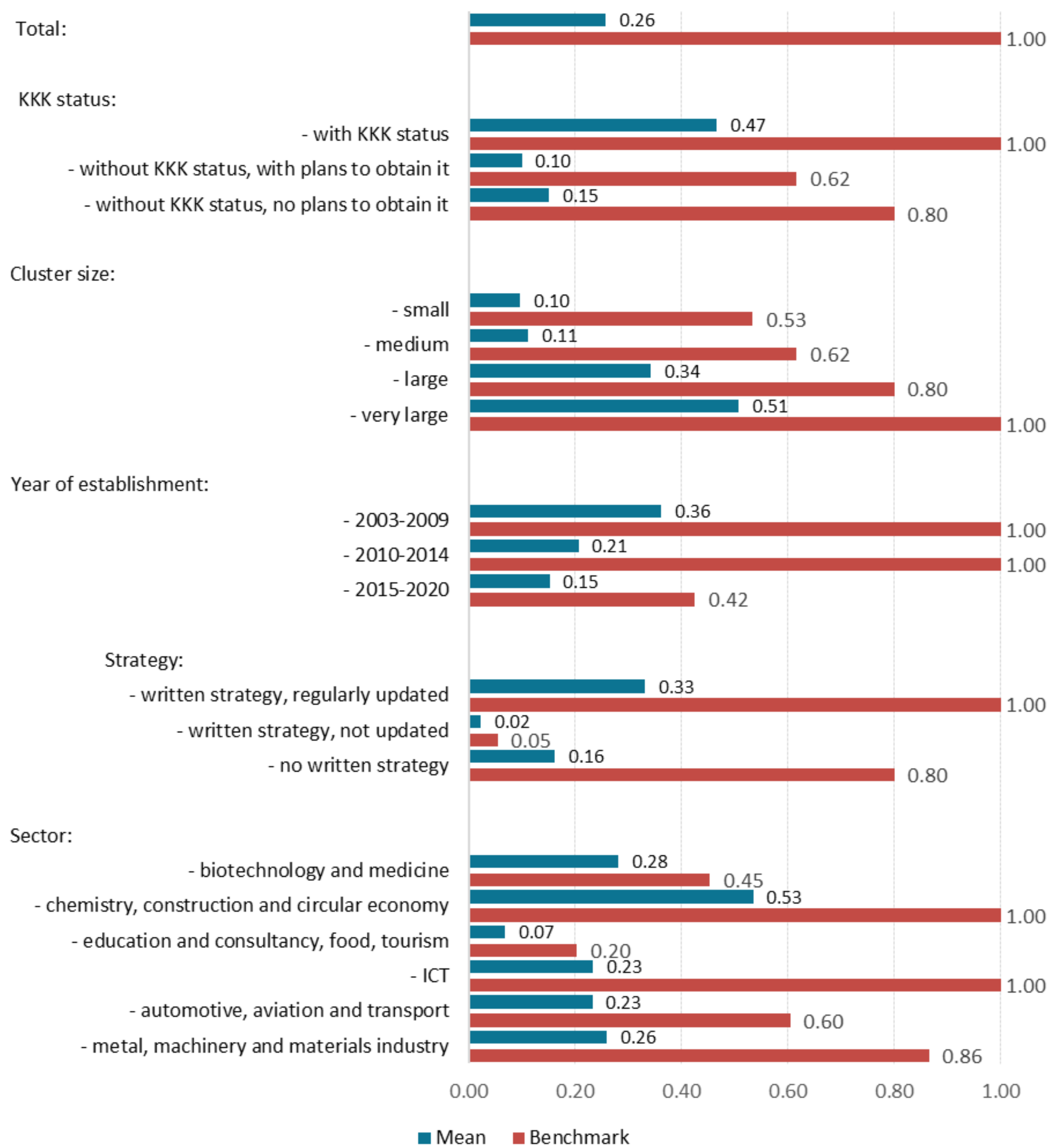
- **Investment in IT infrastructure.** Expenditure on IT infrastructure declined compared to the previous period. In 2022–2023, such spending averaged PLN 1.08 million per cluster (with a median of only PLN 250, indicating no significant investment in at least half of the clusters). Two years earlier, the average was higher (PLN 1.81 million, median PLN 650). The decline suggests that following the pandemic-driven surge in digitalisation (when some clusters invested in platforms and remote collaboration tools), a saturation point has been reached – fewer clusters are now making substantial IT investments, often limiting expenditure to minor equipment purchases or maintaining existing systems. The range of reported amounts remains broad: some clusters spent only a few hundred PLN, while one cluster invested as much as PLN 30 million (benchmark; previously 50 million). This indicates that only a small number of clusters engage in significant IT investment, while most rely on basic, low-cost solutions.
- **Cluster members' perspective.** According to member responses, the material and organisational resources available in clusters are rated quite positively, although there is considerable variation between structures. The communication platform received the highest rating – an average score of 4.3 on a five-point scale.[18] – reflecting strong appreciation for tools that support information exchange and internal communication. R&D infrastructure (3.9) and production infrastructure (3.5) were rated lower, implying that not all clusters offer technical resources suited to member needs. Financial instruments received the lowest ratings, with an average of 3.4, showing limited access to funding or capital support mechanisms within clusters. Nearly half of respondents regarded these resources as only partially meeting their needs, and only one in five rated them highly. Overall, the results suggest that while clusters provide basic infrastructure and communication channels, there is still a need for further development, particularly concerning financial instruments and the alignment of technical infrastructure with member expectations.

[18] The survey offered the following response options: "Low rating", "Average", "High rating", and "Don't know/Not sure". To improve the clarity of the analysis, the responses were quantified and presented numerically, where 1 represents a low rating, 3 an average rating, and 5 a high rating. An average score was then calculated for the responses provided by cluster members. The same approach is applied to all other results from the cluster member survey cited in this chapter where a rating scale is used.

4.2.3. Financial resources

In the sub-area "Financial resources", the average results remain below the benchmarks, indicating that only a few organisations are capable of accumulating substantial resources and securing stable financing.

Figure 22. Mean and benchmark for the sub-area: financial resources



Source: own elaboration based on the cluster coordinators' survey (N = 42).

At the 'Financial resources” sub-area level, a clear improvement in the financial health of clusters is evident compared to the previous edition, both in total budgets and own resources, which have become a more significant pillar of cluster activities. An increasing number of clusters are able to generate capital through membership fees or market services, indicating a maturing business model and less reliance on grants. A slight improvement is also visible in securing public funding, although only a portion of the cluster population utilises this support effectively, reflecting considerable variation in application capacity. Financial instruments for members remain underdeveloped and are available in only a few clusters – the role of a financial intermediary remains niche. From the members’ perspective, financial resources are considered moderate, with expectations centred on expanding the range of practical services and support. Overall, while the financial condition of clusters is improving, the main challenge remains developing financial mechanisms that provide genuine support for businesses within the cluster. Results at the level of partial indicators:

- **Cluster budget (total funds at the coordinator’s disposal).** The financial condition of clusters has clearly improved. The total funds available to the coordinators (from all sources) for 2022–2023 averaged PLN 4.09 million per cluster (median approximately PLN 847 thousand), compared to PLN 2.34 million (median PLN 150 thousand) in the previous edition. During this period, 18 clusters operated with budgets exceeding PLN 1 million (up from 13), while only six clusters had budgets below PLN 100 thousand (down from 11). The maximum value also increased – the leading cluster had nearly PLN 54.9 million (versus PLN 37.95 million previously). The annual analysis shows a strong upward trend: the average cluster budget grew from approximately PLN 1.71 million in 2022 to around PLN 2.38 million in 2023, representing a year-on-year increase of 39% (continuing the upward trend observed in 2020–2021, when an increase of 23% was recorded). This significant rise in funds suggests increased project activity and more effective fundraising by clusters. It is possible that some clusters benefited from new funding programmes or grants in 2022–2023, contributing to higher budgets (as reflected in the near doubling of the median). However, the distribution remains broad – alongside several well-resourced clusters, there are still structures operating with very limited budgets.
- **Clusters’ own resources.** The growth in clusters’ own resources – funds generated independently (e.g., membership fees, service revenues) – is particularly notable. The average value of own resources in 2022–2023 reached PLN 12.39 million (median PLN 423 thousand), compared with PLN 4.24 million (median PLN 122 thousand) two years earlier. This reflects nearly a threefold increase in the average level of self-financing and more than a threefold rise in the median. An increasing number of clusters are able to accumulate significant own capital – 13 clusters reported more than PLN 1 million in own resources (up from 10), while only two clusters declared zero (down from six).

Conversely, half of the clusters still operate with no more than approximately PLN 0.42 million (over a two-year period). One cluster amassed an unprecedented PLN 400 million in own resources – a record in the history of the benchmarking exercise. Such substantial growth may result from intensified business activities (e.g., increased membership fees, paid advisory or training services) and a growing awareness of the importance of reducing dependence on public funding. Own resources have thus become an increasingly vital pillar of cluster budgets, illustrating the growing maturity of certain cluster enterprises models.

- **Public funding obtained by clusters.** External (public) funding also increased, although not as strongly as self-financing. The average cluster received approximately PLN 5.59 million from public sources (such as national grants, EU funds, etc.) in 2022–2023, compared to roughly PLN 4.24 million two years earlier. The median of public support rose from PLN 122 thousand to PLN 336 thousand, indicating that many clusters still either do not access public funds or do so minimally (half received less than PLN 336 thousand over two years). Nonetheless, the leading clusters made significant use of available programmes – the top-performing cluster secured about PLN 120 million in public funding (previously PLN 150 million, although these figures may include large infrastructure projects or consortia where funds are shared among multiple entities). The high level of variation (with the average notably exceeding the median) persists, showing that only a subset of well-prepared clusters can effectively compete for grants and funding, while others either do not meet eligibility criteria or do not apply. In 2022–2023, this may have been influenced by the transition period between EU financial frameworks – the winding down of 2014–2020 funds and preparations for the new FENG 2021–2027 programme. Nevertheless, some improvement is evident. More clusters accessed at least some public funds, and several leading clusters secured substantial amounts.
- **Financial instruments for cluster members.** Clusters still rarely act as intermediaries in providing financial instruments, such as loan or equity funds, to their members. The median number of financial instruments available through the cluster is zero – more than half of the clusters (26) did not offer any of the assessed instruments. On average, 0.8 financial instruments per cluster were available in the 2024 edition (up slightly from 0.7 previously), indicating only minimal progress. The most common instruments are loan funds and venture capital initiatives—offered by approximately 21% of clusters (previously 19%). Seed capital instruments appear less often (12%, up from 10%), and guarantee funds even less so (7%, down from 10%). Some clusters reported additional forms of financial support, such as cascade funding (e.g., from Euroclusters projects) or vouchers for start-ups, but these are not traditional financial instruments as defined by the Act of 29 July 2005 on Trading in Financial Instruments or by International

Accounting Standards; instead, they are specific forms of aid. Overall, the role of financial intermediary remains underdeveloped within Polish clusters – only a few of the largest or best-funded clusters have established mechanisms to support members financially, such as loan funds, which remains a niche with potential for future growth expansion.

- **Cluster members' perspective.** In the area of financial resources, cluster members report limited support and moderate satisfaction with available instruments. The average rating for the availability of financial instruments (such as loan and guarantee funds, venture capital, or seed capital) was 3.4 on a five-point scale, indicating that for many firms, the offer is insufficient or difficult to access. Some respondents noted that the use of financial instruments within clusters remains the domain of a few rather than a widely accessible support mechanism. A small proportion of respondents expressed willingness to increase membership fees if the service offering is expanded – expectations were mainly centred on training, advisory services, and internationalisation support. These results suggest that although members recognise the importance of stable financial resources for cluster development, the current level of financial instruments does not fully meet their needs, and their expansion depends on the introduction of additional practical, high-value-added services.

4.3. Cluster processes

The "Cluster processes" area covered both internal and external activities carried out within the cluster. The assessment in this area included:

- **Management processes** – the existence of strategic and operational documents, the presence of specialised management bodies, surveys of member needs and satisfaction, and quality standards implemented in cluster enterprises;
- **Cluster communication** – direct contacts within clusters (meetings) and the use of communication tools;
- **Market activity** – collaboration along the value chain (including joint procurement and distribution), revenues generated by cluster members, and the value of online sales;
- **Marketing activity** – media presence, joint promotional and marketing activities, including joint participation in trade fairs and exhibitions;
- **Innovation activity** – the availability and use of pro-innovation services within clusters, the presence of institutions supporting technology transfer, and the diagnosis of the technological potential of cluster firms;
- **Cluster digitalisation** – the degree of digitalisation among cluster members (use of IT systems and Industry 4.0 technological solutions).

In the Cluster processes area, the highest benchmark value – 0.80 – was achieved by one of the assessed clusters. This result indicates a high level of development in cluster processes. Simultaneously, the high values of the average and median (0.45 and 0.44 respectively) show that a significant number of clusters achieved medium to high scores in this area. Among the assessed sub-areas, Cluster digitalisation (average 0.74, median 0.78) and Management processes (average 0.61, median 0.65) received the highest ratings. This demonstrates both the advanced level of professionalisation among cluster coordinators and the ongoing digitalisation initiatives within clusters. Benchmark values were also high in the sub-areas of Market activity, Cluster communication, and Innovation activity.

Table 5. Assessment for the area: cluster processes

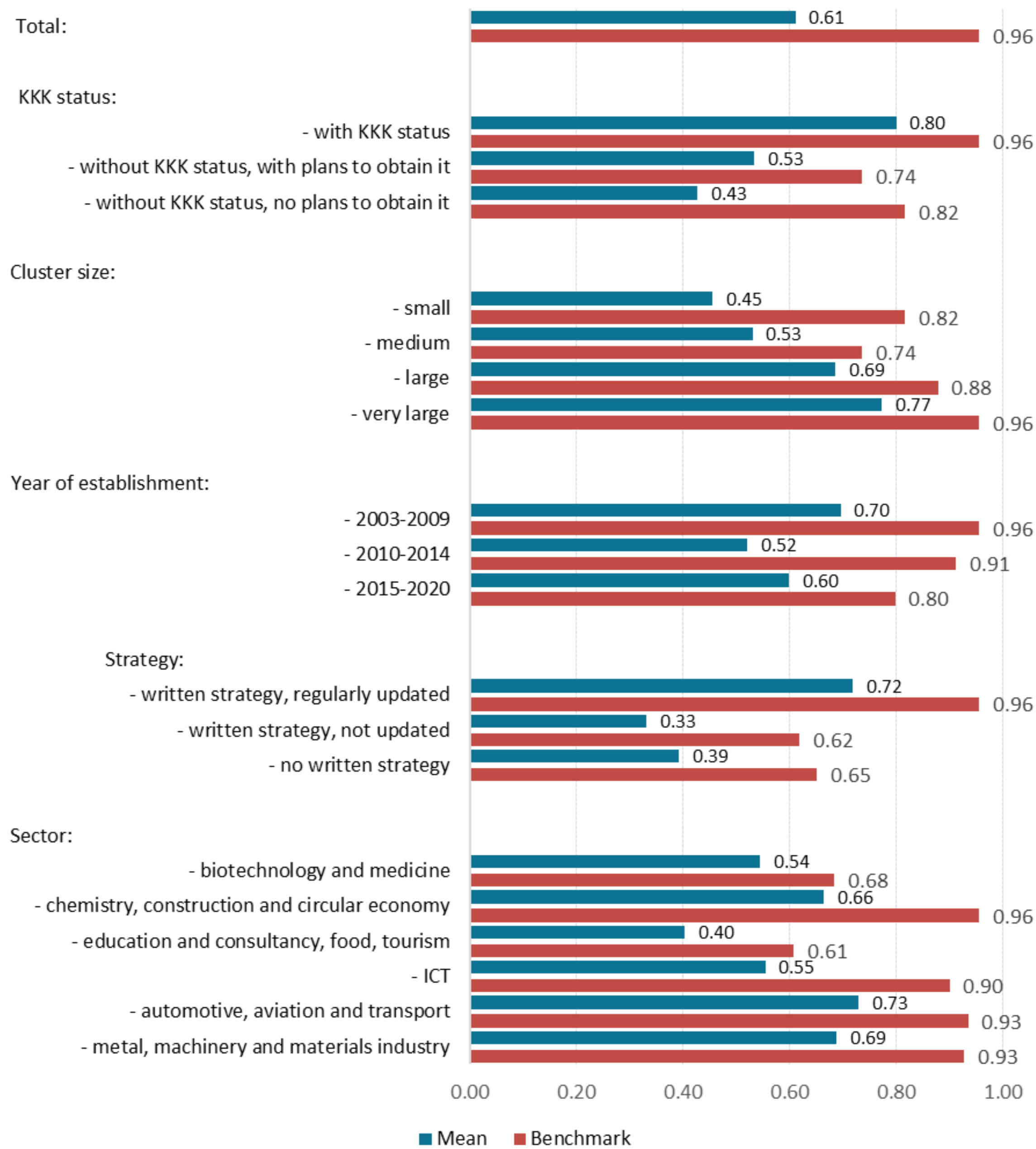
Sub-area	Mean	Median	Benchmark
Management processes	0.61	0.65	0.96
Cluster communication	0.41	0.35	0.94
Market activity	0.33	0.28	0.97
Marketing activity	0.31	0.28	0.80
Innovation activity	0.41	0.34	0.94
Cluster digitalisation	0.74	0.78	1.00
Overall score for the area	0.45	0.44	0.80

Source: own elaboration based on the cluster coordinators' survey (N = 42).

4.3.1. Management processes

In the sub-area "Management processes", the average results of clusters are relatively high, indicating that a large group of structures meets many of the criteria assessed.

Figure 23. Mean and benchmark for the sub-area: management processes



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The “Management processes” sub-area is one of the strongest dimensions within the assessed clusters, indicating their growing level of professionalisation. Most structures possess formal development strategies and action plans which – when regularly updated – lead to significantly improved benchmarking results. The functioning of cluster councils, working groups, and regular internal communication is becoming standard practice, as is monitoring member satisfaction and implementing quality standards within member firms. This trend has remained steadily strong since the previous edition of the study, reflecting the increasing maturity of cluster governance mechanisms. However, the member perspective highlights certain limitations – not all members are involved in strategy development or operational decisions, and some express a need for greater transparency and wider engagement of the cluster community. This suggests that the main challenge is no longer merely the presence of documents or structures, but fostering genuine member participation in governance processes, which could enhance a shared sense of responsibility and boost the effectiveness of cluster operations. Results at the level of partial indicators:

- **Management processes.** This sub-area includes elements such as the existence of strategic and operational documents (cluster development strategies, action plans), specialised governance bodies, surveys of member needs and satisfaction, and the implementation of quality standards within cluster firms. The average score for management processes was 0.61, with a median of 0.65 – one of the highest values in the entire study. This suggests that most clusters have developed relatively mature governance mechanisms, while the best-performing clusters achieved nearly maximum results (benchmark 0.96). According to the report’s authors, this indicates a high level of professionalisation among cluster coordinators..
- **Development strategy.** Most clusters (29) have a formal development strategy—a document that outlines their mission, objectives, and action plan. Notably, clusters with an up-to-date and regularly revised strategy achieved markedly better results than those without a strategy or with an outdated one. No cluster lacking a strategy or unable to update it reached a high position in the study. The best results were seen among well-established clusters—large, long-standing organisations with the status of National Key Cluster and a written, regularly updated strategy. This emphasises the importance of planned management—continually improving the strategy and monitoring its implementation is linked to stronger cluster development.
- **Governance standards.** The existence of operational structures such as cluster councils and working groups supporting the coordinator is increasingly becoming standard practice. Most clusters hold internal communication through regular member meetings (38 clusters) and utilise digital tools for communication (all assessed clusters use at least one). Most clusters also monitor member satisfaction and needs, for instance via surveys (39 clusters, including 22 that do so regularly). During the analysed period, 16

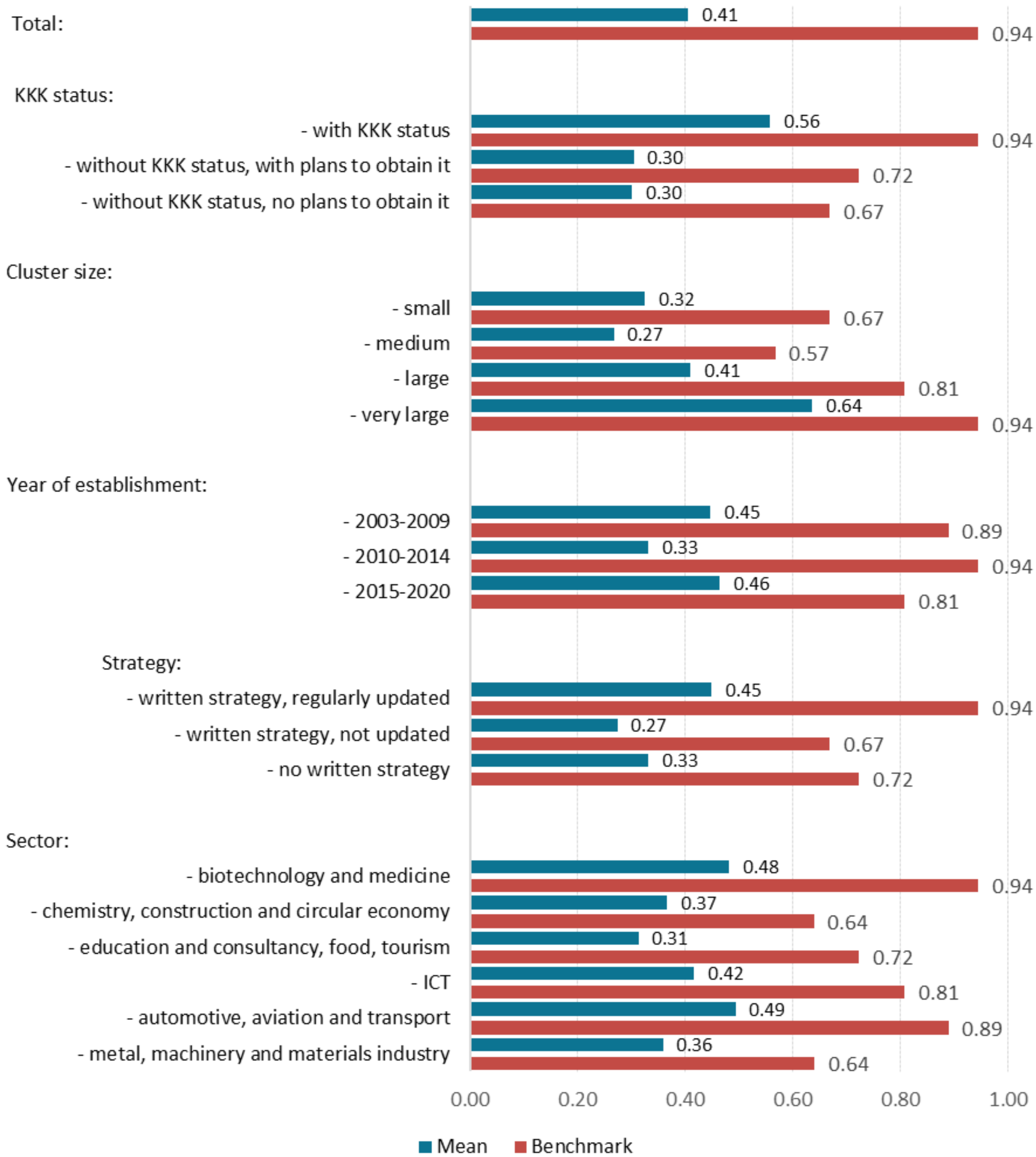
clusters received the European Clusters Excellence Labelling Structure (EUCLES) distinction (formerly ESCA), confirming high governance standards. All these elements demonstrate the growing maturity of cluster governance in Poland. Compared with the 2022 edition, the high level of formalisation in cluster management has been maintained – a strength that was already prominent and continues to be so.

- **Cluster members' perspective.** Regarding management processes, respondents note a moderate level of involvement and highlight the need for greater transparency and systematisation of coordinator activities. Only a portion of respondents participated directly in developing the cluster's strategy – 28% as members of preparatory teams and 37% through participation in consultations, meaning more than one third of members (35%) had no involvement in this process. These findings show that although strategic documents and action plans exist formally, their development does not broadly engage the cluster community. Simultaneously, more than half of respondents indicated that the number of coordinator staff dedicated to cluster operations is adequate, while one in six considered it insufficient, which may impact governance efficiency. The member perspective suggests that a key challenge for many clusters is not just the existence of management documents and structures but also ensuring meaningful member participation in decision-making and daily activities to strengthen shared responsibility and transparency in governance.

4.3.2. Cluster communication

In the sub-area "Cluster communication", the average results remain considerably below the benchmarks, indicating that although some clusters have established strong communication practices, most still demonstrate limited effectiveness and engagement in this field.

Figure 24. Mean and benchmark for the sub-area: cluster communication



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area "Cluster communication" reveals considerable variation between clusters regarding internal cooperation. Although the top-performing clusters achieve very high results—such as intensive collaboration in sales, promotion, and innovation activities—the overall results (e.g., the average scores) remain moderate. In many clusters, joint purchasing, shared marketing activities, or collaborative innovation projects are still not standard practices. Internal communication, while present in most initiatives, often remains basic and does not involve all members with equal engagement. From the perspective of firms participating in clusters, the outlook is more positive – over half of enterprises report tangible benefits from cluster membership. The challenge for the future is to strengthen systematic cooperation, especially in smaller and younger structures, so that the potential for market-oriented collaboration can be more fully realised. Results at the level of individual indicators:

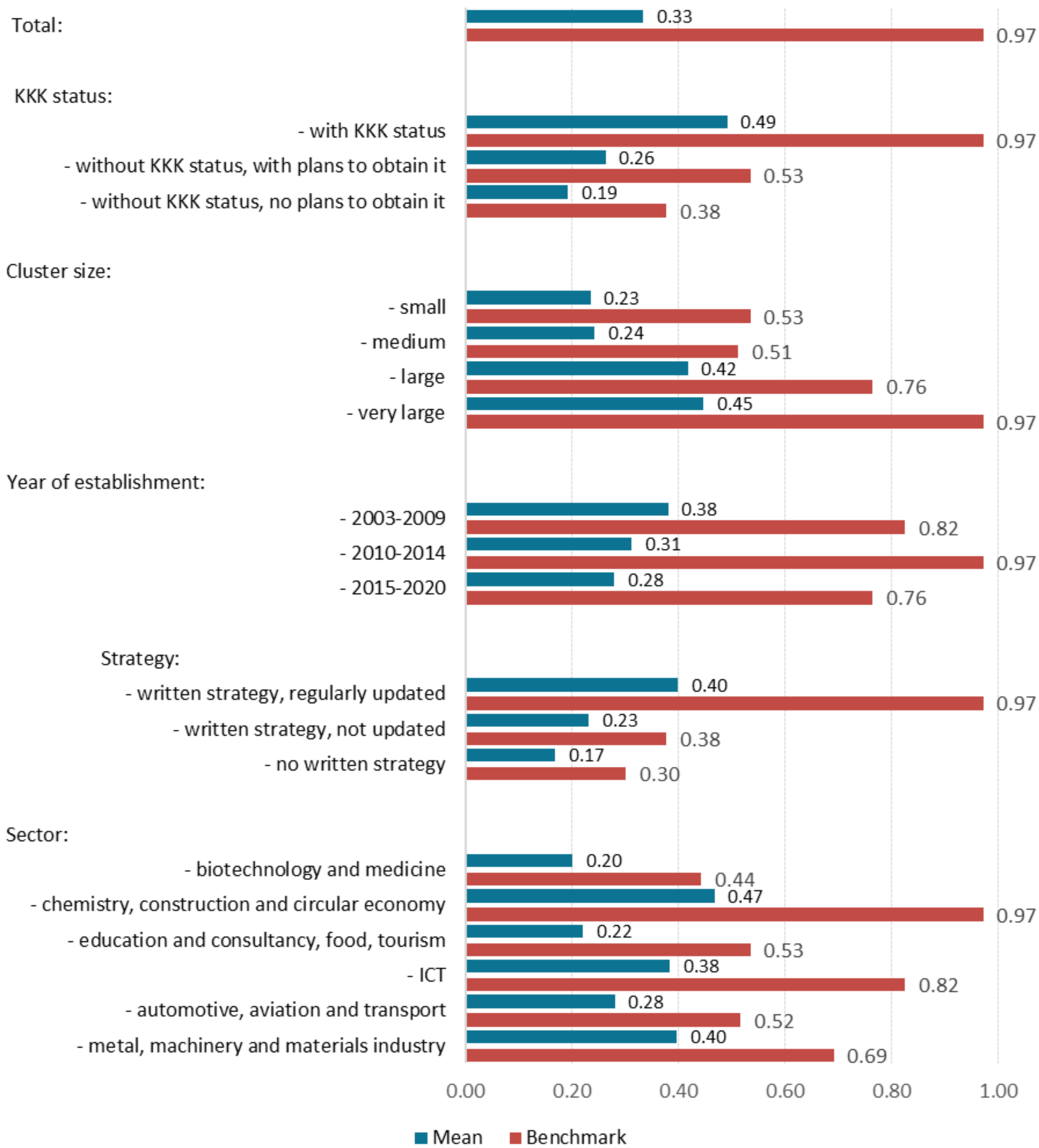
- **Internal cooperation**. Internal cooperation processes pertain to collaboration among cluster members – including joint initiatives, projects, and resource sharing – as well as effective communication within the network. The study examined, among other aspects, collaboration within the value chain (e.g., joint procurement, distribution, or production cooperation), joint marketing activities (such as shared promotion, participation in trade fairs and exhibitions), and innovation-related activities within the cluster (use of pro-innovation services, presence of technology transfer organisations, joint R&D projects). The results prove to be diverse. On one hand, top-performing clusters achieved very high scores across internal cooperation sub-areas – with leaders in every category (market, marketing, and innovation) scoring close to the maximum. This indicates strong potential: some clusters collaborate intensively (in joint sales, promotion, and innovation deployment). On the other hand, average values and medians in these categories remain moderate or even low. For example, the median for market and marketing activity was around 0.28, and 0.34 for innovation activity – significantly lower than for management processes. This suggests that, alongside a group of leading clusters, internal collaboration is not yet fully developed in many others. Joint purchasing or joint online sales remain rare, as do joint marketing projects – activities requiring high levels of trust and alignment, which are not always present.
- **Communication**. Effective communication within a cluster is essential for successful cooperation. Most initiatives reported holding regular member meetings (such as assemblies and workshops) and using dedicated communication tools (like intranets, discussion groups, newsletters, etc.). However, the average score for this indicator was also relatively low (median approximately 0.35). In practice, this often indicates irregular contact with less active members or a lack of modern communication tools in some cases clusters.
- **Cluster members' perspective**. A positive signal comes from the assessments provided by cluster members regarding cooperation. The vast majority of entities involved in

clusters perceive tangible benefits from participation. More than half of surveyed members (53.6%) stated that cluster participation brings them significant benefits, while negative assessments were marginal (only 2.8% of respondents). These declarations indicate that even if the level of formal cooperation is not maximised everywhere, members clearly appreciate the synergies – including information exchange, access to shared infrastructure and projects, as well as easier partner matching and acquisition of new orders. It can therefore be concluded that internal cooperation processes are progressing, although considerable room for improvement remains, especially for smaller and younger clusters. In the area of communication, cluster members assessed electronic communication tools relatively highly – these facilitate day-to-day information exchange and achieved an average score of around 4.0 on a five-point scale.

4.3.3. Market activity

In the sub-area "Market activity", the average values stay well below the benchmark levels, indicating that only a few clusters successfully develop collaboration within the value chain and joint business initiatives, while most have limited activity in this area.

Figure 25. Mean and benchmark for the sub-area: market activity



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The “Market activity” sub-area shows moderate progress in economic cooperation within clusters. Activities along the value chain remain steady – most often concerning marketing, sales, and product development – while interest in export-related actions is rising, reflecting the post-pandemic rebound in activity. Group purchasing continues mainly to focus on advisory and training services, indicating untapped potential in cost-saving areas such as the purchase of raw materials or energy. Development of joint distribution channels is slow – traditional trade fairs still predominate, whereas online sales and shared e-commerce platforms remain niche, though joint tendering is becoming increasingly significant. A positive sign is the noticeable rise in revenues of cluster-based enterprises – their growth rate has been several times higher than the national average, confirming the cluster’s role as both a stabilising force and a driver of growth. Results at the level of partial indicators:

- **Cooperation within the value chain.** In 2022–2023, clusters in Poland showed moderate progress in developing cooperation within the value chain. The average number of jointly implemented stages stayed at approximately 3.1 (median 3.0), indicating stability compared to the previous edition. The most commonly reported activities included marketing and sales, product development, and production processes. A noticeable increase in interest in export-related activities is apparent (45% of clusters compared with 37% in the previous edition), which may reflect the post-pandemic revival of activity and the growing focus on internationalisation. Cooperation remains weaker in areas related to logistics and after-sales services, where changes across editions were minimal—highlighting a persistent gap in full cooperation along the entire value chain.
- **Group purchasing.** Support for group purchasing is available across 27 clusters included in the study. The average number of categories of products and services bought jointly was 1.0 — nearly the same as two years earlier. Significantly, both times, advisory, training, and expert services predominate, while joint procurement of raw materials or energy has hardly gained any importance. This indicates a lack of progress in unlocking the potential of economies of scale – clusters rarely move from “soft” collaborative initiatives to more significant purchasing actions that could lead to cost savings.
- **Joint distribution channels.** The joint distribution of products and services is available in 32 clusters. The average number of distribution channels reached 1.7 (median 1.0), slightly higher than in the previous edition (average 1.5). Traditional trade fairs and exhibitions remain the most commonly used channels, while joint online sales are still limited to a small number of clusters. However, interest in joint tendering has increased (29% compared with 21% in the previous edition), which may reflect growing market competition and the search for alternative ways to obtain contracts.
- **Revenues of cluster-based enterprises.** The average increase in sales value in 2022–2023 was 14.2%, compared with just 3.5% in 2020–2021. This represents a significant rise, highlighting that clusters play a stabilising and growth-promoting role in the post-

pandemic economic recovery. The strongest growth was observed in the metal and automotive sectors, likely due to catching up on production backlogs and increasing domestic and foreign demand. Notably, the revenue dynamics among cluster firms were three times higher than the national average (4.8%), confirming the positive impact of cluster cooperation on the economy performance.

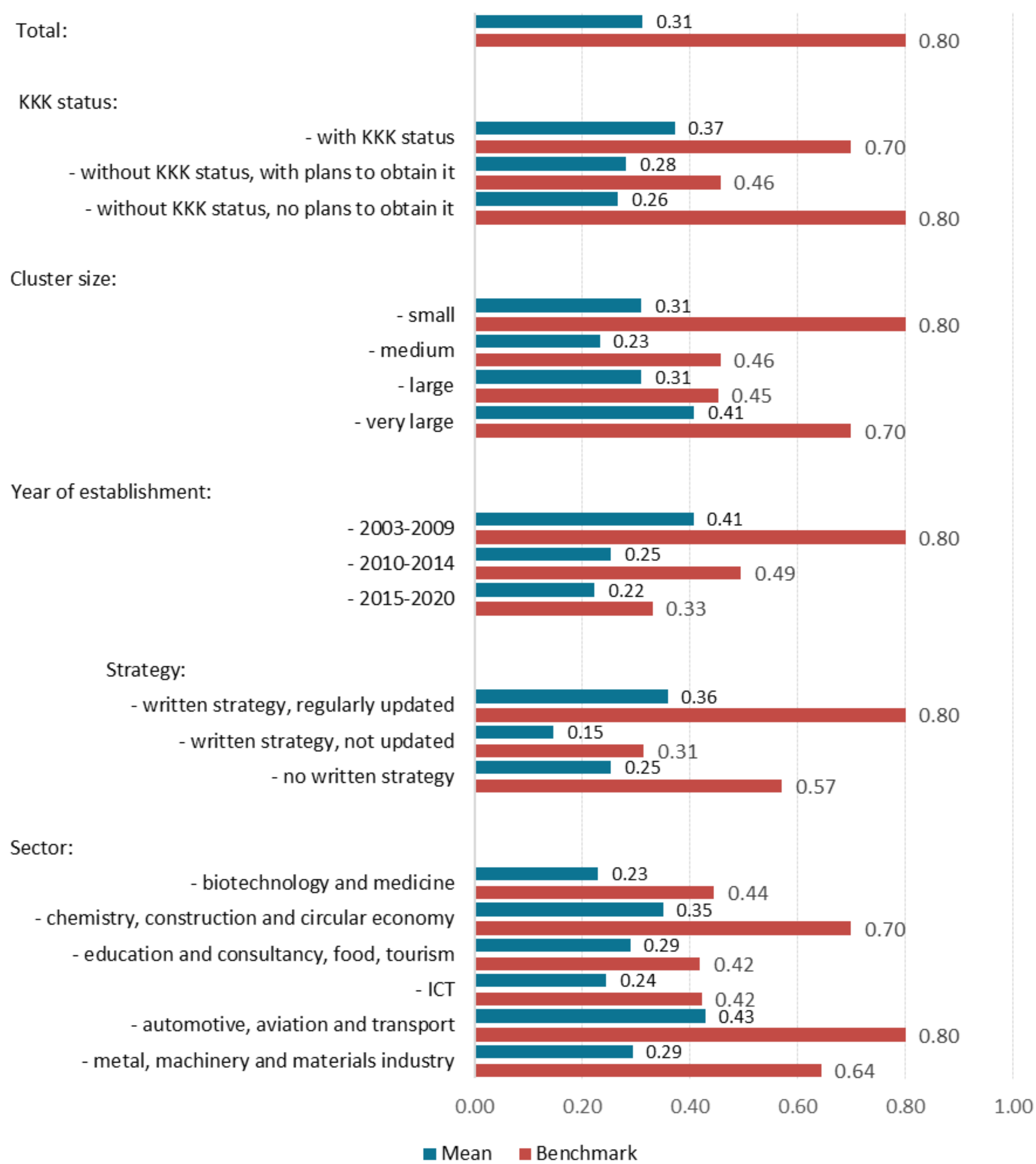
- **E-commerce.** Although the number of clusters reporting online sales among their members increased (16 compared with 12 in the previous edition)[19], the proportion of e-commerce in total revenues remains minimal – the median in both editions was 0%. While the leading clusters improved their figures (78% compared with 65% previously), indicating that some clusters can effectively leverage digital sales channels, most have not implemented solutions that would support the growth of online sales. In this area, systematic efforts are still missing, and barriers may arise from limited technological capabilities or product-specific constraints (e.g., in sectors where e-commerce is less relevant).

[19] The data refer to the indicator entitled "Share of export revenues of cluster-based enterprises in their total sales revenues, calculated for enterprises that generated export revenues in the past year, including the share of e-commerce". This is an example of one of the several dozen indicators used in the benchmarking exercise, the estimation of which requires collecting data directly from cluster members. Only a proportion of the assessed clusters undertake such data-gathering activities. In addition, some financial indicators are not made available by clusters due to the confidential nature of this information.

4.3.4. Marketing activity

In the sub-area "Marketing activity", the average results are significantly lower than the benchmark values, indicating that only some of the clusters effectively conduct joint promotional activities and enhance visibility, while the majority do so on a limited scale.

Figure 26. Mean and benchmark for the sub-area: marketing activity



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area “Marketing activity” shows a clear revival of promotional efforts undertaken by clusters after the pandemic, although their scale and intensity remain very uneven. Online visibility has only partially improved – some clusters achieve high recognisability and attract substantial website traffic, while most still have a limited digital presence. A similar pattern applies to promotional activities: some clusters do them consistently, whereas many only undertake occasional initiatives. Conversely, participation in domestic fairs and other industry events has increased significantly.

From the perspective of cluster members, marketing activity is regarded as a key area of cooperation. Moreover, marketing has been recognised as a priority for the future, suggesting that clusters should enhance their visibility and broaden the range of joint promotional activities as a vital part of building market competitiveness. Results at the level of partial indicators:

- **Online visibility.** In 2022–2023, the marketing activity of Polish clusters showed significant variation, ranging from those with a strong online presence to others with minimal visibility. The number of search engine results for the phrase “cluster name” indicates moderate recognisability – average values declined compared to the previous edition (from 2,410 to 1,404), and the median remains relatively low (143). The highest value reached 15,000. A few clusters are very visible online, while most have limited visibility, which may influence their recognisability among potential partners clients.
- **Website traffic also varied considerably.** Some clusters recorded very high numbers of visits (hundreds of thousands), indicating effective use of online communication tools and high engagement around events. Meanwhile, many clusters reported only symbolic traffic, suggesting that their websites mainly serve as static information points rather than interactive communication channels. Compared to the previous edition, a slight improvement in the average is evident, likely due to the increasing importance of digital activities in the post-pandemic era.
- **Promotional activities.** The number of joint promotional initiatives conducted by clusters and their members remains modest – averaging 4–5 types of activity during the analysed period. These include the use of cluster logos, shared branding (available in 33 clusters), public relations, and advertising (25 clusters). Compared with 2020–2021, the number of such initiatives has risen slightly, indicating a gradual recovery in marketing activities following the pandemic slowdown.
- **Domestic fairs and exhibitions.** Participation in domestic fairs and exhibitions continues to be one of the most significant promotional tools: 33 clusters reported such involvement. In 2022–2023, clusters attended an average of 6–7 domestic events, though the distribution is highly uneven – 13 clusters participated in only 1–3 events, while the most active ones attended more than twenty. This clearly marks an increase

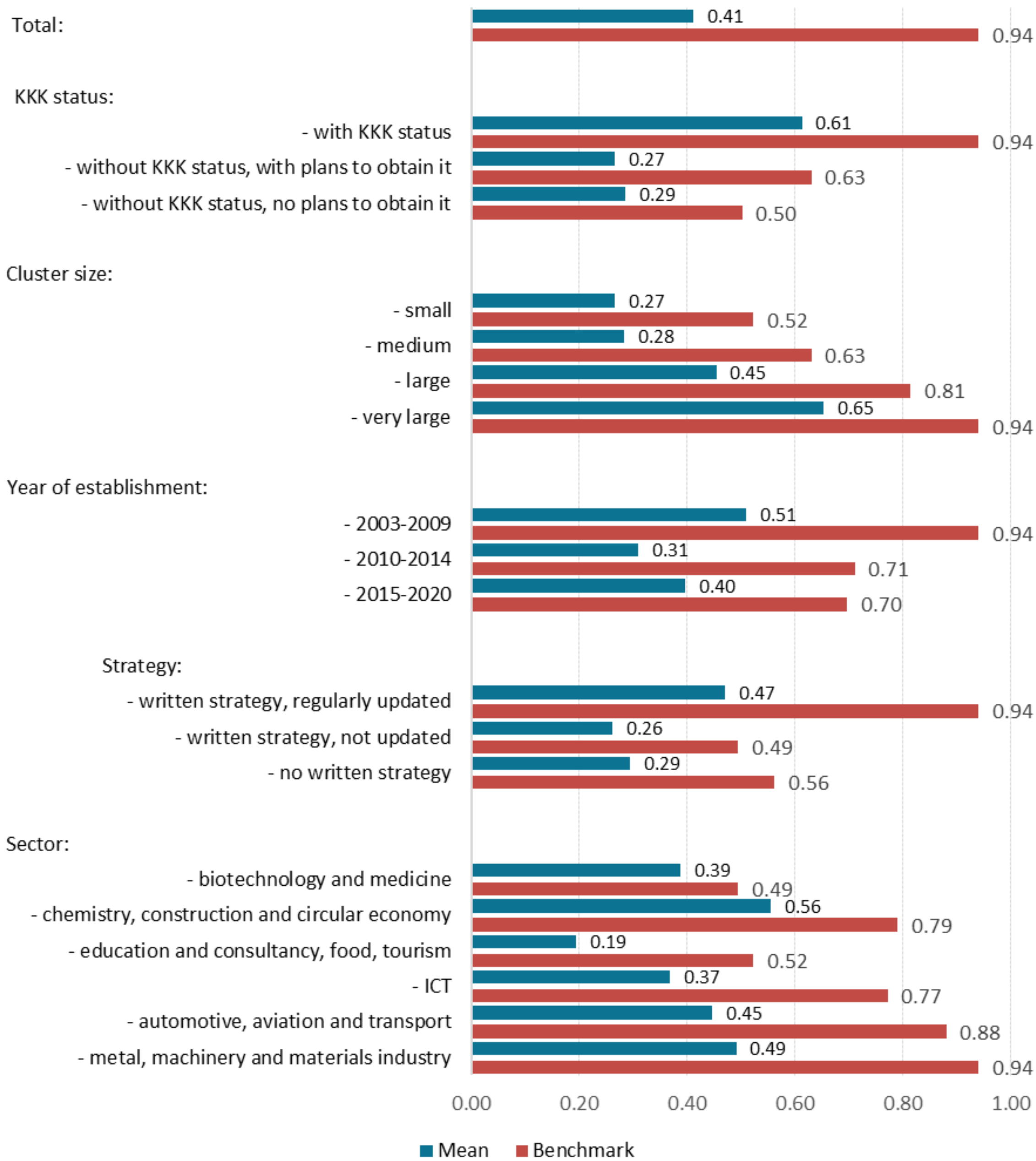
compared to the previous edition, when pandemic restrictions greatly limited these activities. The current results suggest a strong return to traditional promotional and networking formats.

- **Other events.** Additional activities include participation in trade missions, study visits, and industry conferences – reported by 35 clusters. The average number of such initiatives was 4–5 per cluster, with a lower median, indicating that only some clusters develop this area systematically. A noticeable increase compared to the previous period is also evident here, reflecting the lifting of pandemic restrictions and the return of in-person industry events. Overall, marketing activity in 2022–2023 was higher than before but remains quite uneven – with a group of active leaders and many clusters maintaining minimal online visibility and sporadic involvement in events.
- **Member perspective.** Survey findings confirm that marketing activity is regarded as a key area of cooperation and a high priority for cluster members. Joint promotional initiatives were identified as a significant added value – nearly half of respondents (49.7%) confirmed their participation in joint marketing efforts through the cluster, with an additional 21.6% rating these activities as partially achieved. The average evaluation of marketing activity was 4.4 on a five-point scale, making it one of the highest rated functions within the cluster. Furthermore, marketing ranked among the top priorities for the future – its average importance score reached 4.6, reflecting strong expectations to enhance visibility and collaborative promotion, especially in improving market presence and product distribution. These results demonstrate that marketing activity is both valued and considered an essential tool for strengthening the competitiveness of clusters.

4.3.5. Innovation activity

In the sub-area “Innovation activity”, the average results are significantly lower than the benchmark values, suggesting that only a few clusters engage in intensive pro-innovation activities and R&D projects, while most show limited involvement in this area.

Figure 27. Mean and benchmark for the sub-area: innovation activity



Source: own elaboration based on the cluster coordinators’ survey (N = 42).

The sub-area “Innovation Activity” remains one of the weaker aspects of cluster performance. The range of pro-innovation services is limited and mainly includes training, advisory support on intellectual property protection, and commercialisation, with only a small proportion of members utilising these services. Technology audits are uncommon, and technology transfer institutions collaborate with less than half of the clusters. From the members’ perspective, innovation activity is rated as moderate, yet it is also regarded as a priority for the future. Firms may therefore expect coordinators to broaden the portfolio of pro-innovation services, provide stronger support for technology transfer, and initiate joint R&D projects. Results at the level of partial indicators:

- **Pro-innovation services.** In 2022–2023, innovation activity within Polish clusters continued to be one of the least developed areas of operation, although some signs of revitalisation appeared in certain structures. Nearly all clusters (41) provided pro-innovation services. The average number of these services ranged from 3 to 4, while the median was lower, at around 2. The most common forms of support included thematic training, advisory services on intellectual property protection, and assistance with commercialising research outcomes. Compared to the previous edition, there was no clear increase in the number of services, indicating that the development of pro-innovation activities is progressing slowly and remains reliant on access to project-based funding.
- **Use of pro-innovation services by members.** Only a relatively small number of members utilised pro-innovation services – on average, several dozen entities per cluster (around 17.2% of all members across the sampled clusters), with some clusters reporting higher figures. This indicates that even when the offer was more developed, its utilisation was selective and did not reach a wide group of members. Technology audits performed even worse: more than half of the clusters did not carry out a single audit, and the overall average was less than one audit per cluster over the two-year period. For comparison, the results in 2020–2021 were similar, suggesting that systemic barriers (such as limited resources, insufficient competencies, or lack of tailored support) have yet to be overcome..
- **Institutions supporting technology transfer.** Such institutions operated in a significant portion of clusters (34). In some instances, they were academic entities, technology transfer centres, or science and technology parks collaborating with clusters. However, the lack of systematic integration of these institutions into most cluster structures limits their ability to serve as bridges between science and business. Similarly, the purchase of knowledge and technologies (e.g., licences, know-how) for cluster needs was rare and occurred only in isolated cases. This may suggest that many clusters operate with limited financial resources for investment in advanced solutions, or that, at least for

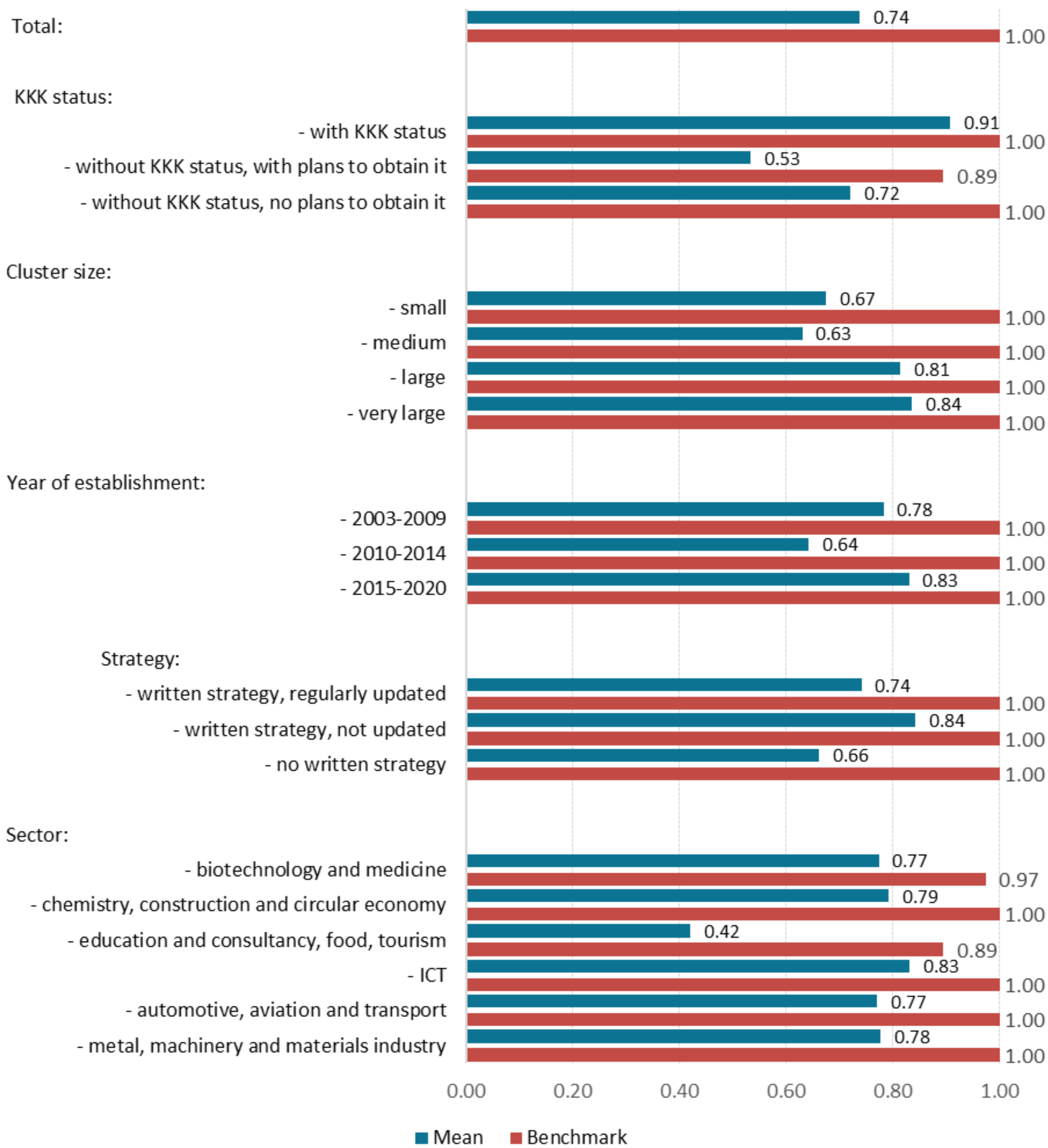
some, external knowledge acquisition is unnecessary because relevant expertise exists within the cluster membership.

- **Cluster members' perspective.** Survey results indicate that innovation activity is rated moderately but shows clear potential for further growth. Only 27.8% of members reported that their organisation participated in joint innovation activities within the cluster, while a further 20.9% indicated that this impact had been partially achieved. The average rating of coordinators' innovation efforts reached 3.6 on a five-point scale, which is lower than those for marketing or integration activities. At the same time, respondents clearly emphasised that innovation remains a future priority – the average importance of innovation in clusters' development plans reached 4.4. This demonstrates strong expectations that coordinators will expand pro-innovation services, enhance technology transfer support and initiate joint R&D projects. The results show that current levels of innovation activity do not fully meet members' needs, yet the area remains one of the key themes for future cluster development.

4.3.6. Cluster digitalisation

In the sub-area "Cluster digitalisation", the average results are fairly high and close to benchmark levels, indicating that many clusters actively adopt digital solutions and Industry 4.0 technologies, although the leaders show markedly stronger results (implementing all types of technologies listed in the questionnaire).

Figure 28. Mean and benchmark for the sub-area: cluster digitalisation



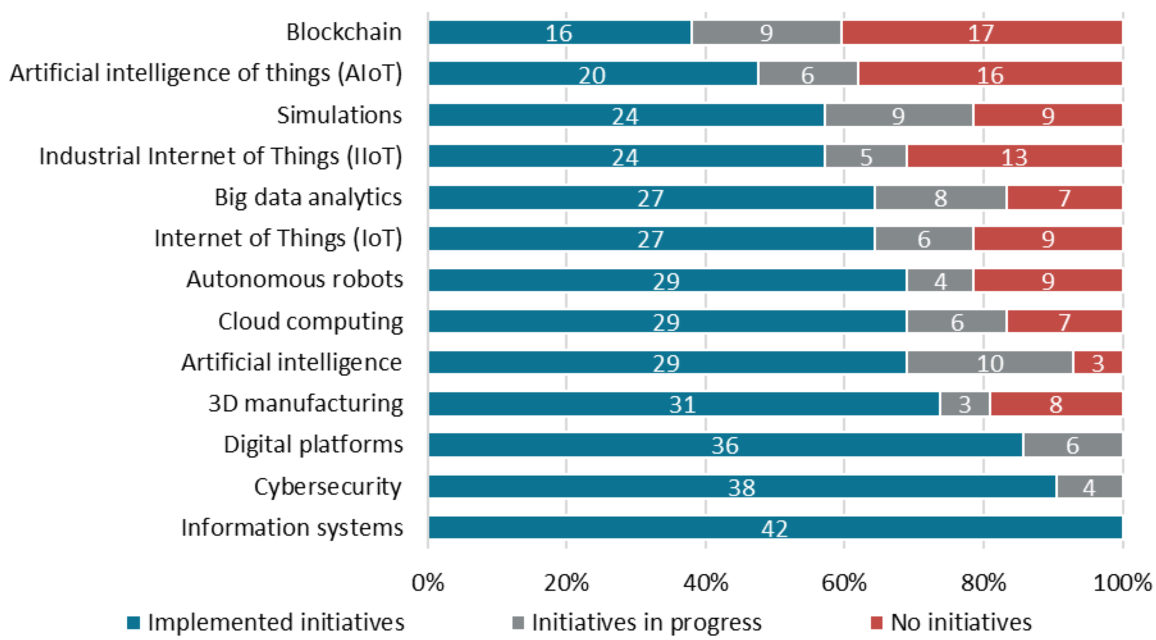
Source: own elaboration based on the cluster coordinators' survey (N = 42).

The "Cluster digitalisation" sub-area stands out as one of the strongest dimensions of cluster performance. Most clusters have already implemented a wide range of IT solutions, with the highest results observed among large, mature initiatives holding the status of a Key National Cluster (KKK), which systematically develop IT platforms and support firms' digital transformation through ERP deployments, process automation, and the introduction of IoT (Internet of Things) technologies. The COVID-19 pandemic accelerated these processes by forcing the adoption of remote tools, and this trend has continued in subsequent years. However, nearly half of all clusters still lack a dedicated digitalisation strategy.

From members' perspectives, the potential of digital transformation greatly exceeds its current utilisation – only about one in three organisations has so far adopted digital transformation services, yet more than half express willingness to do so in the future. This suggests increasing expectations for coordinators to broaden the range of digital services, develop cooperation ecosystems based on Industry 4.0 technologies, and offer more effective support to firms undergoing digital transformation. Results at the level of partial indicators:

- **Cluster digitalisation.** Digitalisation processes proved to be one of the most significant aspects of cluster functioning. The benchmarking evaluated the level of digitalisation across cluster members – including the utilisation of advanced IT tools in management and communication, as well as the adoption of Industry 4.0 technologies within cluster firms.

Figure 29. Use of Industry 4.0 technologies in clusters



Source: own elaboration based on the cluster coordinators' survey (N = 42).

Digitalisation emerged as one of the strongest areas across all clusters. The average score for this sub-area was the highest among all process categories: the mean reached 0.74 and the median 0.78 (with a benchmark maximum of 1.00). By comparison, the median for most other process sub-areas did not exceed 0.40. Digitalisation is therefore a clear differentiator – the average Polish cluster has already adopted multiple IT tools and demonstrates a relatively high level of digital transformation.

- **Digitalisation and cluster size.** The strongest results were observed among very large, long-established clusters holding KKK status and maintaining an up-to-date strategy. In other words, the more mature and professionally managed the cluster, the higher its level of digital advancement. These clusters frequently invest in platforms that streamline cooperation (e.g., partner-matching portals, CRM systems for members, shared project-management tools) and promote digital transformation within firms (ERP implementation, production process automation, IoT, etc.). Smaller clusters—especially those representing traditional sectors—recorded lower levels of digitalisation, often being at the initial stages of the transformation process. COVID-19 served as a major accelerator, driving the adoption of remote communication and cloud tools, with these practices becoming a lasting element of cluster operations.
- **Digitalisation strategy.** Although there are strong overall results, room for growth remains. According to coordinator data, nearly half of clusters still lack a dedicated digitalisation strategy or only have a general strategy loosely connected to digital transformation. This indicates that even though digital tools are being adopted, the wider planning of digital development – both at cluster and firm levels – is still unfinished. Recent support measures aim to close this gap. For example, the "Development of cluster services for enterprises" call (Measure 2.17 FENG), launched in 2023, strongly focuses on cluster projects encouraging digital transformation among SMEs and the adoption of advanced technologies. Consequently, digitalisation is likely to become even more important in the coming years, fostering the development of digitally enabled cooperation ecosystems and technologically integrated value chains.
- **Cluster members' perspective.** Interest in digitalisation and Industry 4.0 technologies clearly surpasses current service adoption. Only 31.1% of respondents reported using digital transformation services provided by their cluster, while 56.7% expressed a desire to use them in the future, and just 12.2% saw no need for this. This indicates that digitalisation is regarded as a strategically important area, but the current offerings and their utilisation fall short of expectations. Many firms actively seek support in this field, presenting a significant opportunity for clusters to expand their service portfolio – from advisory support to practical technological adoption. Survey results also show that one in three organisations (30.0%) experienced improvements in their operations thanks to cluster involvement, while 40.9% reported no noticeable effect and 29.1% could not

assess it. Expectations for cluster actions in the area of digitalisation and Industry 4.0 are high – the average importance rating reached 4.4 on a five-point scale[20].

[20] The survey offered the following response options: “No”, “Average”, “Yes”, and “Don’t know / hard to say”. To enhance the readability of the analysis, these responses were quantified and presented numerically, where 1 corresponded to “No”, 3 to “Average”, and 5 to “Yes”. An average score was then calculated based on the cluster members’ responses.

4.4. Cluster results

Another benchmarking area, "Cluster results", concerned the assessment of cluster development in 2022–2023 across the following sub-areas:

- **Development of collaboration in the cluster** – incubation of new business activities (start-ups, spin-offs/spin-outs), joint project implementation, building joint market offers, joint sales, securing joint contracts, and strengthening public–private partnerships;
- **Development of innovation in the cluster** – joint activities in the field of research, development and innovation (R&D&I), knowledge transfer within clusters, and the protection of industrial property;
- **Development of competences in the cluster** – the number of initiatives aimed at enhancing the competences of representatives of cluster members and the coordinator's staff.

In the Cluster results area, the highest score – 0.90 – was achieved by one of the clusters included in the study. This outcome reflects a very high level of development across all sub-areas, including the development of collaboration within the cluster, the initiation of innovation-related activities, and the strengthening of member and coordinator staff competences. This cluster stands out in particular due to its strong engagement in joint project implementation, the creation of joint market offerings, and initiatives aimed at enhancing innovation capacity and human capital. At the same time, the relatively low values of the average and median (0.25 and 0.13 respectively) indicate that a substantial proportion of clusters demonstrate limited activity in this area.

Table 6. Assessment for the area: cluster results

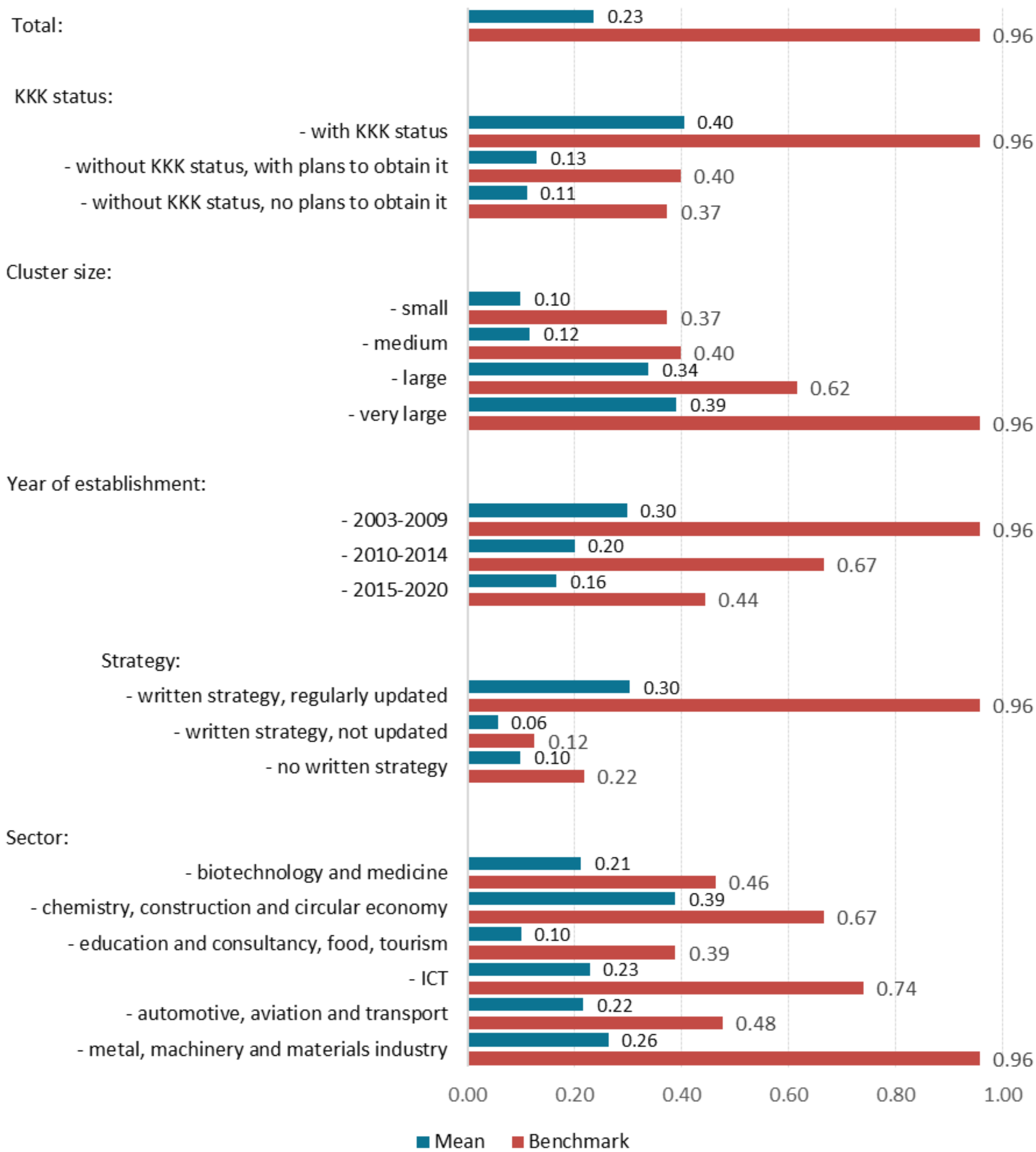
Sub-area	Mean	Median	Benchmark
Development of collaboration in the cluster	0.23	0.15	0.96
Development of innovation in the cluster	0.25	0.11	1.00
Development of competences in the cluster	0.34	0.30	0.83
Overall score for the area	0.25	0.13	0.90

Source: own elaboration based on the cluster coordinators' survey (N = 42).

4.4.1. Development of collaboration in the cluster

In the sub-area "Development of collaboration in the cluster," the average results are notably lower than the benchmarks, indicating that only a few clusters effectively develop joint initiatives and projects, while most operate on a limited scale.

Figure 30. Mean and benchmark for the sub-area: development of collaboration in the cluster



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area "Development of collaboration in the cluster" emphasises the broad scope of joint activities conducted within Polish clusters. The formation of new companies and cooperation between large firms and start-ups remains limited – occurring only in a handful of clusters. Joint projects co-financed from public funds are more prevalent, although their number and size vary greatly, and widespread participation of members remains uncommon. Joint products, services, production collaboration, or shared sales are still characteristic of only a small number of clusters, as are joint procurements, which tend to be focused in a few more established, sector-specific initiatives. From the members' perspective, however, the outlook is more optimistic – most firms confirm that participation in a cluster helps build relationships, foster integration, and promote collaboration, with some reporting involvement in innovative or R&D projects. This suggests that clusters play a significant role in shaping networks of connections, although their potential to produce measurable business results has not yet been fully realised indicators[21]:

- **New firms and start-ups within clusters.** Cluster activity in creating new entities (start-ups, spin-offs/spin-outs, special-purpose vehicles) remains limited and concentrated in a small number of clusters. On average, about 1.9 such enterprises were established per cluster in 2022–2023, although the median was zero, indicating that at least half of the clusters did not generate a single new entity of this kind. Only 19 clusters reported any new firms, and just two clusters recorded more than 10. Compared to the previous edition (2022), the situation stayed similar – the average was also 1.9 and the median zero, with 15 clusters reporting any new firms, two of which exceeded 10. These results point to a high level of concentration: while most clusters do not produce new companies, a few highly active clusters account for almost all such activity (maximum 14 in 2024, compared with 21 previously).
- **Cooperation between large firms and start-ups.** A similar pattern appears in cases of collaboration between technology start-ups and large companies within clusters. The average number of documented cases was around 2.0 per cluster, with a median of 0, indicating that most clusters recorded none. Such collaborations took place in 20 clusters, but most were isolated examples. Only one cluster stood out, reporting 23 cases of cooperation. Compared to the previous edition, the figures are similar – 19 clusters reported such cooperation in 2020–2021. The consistently low median confirms that only a few clusters specialise in connecting start-ups with large enterprises, while most do not engage in this activity at all.
- **Joint projects co-financed from public funds.** Joint projects within clusters (e.g., research, investment, or development projects) funded by public sources are fairly common, although their scale varies greatly. In 2022–2023, 32 clusters (76%) reported

[21] The complete set of partial indicators for the "Cluster results" sub-area is provided in Annex 12.1.3.

at least one such project. The average number was 3.2 per cluster, with a median of 2, and only three clusters carried out 10 or more projects. This indicates that while participation in public projects is widespread, most clusters undertake a relatively small number of initiatives – half no more than two. Compared with the 2022 edition, the proportion of active clusters increased slightly (previously 29 clusters), and the average remained similar. In both editions, only three clusters completed ≥10 projects, suggesting a stable core of project leaders.

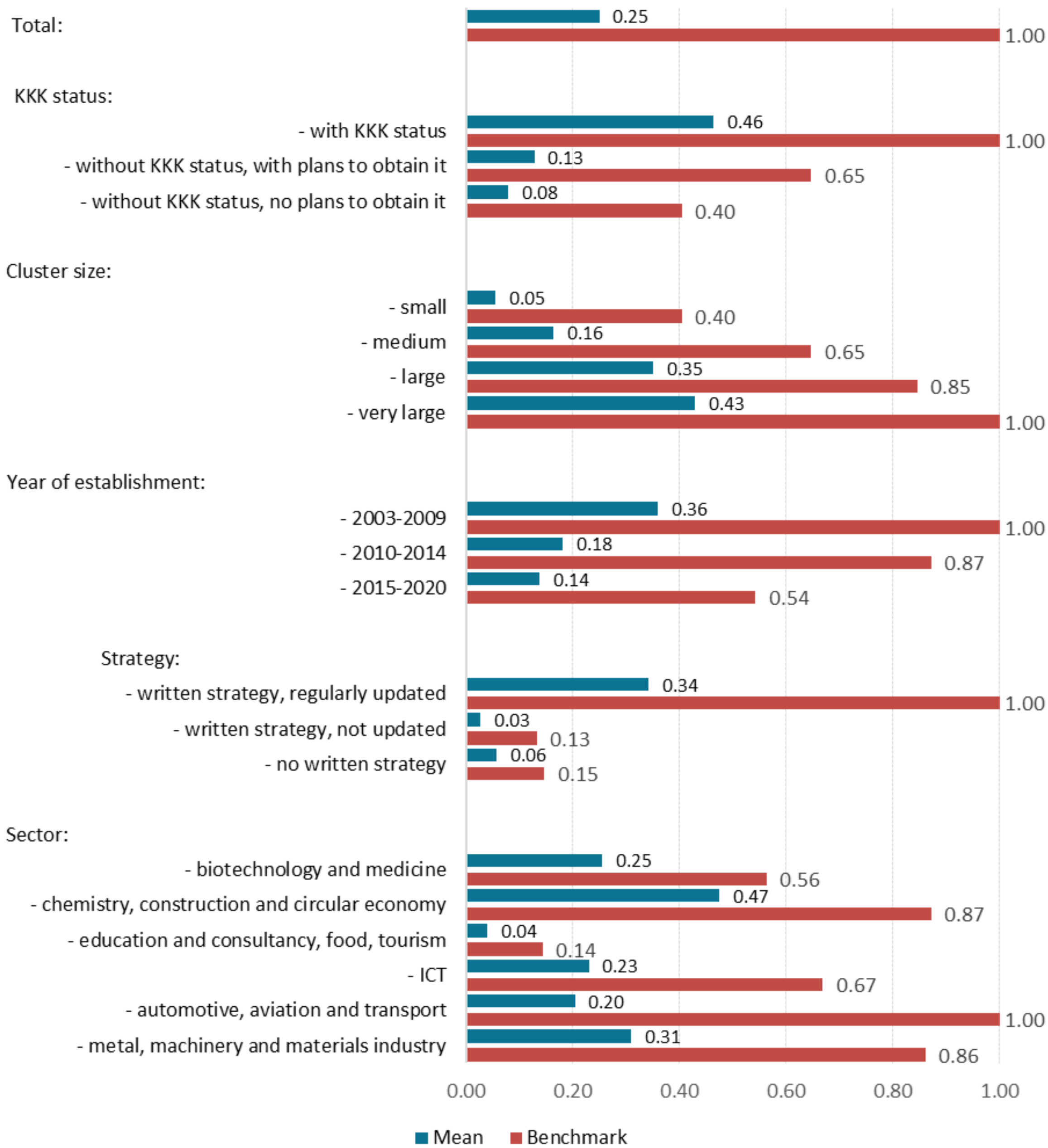
- **Member involvement in projects.** On average, 18.4 members participated in joint publicly co-financed projects, with a median of 10. This equates to about 17.5% of the total membership across all clusters, indicating that only a relatively small proportion of firms take part in such initiatives. Only 11 clusters involved more than 20 members, with the rest showing lower participation levels. In the previous edition, the average was 20.1 (but with a median of just 5), highlighting strong polarisation – a few clusters engaged many partners, while most engaged very few. The decrease in the share of members involved (from 40.7% to 17.5%) underscores a persistent difficulty in encouraging widespread participation, with activity usually led by a small core of highly engaged organisations.
- **Value of implemented projects.** Clusters differ greatly in the financial value of their jointly funded publicly co-financed projects. The average declared value was around PLN 22.8 million (median PLN 2.1 million), but the differences were considerable – the leading cluster reported a total of PLN 295 million. Nine clusters reported no project value at all, meaning that the vast majority (33) engaged in publicly funded projects. Seven clusters recorded projects worth less than PLN 1 million, while in 14 clusters the value exceeded PLN 10 million. Similar variation was seen in the previous edition (average PLN 26.9 million, median PLN 0.7 million, maximum PLN 312 million). The lower number of clusters not reporting values (9 vs 17 previously) suggests improved reporting and possibly broader access to funding. Nonetheless, the distribution remains highly uneven – only a few clusters secure substantial resources, while many operate on a smaller scale.
- **Joint products and services.** Joint products or services developed by cluster members were reported by 24 clusters, although in most cases the number of new solutions did not exceed 10. The average was 3.5 per cluster, with a median of 1, indicating that half of the clusters developed no more than one new joint product or service. One leading cluster reported 16 (benchmark). Results are similar to the previous edition, when 22 clusters reported new joint products/services (average also 3.5, median 1.5), with a top result of 30. Although a few clusters achieve notable outcomes, the low median suggests that product-oriented cooperation remains marginal for most.

- **Joint production and service delivery.** Twenty-five clusters (60%) reported cooperation among members in joint production or service delivery. However, the scale remains modest – on average, about seven entities per cluster were involved, with a median of three. Across all clusters, fewer than 300 entities participated in such activities (less than 7% of all members). Only seven clusters engaged more than ten firms, while most involved only one or two. Compared with the 2022 edition, the situation remains similar – previously, 22 clusters reported joint production (average 6.9 firms, median 2, with under 5.5% of members involved). This indicates a lack of strong mechanisms to encourage firms to jointly develop market offers, with most focusing on their own initiatives and business cooperation emerging only sporadically.
- **Joint sales.** Only a small number of clusters generate joint sales of products or services on a meaningful scale. Fifteen clusters (around 36%) reported revenue from jointly offered products or services. The average declared value was PLN 15.1 million, but the median was zero, indicating that over half of the clusters do not conduct joint sales or do not measure them separately. Variation is considerable – the highest figure was PLN 500 million. Coordinators note that such revenues are often difficult to estimate, which suggests the actual number of clusters engaged in joint sales may be higher. In 2020–2021, this was even less common – only eleven clusters reported such revenues. Overall, only a few clusters generate significant joint income, most likely due to the presence of large firms or consortia.
- **Joint procurements** (e.g., jointly won tenders delivered by several firms) were reported by 19 clusters – almost half of those surveyed. The average number of joint procurements was 6.2 over two years, with seven clusters reaching at least 10. In 2022, slightly fewer clusters (16) reported such activities, although the average was higher (9.0), likely due to one exceptionally active cluster. Overall, joint tendering is not yet widespread, and only certain clusters – typically the more organised or sector-specific – achieve stronger results in this area.
- **Cluster members' perspective.** Cluster members highly value the development of cooperation – 64.2% indicated that participation in the cluster helped to establish and strengthen relationships. Furthermore, 40.0% reported engaging in cluster projects, and nearly half (49.7%) in innovation or R&D activities. Joint marketing efforts were noted by 49.7%, while 69.6% emphasised integration through relationship-building. At the same time, there is scope for improvement, particularly in developing local supply chains, which only one in four organisations experienced as an outcome. Overall, the results affirm that clusters play a significant role in connection-building and cooperation, although their potential to generate full network effects has not yet been fully realised.

4.4.2. Development of innovation in the cluster

In the sub-area "Development of innovation in the cluster", the average results remain significantly below the benchmark values, indicating that only a small number of clusters actively participate in joint R&D projects and innovation efforts, while most demonstrate limited activity in this field.

Figure 31. Mean and benchmark for the sub-area: development of innovation in the cluster



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area "Development of innovation in the cluster" shows a clear decline compared to the previous benchmarking edition. The downturn affects both the number and value of innovation and R&D projects, as well as member involvement, the number of implemented innovations, and technology transfers. The only indicator that remains relatively stable – and even increases – is the number of filed and granted intellectual property rights, although this concerns only a limited group of clusters. Overall, the results highlight the need to strengthen mechanisms for joint project implementation, build absorptive capacities among members, and intensify processes of knowledge commercialisation and innovation diffusion. Results at the level of partial indicators:

- **Innovation and R&D projects.** In the current edition, the number of joint innovation and R&D projects conducted within clusters decreased significantly. The average dropped from 4.0 in the 2022 edition to 1.8 in 2024, while the median fell from 2.0 to 0.0. A total of 19 clusters reported at least one such project, compared with 27 in the previous edition. Only two clusters achieved double-digit figures (10 and 11 projects), whereas two years earlier, the leading cluster reported as many as 73 innovation-related projects. This indicates a clear slowdown in the overall pace of cluster-based R&D collaboration.
- **The number of members involved in joint innovation projects also fell.** The average decreased from 9.4 to 7.6, and the median from 4.0 to 1.0. In 2022, an average of 8.9% of all cluster members (376 out of 4,208 entities) participated in R&D projects; today, this share is at 6.5% (321 out of 4,942 entities). Only 11 clusters had at least 10 participating members. These results show that R&D cooperation remains limited and does not involve a wide range of enterprises.
- **A decline is visible also in the value of projects implemented.** In 2022, the average value reached PLN 18.1 million (with as much as PLN 27.5 million among active clusters), and the median was PLN 1.1 million. Currently, the average has decreased to PLN 15.2 million, and the median to PLN 0.0 – indicating that many clusters were unable to report any financial value for their R&D activities. Conversely, 13 clusters reported project values exceeding PLN 5 million, demonstrating that despite the overall decline, some structures continue to attract substantial funding. Among those clusters active in this field, the average value reached PLN 36.4 million.
- **Implementation of product and process innovations.** The number of implemented product innovations more than halved. The average dropped from 15.6 in 2022 to 5.8 in 2024, and the median decreased from 2.0 to 1.0. The previous edition's leader reported as many as 294 implementations; the current leader reached 133. A similar trend is evident in business process innovations – the average declined from 9.1 to 4.2, while the median remained at 0.0. In 2022, the most active cluster recorded 123 such

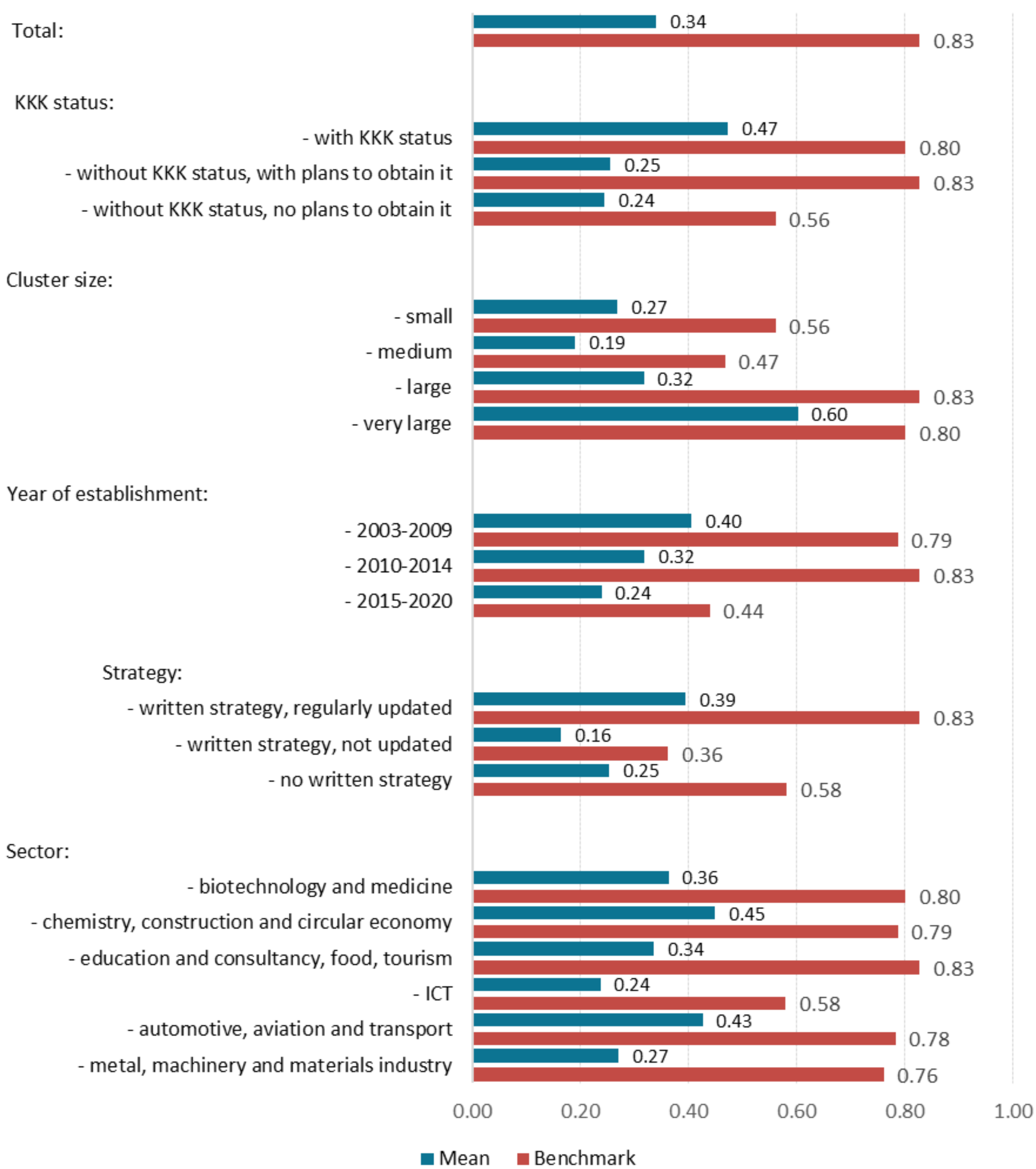
innovations; now the leader achieved 57. These results indicate that innovation diffusion within clusters has weakened significantly.

- **Technology transfer.** Only 15 clusters reported any technology transfer activity, compared with 22 in the previous edition. The average number of transfers declined from 3.7 to 2.0. Previously, six clusters reported at least 10 transfers; now only three have reached that threshold. The results confirm that technology transfer activities remain incidental rather than systemic, which limits the potential for innovation diffusion within cluster structures.
- **Patents and intellectual property rights.** Amidst declines in other indicators, the volume of filed and granted IP rights remains notable. In 2022, cluster members submitted 368 applications and secured 279 rights (average 9.0). In the 2024 edition, filings dropped to 167, but granted rights rose to 343, increasing the average to 12.1. Simultaneously, this activity has become concentrated within fewer structures—12 clusters compared with 16 in 2022. These figures suggest that, although current activity has slowed, the impact of earlier filings is now evident in the form of granted rights.
- **Cluster members' perspective.** Innovation development within clusters is viewed moderately positively, although the outcomes clearly show selective effects. More than one third of respondents (36.9%) reported that their organisation introduced new product or process innovations thanks to cluster participation. Notably, 27.8% of members engaged in joint innovation initiatives, and a further 20.9% regarded these effects as partially achieved. This suggests that while clusters create favourable conditions for innovation, only a smaller group of firms actively benefit. The high proportion of "No" and "Difficult to say" responses indicates that innovation effects are not yet widely experienced among members. These results imply that the potential of clusters in supporting innovation remains largely underexploited and needs strengthening, particularly through the development of pro-innovation services and mechanisms for technology transfer.

4.4.3. Development of competences in the cluster

In the sub-area “Development of competences in the cluster”, the average results are noticeably lower than the benchmarks, indicating that only some clusters undertake extensive training and educational activities, while most conduct them to a limited degree.

Figure 32. Mean and benchmark for the sub-area: development of competences in the cluster



Source: own elaboration based on the cluster coordinators’ survey (N = 42).

The sub-area “Development of competences in the cluster” shows an increase in the number of initiatives aimed at enhancing competences within clusters in the current edition of the cluster benchmarking. Overall, clusters are becoming more active in developing the skills of both their members and their management teams. This is a positive finding in light of the previously observed decline in innovation. The results suggest that the educational and training capacity of clusters remains one of their main strengths. Results at the level of partial indicators:

- **Number of initiatives aimed at enhancing the competences of cluster members.** In the latest edition of the study, there was an increase in the number of initiatives aimed at enhancing the skills of cluster members. The average was 27.6 and the median 19.0, compared to 25.7 and 15.0 in the 2022 edition. The maximum value also rose from 121 to 157. This indicates that clusters are becoming more active in organising training and educational activities. In the 2022 edition, only two clusters reported no such initiatives; in the current edition, there were three, while 26 structures carried out at least 10 activities. Notably, a total of 519 courses, training sessions, and workshops, along with 429 conferences, seminars, and webinars, were recorded across all surveyed clusters. The main themes included digital transformation and Industry 4.0, green transformation and the circular economy (GOZ), internationalisation, and innovation financing. More specialised training is also developing, covering areas such as law, safety, new technologies, ESG, cybersecurity, and collaboration with the public sector.
- **Number of entities participating in competence-building activities.** A clearer increase is observed in the number of entities involved in competence-building initiatives. In the 2022 edition, the average was 78.9, the median was 60.0, and the maximum was 245. In the current edition, these figures rose to 103.0, 58.5, and as many as 401 respectively. A total of 4,327 participations were recorded, compared with 3,235 two years earlier. It is not straightforward to convert these figures into the share of members engaging in such activities, as a single entity may have participated in multiple forms. Especially high levels of activity were noted in large and very large clusters, particularly in the ICT sector, where the number of participants often exceeded 200, and in eight instances, was above 100. It should be remembered that this indicator allows for multiple counts of the same entity if it participated in several initiatives.
- **Number of training activities for the cluster coordinator’s staff.** The indicator related to training for the cluster coordinator’s staff has also improved compared to the previous edition. In the 2022 edition, the average was 5.8, the median 4.0, and the maximum 20. These figures have now risen to 8.4, 3.5, and as many as 150, respectively. Only seven clusters reported no activity in this area, while in 10 cases the number of training activities exceeded 10. This suggests that coordinators are increasingly investing in developing their own skills, which could lead to better management of the cluster structure and more effective support for its members.

- **Cluster members' perspective.** Competence development is a tangible outcome of participation in clusters – nearly 60% of respondents confirmed that employees in their organisations had engaged in training, workshops, or courses organised within cluster structures. This demonstrates that clusters are important for creating opportunities for upskilling and knowledge sharing, especially in technical, managerial, and emerging technology areas. However, 28.9% of respondents indicated that their organisation had not yet utilised such support, and 11.2% found it difficult to provide a clear answer. This indicates that, despite high activity levels and clear benefits, not all companies are equally involved (or see themselves as involved) in competence-building activities. The findings point to the need to expand the reach of educational offerings and tailor them more effectively to the specific needs of different member groups, so that competence development can become a more inclusive and widespread result of cluster cooperation.

4.5. Cluster impact on the environment

Within this benchmarking area, the following sub-areas were assessed:

- **Cooperation with the external environment** – collaboration between the cluster and external entities such as public authorities, business support institutions, the R&D and education sector, as well as other cluster organisations and business associations;
- **Influence on shaping external conditions** – participation in consultative bodies at national and regional levels, activities with social impact, and lobbying-related initiatives;
- **Impact on the natural environment** – the number of initiatives aimed at improving the state of the natural environment;
- **Specialisation and advanced technologies** – the number of enterprises conducting economic activity aligned with the cluster's National Smart Specialisation and Regional Smart Specialisation, as well as the number of enterprises engaged in technologies considered essential for the EU's future economic development (Key Enabling Technologies – KETs).

In the "Cluster impact on the environment" area, one of the clusters achieved the highest score of 0.92, while the second-best cluster recorded a significantly lower score of 0.75. This result signifies a very high level of activity in key sub-areas, including cooperation with the institutional and business environment, participation in consultative bodies, and initiatives aimed at shaping regional and national framework conditions for development. This cluster also stands out for its environmental protection initiatives and strong alignment with National and Regional Smart Specialisations. Meanwhile, the relatively low average and median values (0.33 and 0.30 respectively) suggest that a considerable proportion of clusters achieved low or average results in this area. At sub-area level, some clusters attained maximum or near-maximum scores, as evidenced by benchmark values at or close to 1.00 across each of the assessed sub-areas.

Table 7. Assessment for the area: cluster impact on the environment

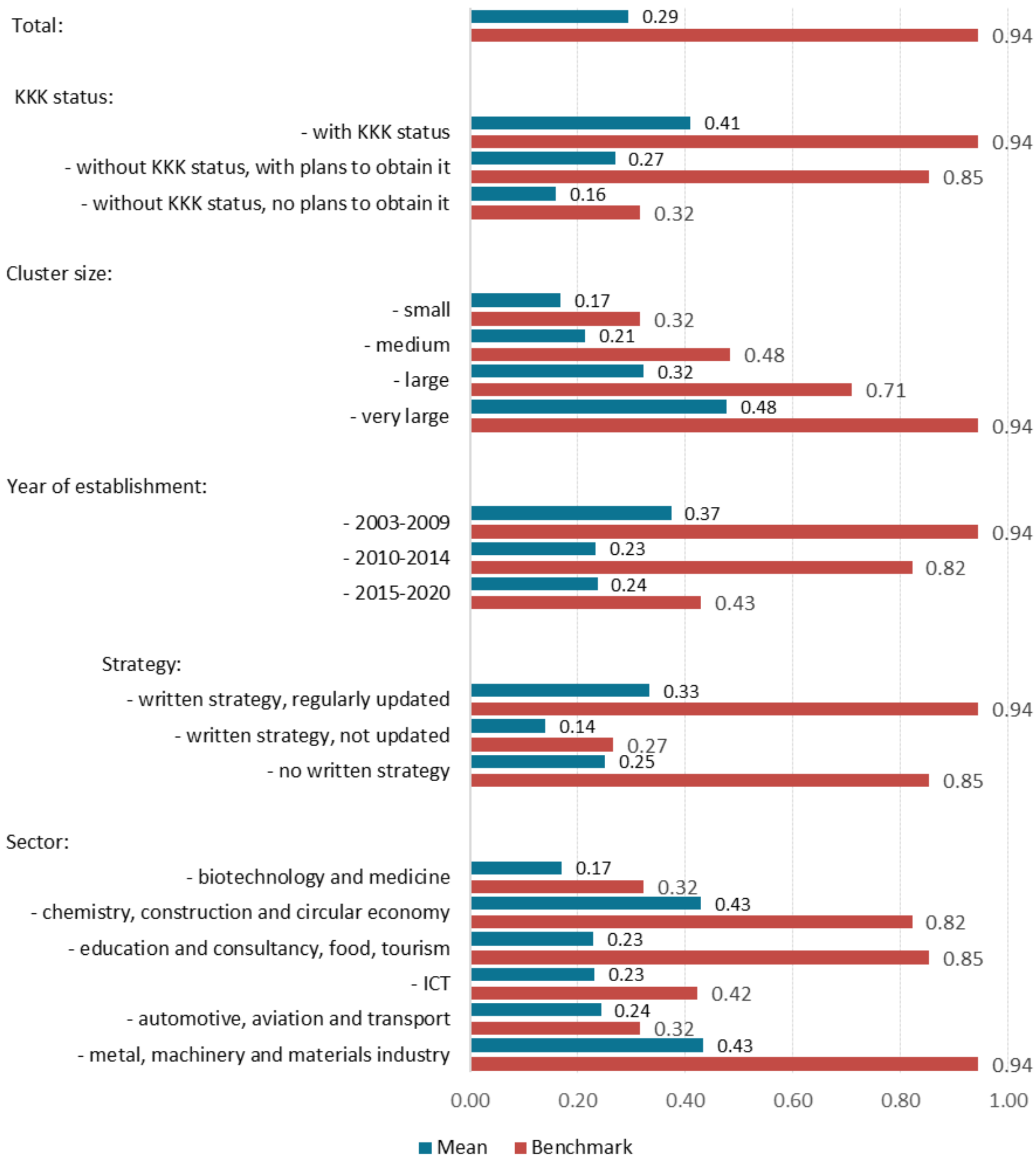
Sub-area	Mean	Median	Benchmark
Cooperation with the external environment	0.29	0.27	0.94
Influence on shaping external conditions	0.41	0.42	1.00
Impact on the natural environment	0.40	0.38	1.00
Specialisation and advanced technologies	0.32	0.25	1.00
Overall score for the area	0.33	0.30	0.92

Source: own elaboration based on the cluster coordinators' survey (N = 42).

4.5.1. Collaboration with the external environment

In the sub-area "Collaboration with the external environment", the average results are significantly below the benchmarks, indicating that only a few clusters establish broad and systematic relations with business support institutions, the R&D sector, or public administration, while most operate in this area in a limited manner.

Figure 33. Mean and benchmark for the sub-area: collaboration with the external environment



Source: own elaboration based on the cluster coordinators' survey (N = 42).

"Collaboration with the external environment" indicates that although Polish clusters interact with public authorities, business support institutions, and the R&D/education sector, this collaboration varies considerably in scope and depth. Some clusters hold numerous formal agreements and actively utilise different forms of support (especially promotional and financial), yet many have no formalised contacts with public administration or academia at all. Relationships with business support institutions are relatively common but not universal, while cooperation with the R&D and education sectors often remains limited to isolated initiatives – despite the presence of a few leaders with extensive networks of partnerships. A positive development is the increasing involvement of some clusters in skills development, including co-creating new education programmes or organising internships and student placements. Conversely, inter-cluster cooperation remains far from widespread and is restricted to a small number of formal agreements.

From the members' perspective, cooperation with the external environment is visible but not yet regarded as a major strength: fewer than half of respondents report stronger links with academia, and the role of clusters as partners in shaping public policies remains limited. Overall, the findings indicate that clusters have the potential to exert a greater influence on their institutional and educational environment, though their current impact is mainly restricted to a few more advanced initiatives. Results at the level of partial indicators:

- **Public authorities.** On average, clusters maintain around eight active agreements with public authorities, but the median is only two – meaning that half of all clusters have two or fewer such agreements. One third (14 clusters) have no formal cooperation with local or central government at all (previously 15). A small number of highly active clusters drive the average upwards, indicating substantial variation across the population. While many clusters have no formalised links, some level of informal interaction (e.g. participation in consultations or local events) may still occur, so the absence of an agreement does not necessarily imply the absence of cooperation.
- **Forms of support from public authorities.** On average, clusters receive about two types of support (with a median of two). The most common are promotional activities (57% of clusters) and financial support (45%). Training/educational and organisational support are also quite frequent (33% each), with organisational support increasing since the previous edition. Legal assistance remains uncommon (7%). Some clusters benefit from additional mechanisms beyond the standard list, such as participation in CORNET calls or regional projects. Overall, the structure of support stays similar to the previous edition, with promotion and funding remaining the main pillars.
- **Business support institutions (BSIs).** Two thirds of clusters (28) collaborate with BSIs – slightly fewer than in the previous edition (32). The average cooperation involves around 3.8 agreements (median two). Collaboration with BSIs is a natural extension of

cluster activity, as many BSIs act as cluster coordinators or join clusters to expand their networks. BSIs offer useful services such as advisory and training, and in past KKK competitions, having an accredited innovation centre was considered an advantage. Despite this, one third of clusters report no collaboration at all, indicating room for improvement.

- **R&D and education sector – formal agreements.** About two-thirds of clusters have at least one formal agreement with a research or education institution, although the proportion with no agreements has increased. Currently, one-third have no such agreements (previously, fewer than a quarter). The average number of agreements rose from 3.9 to 6.8, but this is heavily influenced by outliers—one cluster reported 137 agreements. The median dropped from three to one, indicating that most clusters have only limited formal ties. This highlights the presence of a few highly networked leaders and many clusters with minimal or no formalised R&D cooperation.
- **R&D and education sector – intensity of co-operation.** Clusters engage with academia in various ways. The study examined four types of collaboration; on average, clusters participated in about 2–3 of them (mean 2.6; median 3). The most common were co-operation with researchers (81%), joint R&D projects (64%), and involvement in teaching activities (60%). Use of R&D infrastructure was less common (48%). These proportions are similar to those in the previous edition. Overall, R&D co-operation remains stable with slight increases in the most prevalent forms.
- **Education and skills development.** Clusters play a vital role in workforce development. In 2022–2023, 28 clusters collaborated to create new education programmes – averaging three per cluster (with a median of two). Most initiatives focused on higher education (24 clusters; 51 programmes), followed by secondary education (16 clusters; 30 programmes), and less often, vocational education (12 clusters). Compared to the previous edition, activity declined slightly but remains notable. Nonetheless, about one third of clusters did not engage in developing new curricula, highlighting a divide between highly active and more inactive clusters.
- **Internships, placements and industrial PhDs.** Clusters facilitate practical training through internships, student placements, and industrial PhDs. Over the past two years, 2,159 such activities were recorded (1,642 internships, 460 placements, 57 industrial PhDs). The average per cluster was 51.4 (median five), but one particularly active cluster accounted for over 1,200 cases. Excluding this outlier, the average drops to around 22. This figure is higher than in the previous edition (15.6), indicating a modest increase. However, 17 clusters did not partake in any such activities (previously 15). Overall, the trend is cautiously optimistic, but participation remains inconsistent.
- **Inter-cluster collaboration.** Co-operation between clusters (e.g., with other domestic clusters) remains limited but is gradually increasing. Currently, 26 clusters have at least

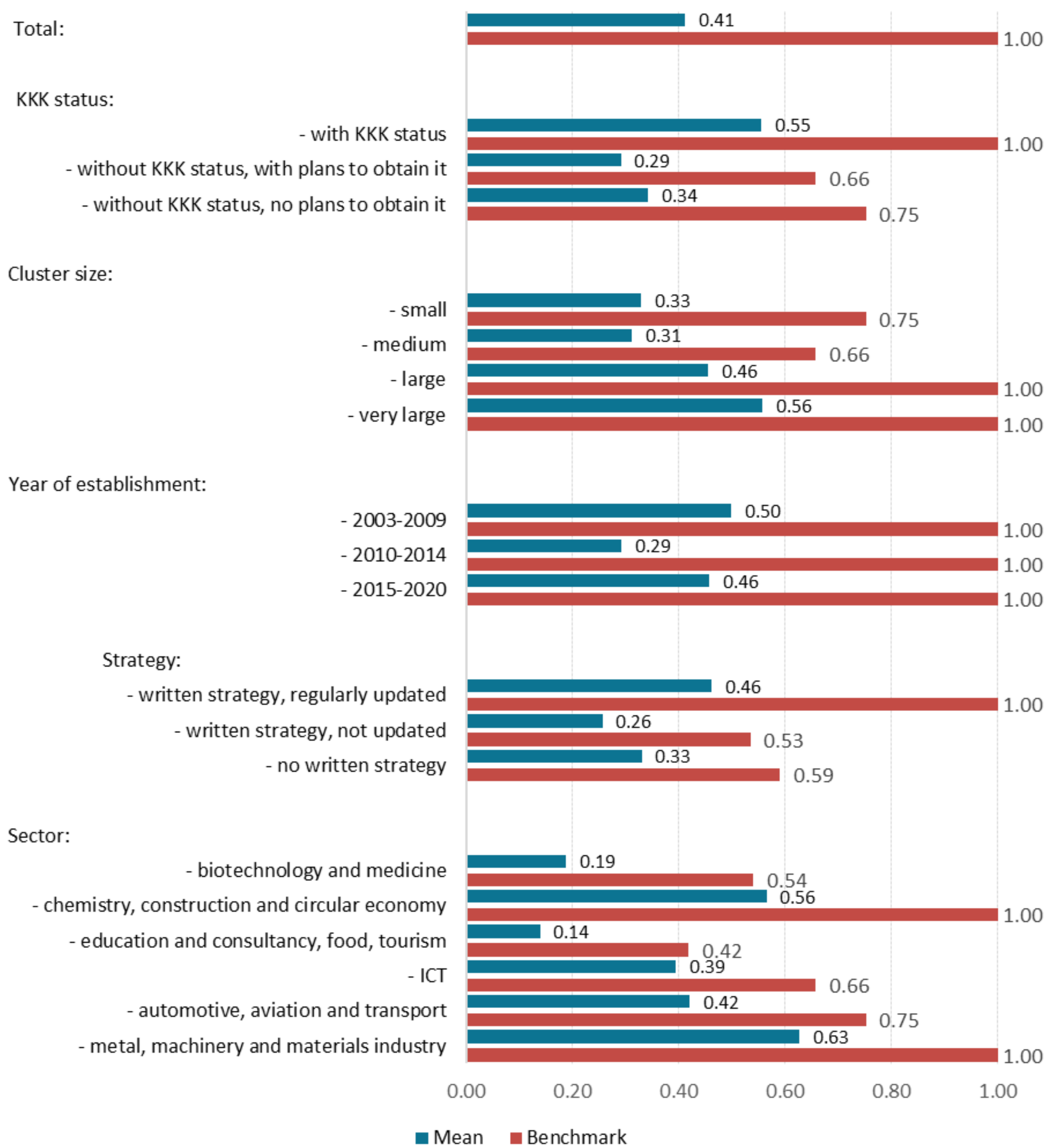
one such agreement (median one), compared with 22 previously. Usually, these involve single agreements – only four clusters have more than five. The highest number is 24 agreements (22 previously). These findings show that while internal networking within the cluster ecosystem is improving, it remains an underdeveloped area with significant untapped potential.

- **Cluster members' perspective.** Members acknowledge external co-operation, but not as strongly as internal integration or competence development. Fewer than half (44.7%) reported strengthening their contacts with research organisations due to cluster involvement. Only 9.3% indicated participation in consultative bodies. These findings suggest that clusters do create opportunities to build relations with academia and other firms, but their role as advocates or partners in shaping public policy remains limited.

4.5.2. Influence on shaping external conditions

In the sub-area "Influence on shaping external conditions", the average results are significantly lower than the benchmarks, suggesting that only some clusters actively introduce initiatives to improve framework conditions, as well as social and environmental actions.

Figure 34. Mean and benchmark for the sub-area: influence on shaping external conditions



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area “Influence on shaping external conditions” indicates that clusters in Poland engage in dialogue with public authorities, business support institutions and the science and education sector, but the level of this engagement varies significantly. Some clusters actively participate in consultative bodies and initiatives aimed at improving the business environment, while for many, these activities are limited to isolated instances. A similar pattern is observed in corporate social responsibility and ESG – several clusters run extensive educational, environmental or charitable programmes, whereas others remain largely inactive. Results at the level of partial indicators:

- **Participation in consultative bodies.** Clusters frequently communicate with public authorities and the socio-economic environment through their representatives in various advisory bodies. In 2022–2023, clusters participated in approximately 3–4 consultative bodies at national or regional levels (average: 3.5; median: 2). Overall, 33 clusters reported that their representatives sit on such bodies, which is a majority of the sample (previously 34 – a very similar figure). In some cases, the involvement is extensive – three clusters participate in ten or more advisory bodies (previously also three). The overall activity of clusters in advisory councils and committees has remained stable. This suggests that a considerable number of clusters aim to influence institutional conditions by representing their industries' collective voice in decision-making. At the same time, a small group of clusters are clear leaders, while many others participate in only one or two bodies, with the median being two advisory bodies. This indicates the presence of a highly engaged core, with others maintaining only minimal involvement.
- **Initiatives to improve the business environment (advocacy activities).** 62% of clusters actively undertake initiatives aimed at improving the conditions for doing business (e.g., advocacy, consultation on legal changes, recommendations submitted to authorities). In the previous benchmarking edition, 32 clusters implemented a total of 187 such initiatives, resulting in an average of 4.6 initiatives per cluster (median: 2). However, as in other areas, the average was inflated by a small number of leaders – only five clusters carried out ten or more initiatives (with the maximum reaching 55). Most clusters limited their activity to a few interventions or did not engage at all. Compared with the previous period, the present edition shows a reduction in the activity of the top-performing clusters (maximum dropped from 55 to 20) and a lower total number of initiatives (121). Nevertheless, clusters’ engagement in shaping the business environment may be considered moderately positive – a substantial number of structures undertook concrete actions, although the intensity varies widely.
- **Social and environmental initiatives (CSR/ESG).** Clusters also report activities in the field of corporate social responsibility and sustainable development. According to the latest edition, 26 clusters (62%) declared initiatives that generate positive societal

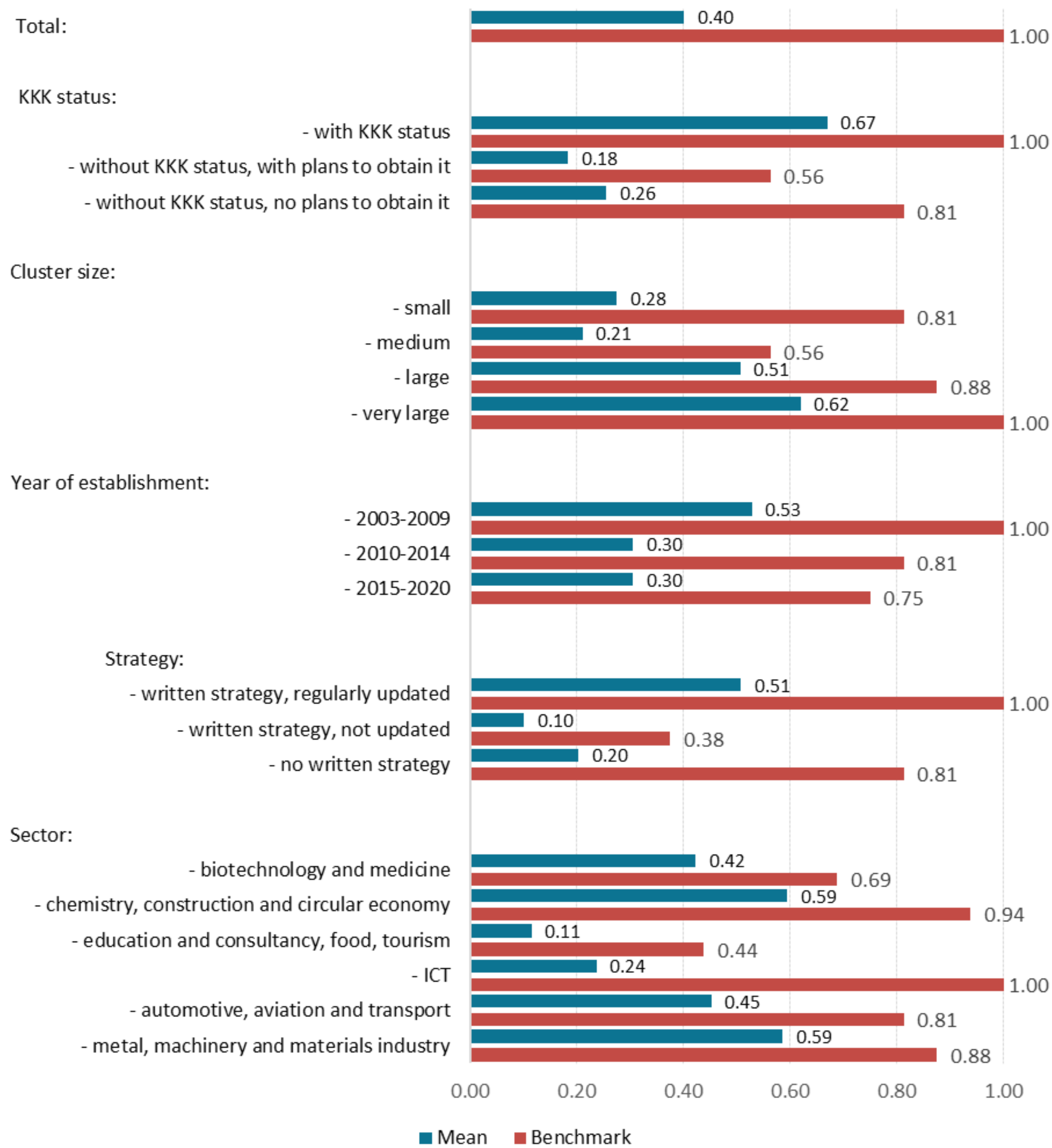
impact (compared to 68% previously). These activities encompass a wide range of actions: educational (training, webinars on sustainability and business ethics), charitable (fundraising, supporting care institutions and Ukraine), pro-environmental (tree planting, encouraging green practices), and collaboration with local communities and young people. Through such initiatives, clusters help build social capital and enhance the positive image of their industries. However, 38% of clusters report no such activity, indicating that a significant proportion remain relatively passive in this area.

- **Cluster members' perspective.** Participation of cluster members in consultative bodies was low – only 9.3% of respondents confirmed representing the cluster in such forums. Members also assessed the extent to which development objectives related to influencing public authorities and other institutions (e.g. educational bodies) had been achieved. These objectives were met according to 36.5% of members (with 10.9% expressing the opposite view). The results show that although clusters have the potential to influence institutional and regulatory environments, in practice, this effect remains modest and is not widely felt by members. This points to the need to strengthen the role of clusters as platforms representing business interests and to increase their involvement in consultative and advocacy processes.

4.5.3. Impact on the natural environment

In the sub-area "Impact on the natural environment", the average results are significantly lower than the benchmarks, indicating that only a few clusters consistently engage in environmental activities in a structured and regular way.

Figure 35. Mean and benchmark for the sub-area: impact on the natural environment



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area “Impact on the natural environment” highlights a growing level of activity by clusters in the field of the green transition and pro-environmental initiatives. In recent years, the scope of activities has increased significantly – from adopting circular economy principles and implementing low-emission and renewable energy projects to securing environmental certificates. Some clusters also run their own tailored initiatives, such as environmental training or tree-planting campaigns. At the same time, there are notable differences between clusters – alongside environmental leaders, there is a group of clusters that undertake activities only to a limited degree or not at all. From the members’ viewpoint, the effects of these initiatives are only moderately visible – only a portion of firms report a tangible improvement in their operations regarding the green transition. Nonetheless, expectations for coordinators in this area are rising, and environmental action is increasingly regarded as a vital development direction. In this context, clusters face the challenge of boosting their environmental impact to meet members' needs as well as the increasing regulatory and market demands. Results based on partial indicators:

- **Activities impacting the natural environment.** Clusters were evaluated based on the pro-environmental actions carried out by coordinators and members. On average, each cluster engages in 6–7 types of environmental activities (mean 6.4; median 6), compared to around three two years earlier (mean 3.1; median 3). This rise indicates that clusters now place greater emphasis on initiatives that support the natural environment. The diversity among clusters is significant – some implement more than a dozen different pro-environmental measures (maximum value 16), while others only a few. The most common activities include:
    - **Circular economy.** Implementing circular economy (CE) principles is the most common activity – currently reported by 69% of clusters (up from 59%). Furthermore, clusters adopting CE do so across various sectors, especially waste management (79.3%), production (75.9%), design (72.4%), and resource management (69.0%). Less frequently, yet still notably, CE is employed in distribution (55.2%) and consumption (44.8%). The broader adoption of CE highlights a significant shift towards circular economy models.
    - **Energy efficiency and renewable energy sources.** More than half of clusters (57%) undertake R&D on low-emission technologies and produce or utilise renewable energy – a marginally higher proportion than in the previous edition (54%). Additionally, 52% of clusters have adopted solutions stemming from energy-efficiency audits (enhancing process efficiency), which is a slight decrease compared to the earlier figure (59%).
    - **Low-emission projects and environmental certificates.** Almost half of the clusters (48%) undertake low-emission economy projects (down slightly from

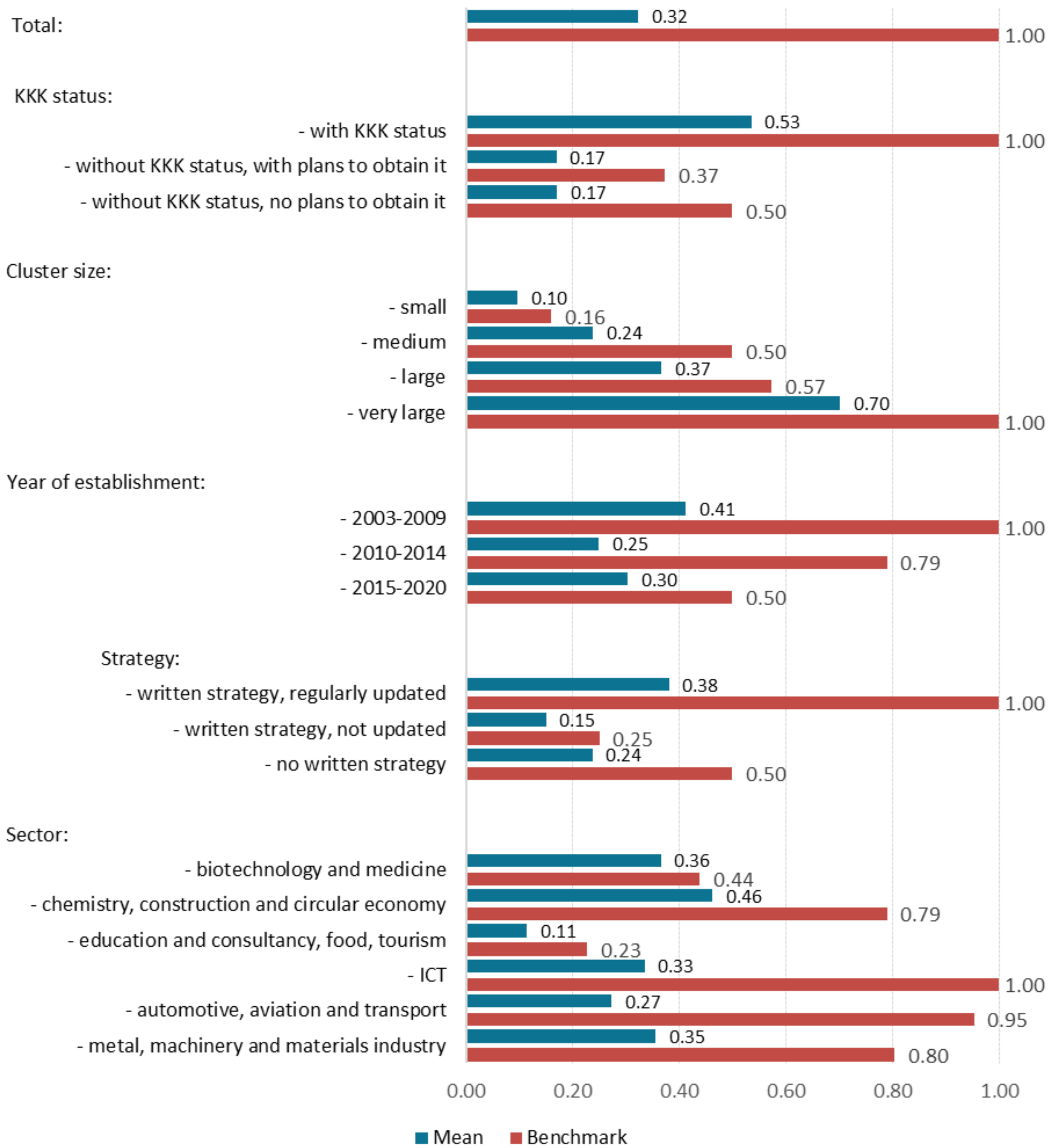
49%, so this remains stable). Furthermore, 38% report owning and implementing green technology certificates (e.g., ETV) or product certificates (e.g., Ecolabel), marking an increase compared to around 34% in the past.

- **Other activities.** Clusters also reported a variety of specific environmental initiatives outside the categories mentioned above, undertaken either by the coordinator or by at least two cluster members. These included environmental training, tree-planting campaigns, or strategic assessments in the field of circular economy. This demonstrates a creative approach by some clusters to improving the condition of the natural environment. Overall, recent years have seen a clear strengthening of the pro-environmental profile of clusters – not only do more clusters undertake activities in this area, but the range of actions has expanded. Nevertheless, significant differences remain: alongside environmental leaders, there are clusters that implement only isolated measures or none at all. A cautious upward trend is observable – environmental awareness and activity in this field are becoming an increasingly important strength of Polish clusters.
- **Cluster members' perspective.** Survey responses indicate that activity in the area of environmental impact remains limited, although increased awareness and expectations are evident. Only 24.7% of respondents stated that participation in the cluster had enhanced their organisation's performance in the green transition—such as deploying low-emission solutions, RES installations, or environmental certifications. Meanwhile, 43.9% reported no such effects, and 31.4% were unsure. Actions taken by the coordinator in this area are rated positively (average score of 4.2 on a five-point scale). The importance of strengthening environmental activities is recognised as significant. In assessing key development directions for the next two years, the green transition received an average rating of 4.0 (although other areas, like innovation, internationalisation, and cooperation development, are deemed even more urgent). This shows that cluster members see a clear need for strong support in this area, expecting initiatives from the coordinator related to both technological advisory services and practical projects to facilitate the shift towards a low-emission economy. Given the increasing relevance of climate policies and ESG requirements, this is an area where clusters will need to boost activity to meet members' expectations as well as changing market and regulatory conditions.

4.5.4. Specialisation and advanced technologies

In the sub-area "Specialisation and advanced technologies", the average results clearly fall below the benchmarks, indicating that many clusters operate across broadly defined, cross-sectoral areas.

Figure 36. Mean and benchmark for the sub-area: specialisation and advanced technologies



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area “Specialisation and advanced technologies” shows that Polish clusters still maintain relatively distinct sectoral profiles and align with smart specialisations, although there is a slight loosening of this concentration. Most clusters still group around two-thirds of their members within the dominant National or Regional Smart Specialisation (KIS/RIS) or within a core PKD (NACE) sector, confirming the ongoing thematic coherence, even if fully single-sector clusters have become less common. Greater diversity appears in the area of technological advancement: only some clusters are based on Key Enabling Technologies (KETs), and the average share of high-tech companies has decreased compared to the previous edition. This indicates that alongside a few highly specialised, large structures operating in advanced sectors, a significant portion of clusters comprises firms from traditional or medium-technology industries. Results at the level of partial indicators:

- **National Smart Specialisations (KIS).** An average cluster comprises approximately 61 enterprises operating within the sector corresponding to its dominant National Smart Specialisation (mean: 61.0; median: 48.5), making up 61% of all its member firms. In the previous edition, the average share was slightly higher at 67%, with a similar number of firms (mean around 65; median 49). In this study, only two clusters reported that 100% of their firms belong to the dominant KIS (compared to three previously). Overall, the slight decrease in the percentage share indicates marginally greater diversification within clusters, though the core specialisation remains strong: typically about two-thirds of members still operate within the dominant KIS. Notably, the maximum value increased significantly, with the leading cluster having 365 firms in its main KIS area (previously 250). This likely reflects the inclusion of a larger sectoral cluster in the sample and does not change the broader trend: outside a few very large clusters, most structures remain much smaller, as evidenced by the lower median..
- **Regional Smart Specialisations (RIS).** The picture for RIS mirrors that of KIS. On average, clusters group 55 firms operating within their dominant RIS (median: 43.5), representing 62% of members. These figures are almost identical to the previous edition (mean: 54 firms; median: 32; also 62%). As before, only a few clusters declare full alignment (100%) of member firms with the dominant RIS (two clusters now, compared to five previously). The overall level of specialisation relative to RIS therefore remains stable: most clusters have a strong core of firms operating within the main RIS field, although this is rarely the entire membership. The rise in the median (from 32 to 43.5 firms) may suggest a slightly larger RIS-aligned core, although this may also reflect sample differences.
- **Sectoral profile (PKD/NACE).** This indicator measures the number of member firms operating within the dominant PKD (NACE) division of the cluster. On average, there are 60.6 firms (median: 42), representing around 65% of the membership. Compared to the previous edition (where the average share was 60% and the mean was 49.6 firms), there

is a moderate increase, indicating a strengthening of sectoral concentration. However, the number of clusters that are entirely single-sector (with 100% of members in the dominant PKD) has declined (from three to two). Overall, the results suggest that clusters continue to have clear sectoral profiles: about two-thirds of members typically operate within the dominant PKD, although there is substantial variation – some clusters are strictly single-sector, while in others, less than half of the members are within the main industry (eight clusters in the current edition).

- **Advanced technologies (Key Enabling Technologies – KETs).** This indicator gauges how many cluster members use key technologies vital for future competitiveness. Clusters vary widely in this aspect. On average, only about one third of member firms are technologically advanced (33% now compared to 41% previously). The typical cluster comprises roughly 33 firms using KETs (mean: 32.7; median: 17), versus 34.8 firms previously (median: 30). Meanwhile, the number of clusters fully based on KETs has doubled (from one to two), and the maximum number of high-tech firms within a single cluster has increased (191 versus 175 previously), indicating the presence of one notably large high-tech cluster. Overall, however, advanced technologies are predominantly present only in a subset of clusters. Many clusters remain focused on traditional or medium-technology industries, highlighting a relative weakness within the ecosystem. Despite the existence of highly specialised high-tech clusters, a significant portion of the landscape remains outside the core technologies shaping the future.

4.6. Cluster internationalisation

Within this benchmarking area, the following sub-areas were assessed:

- **Internationalisation potential** – services provided by the coordinator to support internationalisation and the extent to which they are used by members, as well as the multilingual nature of the cluster's website;
- **International activities** – the cluster's strategic cooperation with foreign entities, international projects implemented within the cluster, industry events organised by the cluster, and foreign direct investment made by cluster members;
- **Export and export-oriented activities** – export outcomes among cluster members, the cluster's participation in foreign trade fairs, and foreign missions and incoming visits from foreign clusters organised by the cluster.

In the Cluster internationalisation area, the best-performing cluster set the benchmark at 0.83 and achieved a significant advantage over the second-highest cluster, which scored 0.74. Meanwhile, the low average and median values (0.29 and 0.28 respectively) indicate that a substantial number of clusters recorded average or weak results in this area. At sub-area level, the highest benchmark was recorded for International activities, meaning that one of the clusters achieved consistently high scores across all partial indicators within this sub-area. Conversely, the very low median value for this sub-area (0.24) suggests that at least half of the clusters undertake very limited activity in this dimension.

Table 8. Assessment for the area: cluster internationalisation

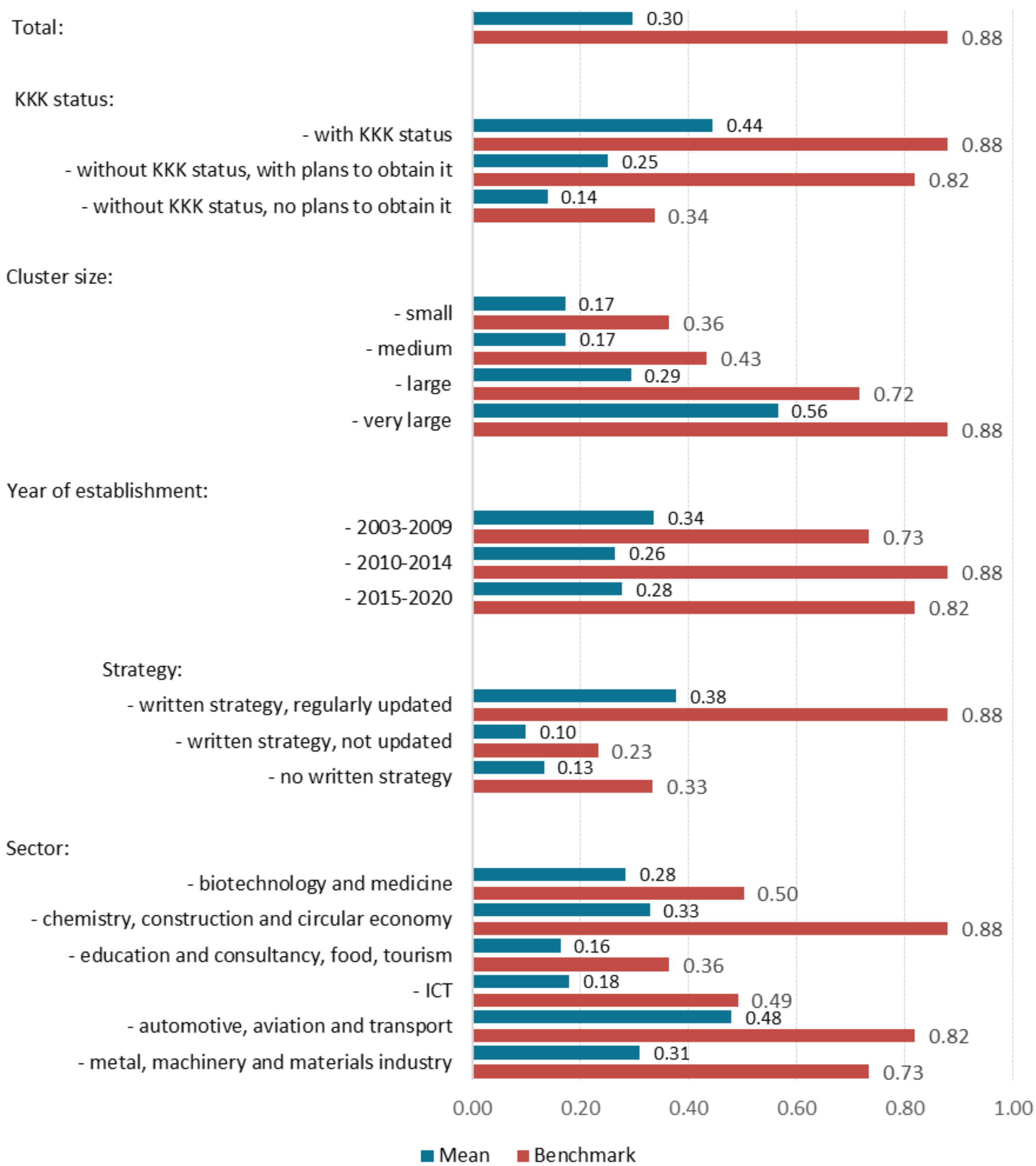
Sub-area	Mean	Median	Benchmark
Internationalisation potential	0.30	0.23	0.88
International activities	0.26	0.24	0.99
Export and export-oriented activities	0.31	0.28	0.78
Overall score for the area	0.29	0.28	0.83

Source: own elaboration based on the cluster coordinators' survey (N = 42).

4.6.1. Internationalisation potential

In the sub-area "Internationalisation potential", the average results are significantly below benchmark levels, indicating that only specific clusters effectively develop services and tools supporting international expansion. The highest-performing cluster did not reach the maximum benchmark value (which, according to the methodology, is 1.00), leaving scope for improvement across all evaluated structures.

Figure 37. Mean and benchmark for the sub-area: internationalisation potential



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area “Internationalisation potential” shows only minor changes compared with the previous edition of the benchmarking exercise. The number of internationalisation services decreased, but the number of members using them increased, indicating that the offer is now more accurately aligned with enterprise needs. The potential for international expansion is developing at a moderate pace, and the key challenge for the coming years remains the expansion and professionalisation of tools supporting international growth, as well as more consistent adaptation of communication to foreign audiences. Results at the level of partial indicators[22]:

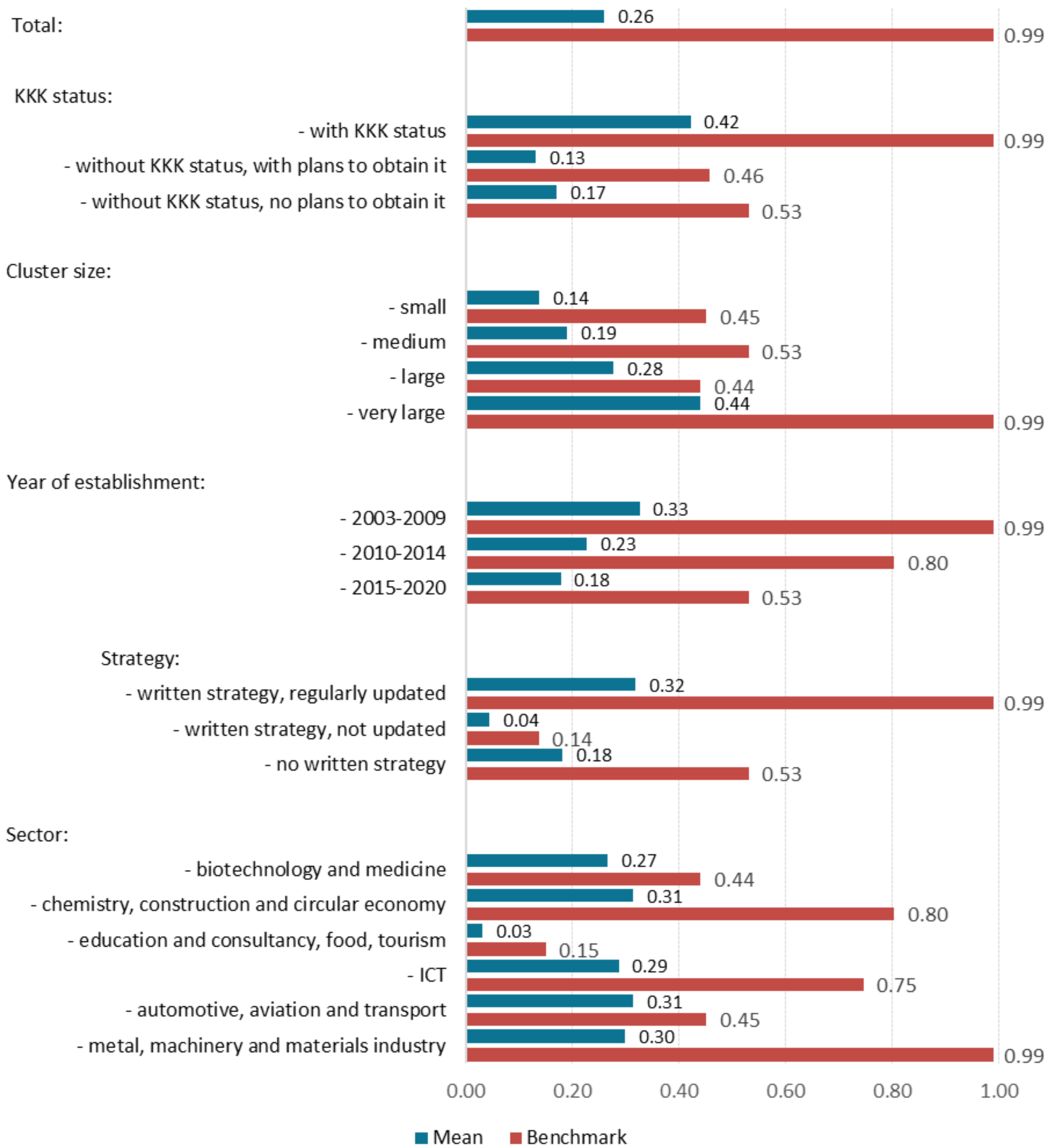
- **Coordinator’s internationalisation services.** A slight decline was observed in the area of services supporting internationalisation. The average number of services decreased from 6.4 in 2022 to 5.1 in the current edition, while the median remained at 3. A total of 34 clusters reported providing such services, slightly more than two years earlier (32), although their intensity was lower. Only five clusters offered more than 10 services (six in 2022). The most common activities included trade missions, participation in international fairs, joint exhibitions, and the promotion of brands and products abroad. The average number of members using these services increased from 23.0 to 25.8, while the median rose from 5.0 to 7.5. In the 2022 edition, a total of 941 entities (approximately 22% of cluster members) utilised such services; this has now increased to 1,085 (also approximately 22%). Notably, in five clusters, more than 100 members utilised internationalisation services.
- **Cluster websites.** The potential for internationalisation was also evaluated based on how accessible clusters are to foreign partners, measured by the availability of foreign-language versions of their websites. On average, cluster websites are available in fewer than two foreign languages (1.7), with a median of 1. As many as 12 clusters (about 29%) do not offer any foreign-language version of their website, which restricts their international visibility. Only one cluster – the leader in this area – provides content in as many as 14 languages (using auto-translation tools). Compared with the previous edition, no notable improvement is seen. The existence of a leader offering 14 language versions was already identified before, while in several clusters the Russian version was removed (often replaced with Ukrainian) due to geopolitical reasons (the war in Ukraine).

[22] The complete set of partial indicators for the “Cluster internationalisation” sub-area is provided in Annex 12.1.5.

4.6.2. International activity

In the sub-area "International activity", the average results are considerably lower than the benchmark values, indicating that only a few clusters undertake extensive international cooperation and participate in international projects, while most are confined to isolated activities.

Figure 38. Mean and benchmark for the sub-area: international activity



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The area "International activity" shows mixed trends. A positive aspect is the rise in the number of international agreements and projects, signalling a gradual expansion of foreign cooperation. At the same time, the financial value of these projects has fallen, as has the level of organising international events. The scale of foreign direct investment – both inward and outward – has also decreased. Overall, international activity within clusters remains but has changed in nature: more initiatives take the form of formal partnerships and project-based cooperation, while their economic importance and capital links are weaker than in the previous edition of the study. Results at the level of partial indicators:

- **International cooperation.** More than two-thirds of clusters (31 out of 42) have formal cooperation agreements with foreign partners, compared to 28 out of 41 in the previous edition. This indicates a slight increase in the number of clusters maintaining structured international partnerships. The number of clusters with extensive partner networks has also grown: six clusters now have ten or more active agreements (previously four). On average, clusters hold around six international agreements (median 3), meaning that outside a group of leaders, most clusters only operate a single international partnership. These agreements often form the basis for further cooperation – such as participation in joint projects (e.g. EU consortia) or organising joint initiatives.
- **International projects.** In the two-year period analysed, slightly more than half of the clusters (23) implemented international projects, compared to 27 in the previous edition. Despite a decline in the number of participating clusters, the total number of international projects increased to 90 (previously around 67). Throughout the sample of 42 clusters, this results in an average of 2.1 projects per cluster (median 1), compared to 1.6 previously. This indicates a concentration of activity: a smaller group of clusters are undertaking more projects than before. It is probable that post-pandemic conditions facilitated more intensive participation in international consortia (e.g., EU programmes), while smaller clusters remain inactive in this area. The average value of international projects is approximately PLN 9.8 million, slightly lower than the PLN 10.6 million recorded previously. The highest project value in this edition is approximately PLN 86 million (compared to PLN 245 million in the previous study). Meanwhile, some clusters reported very small budgets – for three, the value did not exceed PLN 200,000, and for four, the value was below PLN 1 million. This demonstrates that international projects vary considerably in scale and that significant grants are obtained by only a small number of clusters.
- **International events.** Clusters also demonstrated international involvement by organising or co-organising events such as conferences, missions, and seminars. About 70% of clusters (29) reported such activities. As seen in other areas, the scale varies: for most clusters, the number of events was small (median of 2 over two years). The average number of events was approximately 7, although this figure is heavily

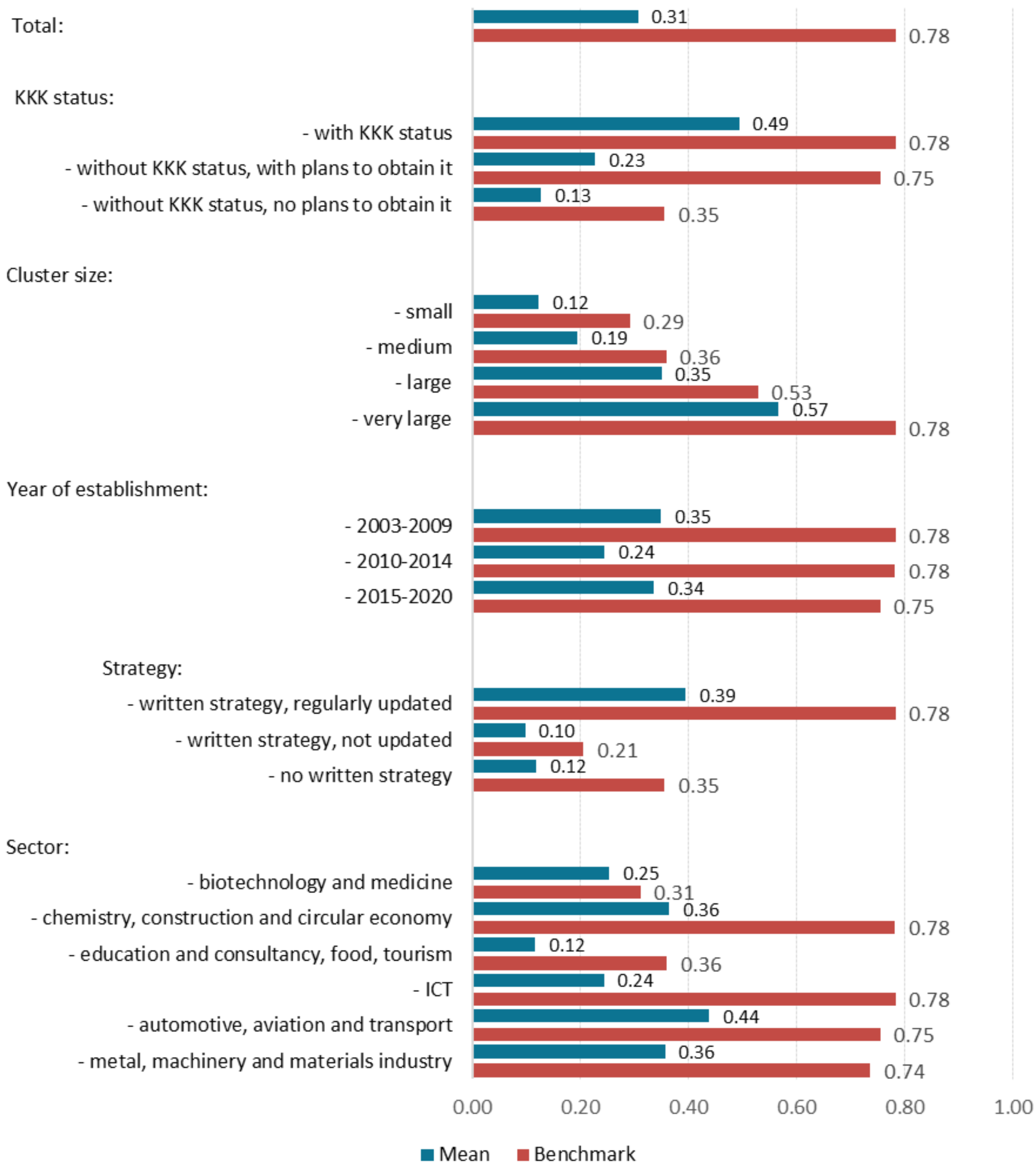
influenced by a single leader who organised 120 events. Excluding this outlier, the averages would be significantly lower. In comparison, in the previous edition, one cluster alone organised 270 events, and the overall average (12.1) was higher, while the median remained 2.

- **Foreign capital and foreign investment.** Another indicator of international engagement is the presence of foreign-owned companies within clusters. In 20 clusters (48%), at least one member company had foreign capital involvement (inward FDI), a level similar to the previous benchmark (19 clusters). The most internationally capitalised cluster had 68 such companies. On average, clusters had around five companies with foreign ownership (previously over nine), whereas among clusters with foreign capital involvement, the average was around 11. The strongest foreign capital presence is found in ICT and automotive clusters, though significant values also appear in manufacturing and construction. Outward investments – cases where member firms hold shares or operate branches abroad – were reported by 19 clusters (previously 18). For this indicator, the median is 0 and the average is 2.7 companies.
- **Cooperation with foreign clusters.** A total of 25 clusters hosted visits from foreign cluster delegations, including study visits and networking events. Most of these were isolated incidents, with a median of 2 visits. Only two clusters organised ten or more such exchanges, and one cluster notably hosted 24 visits. Although the proportion of clusters hosting delegations remained similar to the previous edition—around half—the maximum number of visits per cluster decreased significantly, from 50 to 24.
- **Cluster members' perspective.** From members' perspectives, the potential for internationalisation remains underdeveloped, although it is regarded as strategically important. Only 30.9% of respondents reported using internationalisation services provided within the cluster, while 32.5% stated they had received no such offer, and a further 36.6% received an offer but did not utilise it. These results suggest that the actual impact of clusters on members' internationalisation is limited and affects only part of the ecosystem. Expectations, however, are very high: in the ranking of priorities for the next two years, internationalisation received an average importance score of 4.5. Participation in international trade fairs (4.8), economic missions, and collaboration with foreign partners (both 4.7) were rated particularly highly. These findings highlight a growing awareness of the significance of international expansion and a clear need to enhance support – both through international projects and practical export-oriented services.

4.6.3. Exports and pro-export activities

In the sub-area "Exports and pro-export activities", the average results are significantly lower than the benchmarks. Meanwhile, the top results in the range of 0.74–0.78 show that even the leading clusters have potential for further improvement.

Figure 39. Mean and benchmark for the sub-area: exports and pro-export activities



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The sub-area "Export and pro-export activities" shows a mix of trends. On the positive side, the total number of cluster firms involved in export activities increased (from 1,471 to 1,731), the proportion of exports in their revenues grew (from an average of 29.2% to 36.8%), and their presence in foreign markets expanded slightly (from an average of 31.2 to 32.7 markets). The average number of cluster members taking part in international trade fairs also went up (from 15.3 to 17.9). At the same time, the number of other international events and hosted foreign cluster visits decreased, which may suggest a shift towards more targeted and efficiency-oriented export efforts. Overall, the findings indicate a gradual enhancement of the export-focused profile of clusters, though there are clear limitations in maintaining a high level of visits and participation across a wide range of international events.

- **Number of exporting enterprises.** The results indicate a definite rise in export activity. In 2022, the average number of cluster enterprises generating export revenue was 36.8 (median 30.0; maximum 161). In the 2024 edition, the average increased to 45.6, with the same median (30.0) and an increased maximum of 229. Overall, 1,731 cluster firms were involved in exporting – 42.0% of all cluster enterprises (compared to 1,471 firms or 41.6% in the previous edition). For context, the share of exporters among all Polish enterprises in 2023 was approximately 4.9% for goods and 0.8% for services. This not only confirms a growing exporter base within clusters but also highlights the consistently high proportion of exporting firms among their membership.
- **The share of exports in total sales revenue also increased** – from an average of 29.2% (median 26.8%; maximum 80%) in 2022 to 36.8% (median 32.5%; maximum 86%) in 2024. These results show that exports are increasingly becoming a key revenue source for cluster firms, especially in ICT and manufacturing. The findings also emphasise the growing significance of e-commerce as a channel for international sales.
- **Number of foreign markets.** The average number of foreign markets where cluster firms operate increased from 31.2 to 32.7, with the maximum rising from 120 to 131. The median also grew from 19 to 20. The most commonly reported destinations remain Germany, the USA, and France, while the latest edition saw the Czech Republic, Norway, Portugal, and Spain join the core markets. Some clusters reported activity on an aggregated level (e.g., "EU", "North America", "East Asia"), while others expanded into less typical markets such as Iran, Uzbekistan, or Ghana. These results indicate growing confidence among firms entering more challenging or non-traditional export destinations.
- **Participation in international trade fairs and exhibitions.** This indicator has also improved. In 2022, the average number of organised trips was 8.6 (median 2.0; maximum 107). In 2024, the average increased to 10.0, the median to 4.0, and the maximum to 109. In total, 29 clusters declared participation in trade fairs (27

previously), including 11 clusters that attended at least 10 events and 5 that participated in more than 20.

- **The number of members attending fairs** increased from an average of 15.3 (median 6.0; maximum 127) to 17.9 (median 9.0; maximum 112). In the previous edition, 628 members participated, compared with 753 in the current one – around 15% of all members (noting that some entities may have attended multiple events). Eleven clusters reported participation by more than 20 members, indicating growing business engagement in international promotional activities organised or coordinated by clusters.
- **Participation in other international events.** This indicator includes trips not related to trade fairs, such as economic missions, study visits, conferences, or project-related events. The indicator decreased compared to the previous edition: in 2022, the average number of such events was 12.7 (median 3.0; maximum 251), while in 2024, the average dropped to 8.1, the median increased to 4.0, and the maximum decreased to 58. Although the number of clusters participating in these events remained the same (28), only nine clusters exceeded ten events.
- **Visits from foreign clusters.** The number of foreign cluster visits hosted also declined. In 2022, the average was 3.2 (median 1.0; maximum 50). In the current edition, these values fell to 2.7, 2.0, and 24 respectively. In 2024, 25 clusters hosted visits, with only two reporting more than 10 visits (compared to 24 clusters that exceeded this threshold previously).
- **Cluster members' perspective.** Export and pro-export activities are among the areas where members see effects, although these remain limited in scope. Notably, more than two-thirds of members (67.5%) received offers of internationalisation services provided by or through the cluster (similar to 66.4% in the previous edition), yet only 30.9% utilised these services (33.6% previously). A comparable proportion (34.4%) reported participation in joint export initiatives, and 20.6% confirmed an increase in their organisation's exports due to cluster involvement. These findings suggest that while export-related effects are not widespread across clusters, both the potential and demand for further development of pro-export activities remain strong. On a five-point scale, the importance of international activities was rated at 4.5 – one of the highest scores. The most anticipated forms of support include assistance in organising trade fair trips (4.8), economic missions (4.7), initiating cooperation with foreign partners (4.7), and running international projects (4.6)[23].

[23] The survey offered the following response options: "No", "Average", "Yes", and "Don't know/Hard to say". For the purposes of analytical clarity, these responses were quantified using a numerical scale, where 1 corresponds to "No", 3 to "Average", and 5 to "Yes". An average score was then calculated based on the responses provided by cluster members.

5. Cross-sectoral analyses

In the section on the selection of clusters, the report outlined the method used to classify the clusters participating in the study according to their sectoral profile. The clusters were categorised into six groups representing different sectors:

- Biotechnology and medicine (4 clusters);
- Chemicals, construction and the circular economy (6);
- Education and consulting, food, tourism (6);
- ICT – information technology, electronics, digital technologies, cybersecurity (9);
- Automotive, aviation and transport (9);
- Metal, machinery and materials industries (8).

It is important to emphasise that many clusters function at the intersection of at least two of the aforementioned groups. Examples include:

- **Baltic Sea & Space Cluster** (automotive, aviation and transport / ICT). The cluster connects the maritime and logistics sectors with advanced satellite and space technologies, including ICT solutions for monitoring and communication. It exemplifies a cluster situated between traditional transport and modern digital innovations.
- **NUTRIBIOMED Cluster** (biotechnology and medicine / chemicals, construction and the circular economy / education and consulting, food, tourism). The cluster integrates biotechnology and medicine with the food industry (functional food, nutraceuticals) and elements of the chemical sector. By collaborating with research and educational institutions, it also broadens its activities to include advisory services and skills development.
- **Silesia Automotive & Advanced Manufacturing** (automotive, aviation and transport / metal, machinery and materials industries / ICT). The cluster combines the traditional automotive industry with advanced manufacturing (e.g., automation, robotics) and ICT solutions within Industry 4.0, making it a multi-sector structure that integrates digital technologies with industrial production.
- **LifeScience Kraków Cluster** (biotechnology and medicine / education and consulting, food, tourism / chemicals, construction and the circular economy). Besides biotechnology and medicine, the cluster works in functional food and nutraceuticals, and – through R&D and educational activities – in education and consulting. Many of its projects also cover chemical and environmental applications (e.g. biomaterials technologies).

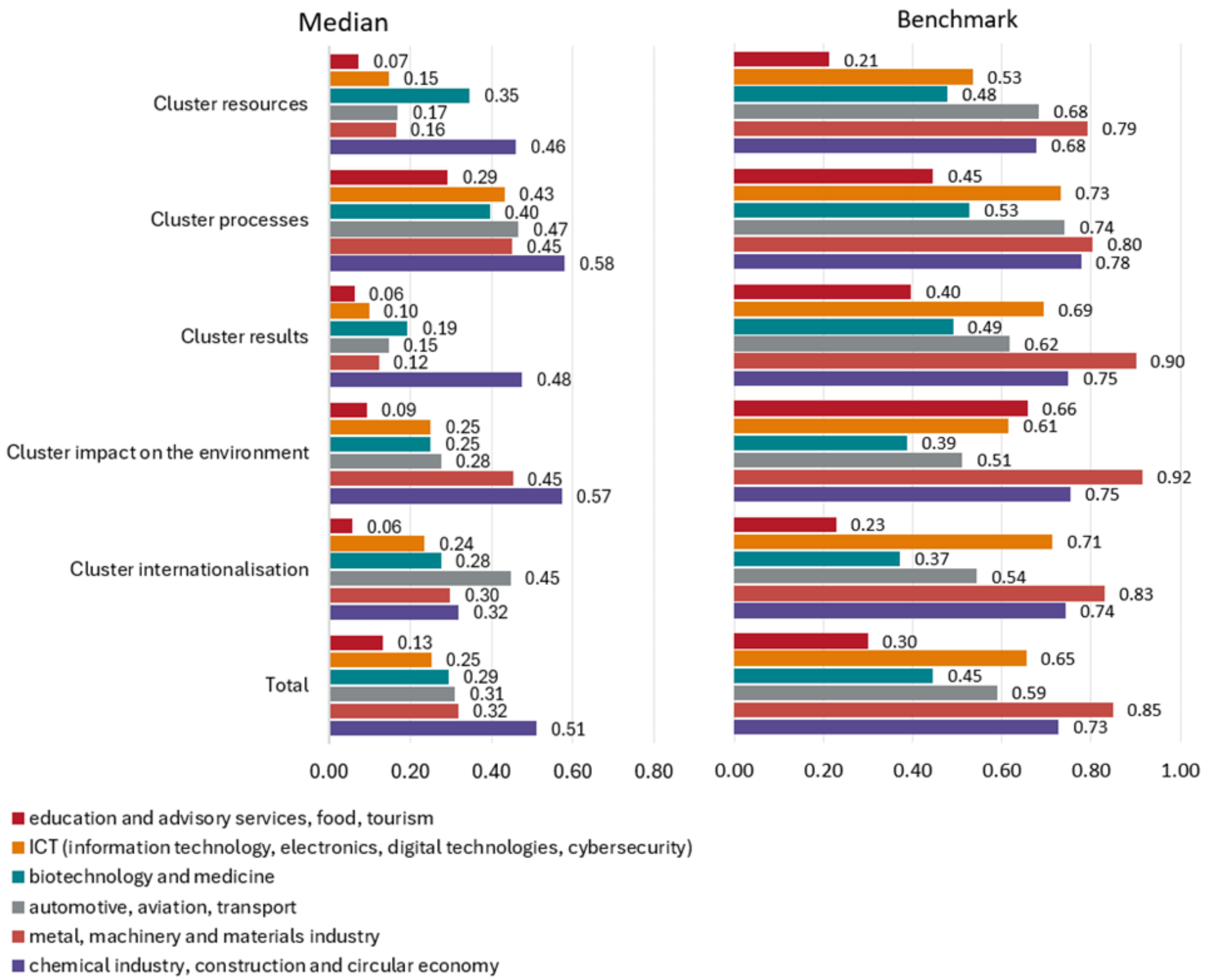
- **Circular Economy and Recycling Cluster** (chemicals, construction and the circular economy / metal, machinery and materials industries / education and consulting). This cluster operates at the nexus of the circular economy and recycling, engaging the chemical, processing, and metal industries. It also works closely with the education and consulting sectors within the context of the green transition, giving it a multifaceted profile.

In the context of sectoral analyses, it is notable that the number of cluster members has steadily increased in recent years. The clusters involved in the study reported a total of 4,942 members, reflecting a 14.6% rise over two years (compared with the previous edition, adjusting for differences in the number of clusters surveyed). Given the limited number of enterprises and organisations operating in a specific sector within a defined geographic area, this trend may suggest a move towards greater interdisciplinarity, with clusters expanding their memberships to include organisations from sectors forming broad value chains. It is also significant that 65% of enterprises operated within the cluster's leading sector (as defined by NACE), further supporting this conclusion.

Cross-sector analyses were conducted for each of the 19 sub-areas in Chapter 5. This section summarises the results at the level of the main areas and overall performance. Calculations were made for both median and benchmark values.

Based on median values, the chemicals, construction, and circular economy sectors achieved the most favourable results, recording the highest scores in four out of five areas. At the other end was the group covering education and consulting, food, and tourism. Very similar overall scores were recorded for three sector groups: biotechnology and medicine (0.29), automotive, aviation, and transport (0.31), and metal, machinery, and materials industries (0.32). An analysis of benchmark values reveals a much more balanced picture; however, the two lowest benchmarks across most areas were most often associated with the education and consulting, food, and tourism group and the biotechnology and medicine group.

Figure 40. Median and synthetic benchmark values by sector



Source: own elaboration based on the cluster coordinators' survey (N = 42).

- **Education and advisory services, food, tourism** constitute the weakest group of industries across all analysed dimensions. The median values are very low (e.g., cluster performance 0.06, internationalisation 0.06), indicating that most clusters in this group operate on a limited scale, with only moderate collaboration effects. Benchmark figures also remain clearly below those observed in other industries.
- **ICT** is positioned significantly higher – the median values for resources (0.15), internationalisation (0.24), external impact (0.25), and processes (0.43) indicate that most clusters demonstrate a moderate level of maturity, while at the same time the benchmarks are very high (e.g., processes 0.73, internationalisation 0.71). This suggests that a number of ICT clusters achieve relatively strong results, particularly in the areas of processes, internationalisation, and cluster performance.

- **Biotechnology and medicine** record average median values (overall 0.29) but relatively low benchmarks (the lowest in internationalisation – 0.37, the highest in processes – 0.53). This suggests that the group is relatively cohesive, yet lacks strong leaders (compared to other industries).
- **Automotive, aviation, transport** demonstrate a strong position in internationalisation (median 0.45 – the highest across all industries), as well as in processes (median 0.47). Benchmarks are also high (e.g. processes 0.74), showing that this sector benefits from well-developed mechanisms of collaboration and foreign expansion, although the performance dimension (0.62) is ranked lower than in the group comprising The metal, machinery and materials industry.
- **The metal, machinery and materials industry** emerge as the clear leader among all groups – while the overall median (0.32) remains moderate, the benchmarks are the highest in the entire dataset: cluster performance 0.90, external impact 0.92, internationalisation 0.83. This suggests that although many clusters in this industry perform at an average level, the top-performing units set the highest standards nationally.
- **Chemicals, construction, and circular economy** Stand out with the highest median values in four out of five areas – e.g., resources 0.46, processes 0.58, performance 0.48, external impact 0.57. This indicates that not only the leading clusters but also the majority within this group achieve strong results, highlighting a high degree of maturity and balanced development across the sector. The overall benchmark is also high (0.73), although it remains slightly lower than in the metal industry group.

A graphical illustration of the partial indicators is provided in the table below, with a discussion of the results presented further down.

Table 9. Results for selected individual indicators obtained by clusters by sector group (average values)

Indicator	Education and advisory services, food, tourism	ICT	Biotechnology and medicine	Automotive, aviation, transport	The metal, machinery and materials industry	Chemicals, construction, and the circular economy
Number of members	88.5	103.4	123.0	112.2	99.9	196.5
Employment across all cluster member entities	2,991	21,267	64,889	41,648	10,754	22,267
Cluster budget, i.e. the total financial resources available to the cluster in the reference period (in PLN thousand, for 2022–2023)	483.8	2,790.1	3,032.6	1,949.0	4,243.6	16,343.5

Indicator	Education and advisory services, food, tourism	ICT	Biotechnology and medicine	Automotive, aviation, transport	The metal, machinery and materials industry	Chemicals, construction, and the circular economy
Value of the cluster's own resources, obtained e.g. from membership fees and revenues generated through business activities (in PLN thousand, for 2022–2023)	97.7	1,523.5	801.8	51,278.4	677.2	7,723.6
Number of meetings organised within the cluster	30.7	32.1	26.0	28.6	11.5	15.3
Number of value chain stages jointly implemented within the cluster	2.5	3.0	1.8	3.4	3.3	4.2
Number of joint promotional activities	3.8	3.9	3.0	4.8	4.8	5.2
Number of pro-innovation services available within the cluster or through the cluster	2.3	4.0	5.0	3.6	4.9	4.3
Number of technological audits carried out in cluster entities via the cluster	0.3	1.4	0.0	2.6	6.3	19.0
Number of IT systems used across the respective value chain stages within the cluster (from a list of nine systems)	6.2	7.8	8.5	7.7	8.1	8.2
Number of start-ups, spin-offs/spin-outs, and special purpose vehicles established within the cluster	0.2	4.8	1.5	0.1	1.9	2.0
Number of jointly implemented projects co-financed from public funds	0.7	3.0	2.5	2.6	5.4	4.7
Number of joint cluster products and services introduced into the market offer	2.2	1.7	0.8	5.7	3.6	5.7
Number of implemented product innovations	0.7	0.9	3.8	15.7	5.4	5.2
Number of technology transfers carried out within the cluster via the cluster	0.5	0.6	0.5	2.7	3.5	3.8
Number of competency-enhancing training sessions attended by cluster coordinator staff (assigned to cluster operations) over the past two years	5.8	4.1	5.5	22.4	3.4	4.8
Number of active cooperation agreements between the cluster and R&D and education institutions	23.7	3.9	0.5	1.4	6.9	6.7
Number of consultative bodies in which representatives of the cluster coordinator participate (representing the cluster)	1.2	2.1	1.5	2.9	6.0	6.7

Indicator	Education and advisory services, food, tourism	ICT	Biotechnology and medicine	Automotive, aviation, transport	The metal, machinery and materials industry	Chemicals, construction, and the circular economy
Engagement of the cluster in activities generating positive social impact (percentage of clusters in a given industry)	17%	67%	25%	67%	100%	67%
Number and type of cluster activities aimed at improving the natural environment	1.8	3.8	6.8	7.2	9.4	9.5
Number of services offered by the cluster and/or via the cluster to support internationalisation (offer from the past two years)	0.5	2.0	3.5	12.6	5.5	3.5
Number of international projects implemented within the cluster (in partnership with foreign entities) over the past two years	0.2	2.8	0.8	2.7	2.6	2.7
Number of international events organised or co-organised by the cluster over the past two years	0.8	4.2	14.5	4.0	17.3	3.7
Number of foreign trade fairs and exhibitions in which the cluster participated over the past two years	1.7	6.4	7.0	16.2	5.8	22.0
Share of export revenues in the total sales revenues of enterprises forming the cluster	22.6%	49.2%	15.0%	52.8%	39.0%	29.4%

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Below is a summary of the results by industry group:

- Education and advisory services, food, and tourism. Clusters in this group are among the smallest and weakest in terms of resources and performance. The average number of members is 88.5, with only 3,000 employees – a stark contrast to the tens of thousands employed in industrial sectors. Cluster coordinators operate with very limited budgets – on average below PLN 0.5 million (with own resources below PLN 100,000) – which significantly restricts the scale of activities. Although the number of meetings (30.7) suggests relatively strong internal integration, market and innovation outcomes remain modest: on average fewer than one implemented product innovation, only 0.2 start-ups/spin-offs/spin-outs or special purpose vehicles established within the cluster, and a very low number of international projects (0.2). Support for internationalisation is also weak (0.5 services for internationalisation per cluster), as is participation in foreign trade fairs (1.7). According to the indicators assessed in the benchmarking exercise, these clusters function primarily as local cooperation platforms rather than strong economic structures, with limited external and environmental impact.

- ICT (information technology, electronics, digital technologies, cybersecurity) consists of medium-sized clusters averaging around 100 members and employing approximately 21,000 people. These clusters have moderate budgets for coordination (PLN 2.8 million) and their own resources (PLN 1.5 million), but they stand out due to their entrepreneurial spirit and advanced competencies. They record the highest average number of start-ups (4.8) and demonstrate extensive use of digital technologies—7.8 IT systems out of nine. Their strengths also include pro-innovation activities (four innovation services per cluster) and participation in international projects (2.8). However, the number of joint products and implemented product innovations remains low (1.7 and 0.9 respectively), indicating that technological potential often does not translate into tangible market results. The sector also shows relatively strong engagement in social activities (67% of clusters) and a moderate level of internationalisation—two export-support services and 6.4 engagements in foreign trade fairs. ICT remains a dynamic yet fragmented sector: alongside strong leaders, many clusters exhibit limited effectiveness..
- Biotechnology and medicine. This sector has the highest employment level, with nearly 65,000 staff, and a relatively large number of members, averaging 123. Coordinator budgets are moderate—around PLN 3 million, with own resources of PLN 0.8 million—but are effectively utilised in the area of innovation: an average of five pro-innovation services and up to 3.8 product innovations implemented—significantly higher than in the previously mentioned sectors. A robust digital infrastructure, comprising 8.5 IT systems, is another strength. However, international project activity is a weakness, with an average of only 0.8 projects. Regarding internationalisation, the number of organised international events is high compared with other sectors, standing at 14.5, the second-highest figure. The industry is clearly focused on R&D and knowledge transfer, although its activity in international projects remains relatively limited. Social and environmental engagement is moderate—only 25% of clusters report pro-social activities, and the number of environmental initiatives, averaging 6.8, is lower than in industrial sectors..
- Automotive, aviation, and transport sectors operate on a significant scale, employing over 41,000 people and comprising approximately 112 members, with coordinator budgets of around PLN 2 million and additional resources exceeding PLN 51 million. This is a highly market-oriented sector: the average number of joint products and services is 5.7, and the number of implemented product innovations reaches 15.7 – the highest among all industries. These clusters perform well across value chains (3.4 stages) and are active internationally, with 12.6 internationalisation services and 16.2 foreign trade

fair participations, showcasing strong foreign expansion. Weaker areas include a relatively low number of pro-innovation services (3.6) and technological audits (2.6), suggesting that innovation in this sector is more driven by implementation than by systematic cluster tools. Social and environmental engagement (67% and 7.2 activities, respectively) is notable, although not as prominent as in the chemical or metal sectors.

- Metal, machinery, and materials industries. This group has an average number of members (approximately 100) and average employment (10,700), but relatively high budgets – PLN 4.2 million (with own resources at just under PLN 700,000). Its strengths lie in collaboration and external engagement: an average of 5.4 joint projects, 3.5 technology transfers, and as many as six consultative bodies in which clusters represent members' interests. The group is also distinguished by pro-social (100% of clusters) and environmental activities (9.4 initiatives). Innovation levels are moderate – 5.4 implemented product innovations, fewer than in the automotive sector but more than in ICT. Internationalisation is relatively strong: 5.5 export-support services and 5.8 foreign trade fair participations during the analysed period. This industry appears stable, balanced, and well embedded in the institutional framework ecosystem.
- Chemicals, construction, and the circular economy. This group is the clear leader in terms of results, particularly regarding scale and resources. The average number of members is nearly 200, with over 22,000 employees. Coordinator budgets are exceptionally high – averaging PLN 16.3 million, several times more than in other industry groups (with own resources of PLN 7.7 million). This industry achieves the highest results in technological audits (19), as well as strong performance in product innovations (5.2 implemented) and joint projects (4.7). Environmental initiatives (9.5) are also a major strength, aligning well with the principles of the circular economy. Internationalisation is very high: 3.5 internationalisation services, 2.7 international projects, and as many as 22 foreign trade fair participations. Social and institutional impact (67% pro-social activities, 6.7 consultative bodies) demonstrates strong ties with the surrounding environment. This industry group most effectively combines scale, resources, and the ability to implement new solutions, while also maintaining a strong international presence.

6. Analysis of cluster resilience to disruptive change

6.1. Introduction

Amid growing crises – from the COVID-19 pandemic and geopolitical shocks to the challenges of the green transition – clusters are becoming a vital force for economic and innovation resilience. Firms within clusters do not operate alone; they function within a network of interconnected relationships that enable them to better withstand shocks and adapt swiftly to changing conditions. This is supported by business literature and academic research. "*Clusters formed as a result of endogenous factors are durable and relatively resistant to crises*"[24]. Enterprises operating in dynamic clusters gain many benefits (e.g., proximity to suppliers, human capital, local knowledge), all of which help promote greater stability even in turbulent times.

This was emphasised in 2020 by European Commissioner Thierry Breton, who highlighted that clusters play a crucial role in rebuilding the EU Single Market's economy towards a greener, more digital, and resilient future. He noted that their strength lies in joint action, collaboration, and partnership, which can effectively turn European-level concepts into local actions implementation[25]. Clusters were described as the "pillars of the bridge" supporting the EU's internal market, emphasising their role as connectors between enterprises, regions, and public policies.

The following sections of this chapter explore how clusters reinforce the resilience of their members, supported by examples from various regions worldwide, and examine how public policies, especially within the European Union, assist clusters in fostering resilience and managing transitions.

6.2. Mechanisms strengthening resilience in clusters

There are several ways in which well-organised clusters can enhance the resilience of the firms and institutions they unite. These include networking and building trust between partners, efficient transfer of knowledge and innovation, shared access to resources, flexibility in adapting to change, and representing members' interests to public authorities.

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[24] Pasieczny, J. (2006). Regional determinants of cluster formation. Research Papers of the Wrocław University of Economics, 1116, 549.

[25] European Clusters Alliance. (2020, 20 May). Clusters need to be included in the recovery plans of the EU Member States. European Clusters Alliance. https://clustersalliance.eu/news/news-from-eca/clusters-need-to-be-included-in-the-recovery-plans-of-the-eu-member-states [accessed: 09.09.2025].

Networking and trust within clusters

Strong internal networks are essential for cluster resilience. Close cooperation and frequent communication among firms, suppliers, customers, research units, and other stakeholders enable swift responses to disruption. During crises, cluster firms can quickly share information on emerging market needs, shortages, or technological solutions – something much harder for enterprises outside these structures. A notable example is from China during the pandemic: studies indicated that regions with a higher concentration of industrial clusters were less severely impacted by the COVID-19 shock, a result attributed to dense informal networks and trust-based collaboration that helped firms share risk and support one another[26]. Local linkages between suppliers and customers within clusters also helped stabilise supply chains and reduce vulnerability to external transport disruptions.

In Europe, the pandemic led to the spontaneous creation of the **European Alliance Against Coronavirus (EAAC)**, a platform for regular teleconferences involving cluster leaders from different countries, supported by the European Commission. The initiative was founded by the **European Clusters Alliance (ECA)**, a pan-European network of clusters and cluster organisations that serves as a collective platform representing cluster interests at EU and international levels. ECA currently unites around 800 clusters and 150,000 innovative enterprises, with membership organised through national cluster associations and ambassadors in countries without a formal cluster network.

The EAAC platform facilitated the exchange of information on missing resources and potential solutions, matched hospital needs with company offers (e.g., the production of masks or ventilators), and enabled real-time sharing of best practices. This form of intensive networking and knowledge exchange was described as the collective intelligence of clusters, aiding in coordinating a rapid industrial response to the crisis[27]. As a result, clusters served as both horizontal connectors (linking firms across sectors) and vertical connectors (connecting business and public administration), thus enhancing the adaptive capacity of the economy.

In the broader context of resilience, the ECA can act as a catalyst for inter-cluster cooperation, support diversification of network linkages, promote knowledge sharing on crisis dynamics and best practices, and advocate for the integration of clusters into EU recovery plans and policy frameworks (e.g., Next Generation EU). Current ECA activities supporting resilience include managing events and services delivered through the European Cluster Collaboration Platform

[26] Based on, among others: Dai, R., Mookherjee, D., Quan, Y., & Zhang, X. (2020). Industrial clusters, networks and resilience to the COVID-19 shock in China (NBER Working Paper No. 28000). National Bureau of Economic Research. http://www.nber.org/papers/w28000 [accessed: 09.09.2025].

[27] Engelmann, U. (2020). Clusters: Strengthening resilience & supporting recovery [Presentation]. European Alliance Against Coronavirus (EAAC). https://clustersalliance.eu/-cms/wp-content/uploads/2021/03/ulla_engelmanneaac_31-7final.pdf?x68876 [accessed: 09.09.2025].

(ECCP), hosting "Clusters Meet Regions" workshops, conducting online sessions on the latest EU policies, as well as crisis-response actions related to the war in Ukraine (in cooperation with the Ukrainian Cluster Alliance)[28].

Importantly, cluster networks rely on trust that often takes years to build through collaborative work within a region. High trust levels facilitate joint emergency responses; for instance, companies might share employees during labour shortages or exchange materials during supply disruptions. These solidarity-based practices were observed in many clusters during the pandemic and again after the outbreak of the war in Ukraine, demonstrating that the social capital developed within clusters significantly enhances the resilience of cluster-based enterprises.

Transfer of knowledge and innovation

Clusters are widely recognised as catalysts of innovation, speeding up the exchange of knowledge among actors and directly enhancing resilience. Within a cluster environment, new ideas, technologies, and know-how spread more swiftly through both formal and informal interactions: meetings, seminars, staff mobility, and joint R&D projects carried out by firms and research institutions. Consequently, cluster firms are able to adopt new technologies or business models more rapidly in response to market changes than enterprises operating independently.

For example, in regions with a strong presence of clusters, innovations related to the green transition (such as low-emission technologies) tend to spread more easily. Industrial clusters involved in the global initiative **Transitioning Industrial Clusters Towards Net Zero** – supported by the World Economic Forum – establish knowledge-exchange platforms that allow smaller firms to access the latest environmental information solutions[29]. According to the Boston Consulting Group, governments seeking to accelerate the green transition should promote cooperation and coordination within clusters, and establish platforms that connect the private sector with research institutions and public administration to speed up the spread of clean technologies and the transfer of research findings into industry.

[28] European Clusters Alliance. (n.d.). Activities: What we do for our community. https://clustersalliance.eu/activites/#what-we-do [accessed: 09.09.2025].
[29] World Economic Forum. (2023). Transitioning Industrial Clusters towards Net Zero [Report]. In cooperation with Accenture and EPRI. World Economic Forum. https://www.weforum.org/publications/transitioning-industrial-clusters-towards-net-zero [accessed: 09.09.2025].

Such proactive public-sector engagement can ensure that the innovation benefits of clusters become "*multiplicative rather than merely additive, generating value that resonates within and beyond clusters, strengthening resilience and broad-based economic growth*"[30].

Knowledge transfer within clusters involves not only technologies but also tacit knowledge, such as practical experience or sector-specific expertise. Geographic proximity and frequent contact facilitate the circulation of this kind of knowledge. In doing so, clusters enhance firms' ability to solve new problems and introduce innovations under time pressure. Companies operating within a cluster learn from each other, imitate effective strategies, and collaboratively develop solutions – an invaluable asset during sudden demand shocks or the necessity to pivot into new activities.

Access to resources and shared infrastructure

Another mechanism that enhances resilience is easier access to diverse resources through cluster organisation. Membership provides firms with certain advantages and support that would be difficult to obtain on their own. Clusters can offer their members a variety of resilience-boosting resources, including access to skilled human capital, information on new business opportunities, and assistance with applications for government support programmes – confirmed, for example, in research conducted on Argentinian clusters[31]. As a result, cluster firms facing shocks (e.g., pandemic lockdowns, disruptions to supply chains caused by the war in Ukraine, or other geopolitical factors) were able to access workers with necessary skills, identify alternative markets more quickly, and utilise emergency support schemes more effectively.

Shared infrastructure established within clusters also plays a vital role. Laboratories, equipment parks—including prototyping facilities—and science and technology parks allow firms to test and deploy new solutions more affordably and with lower risk. During crises (e.g., when supply chains are disrupted and substitutes for unavailable inputs are required), such infrastructure facilitates the quick development of local alternatives to missing products.

Furthermore, clusters often assist members in securing capital and finance. Cluster organisations frequently act as intermediaries in dealings with banks, investment funds, and public programmes, enhancing the credibility of the group of firms overall. Some clusters

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[30] Daniel, C., Pande, V., Rafih, R., Morihara, M., Caines, C., & Zuzek-Arden, T. (2024, 10 May). Are economic clusters ready for the green transition? Boston Consulting Group, p. 7. https://www.bcg.com/publications/2024/supporting-economic-clusters-in-green-transition [accessed: 09.09.2025].

[31] Díaz de Astarloa, B., & Tacsir, E. (2022). Cluster Initiatives and Economic Resilience: Evidence from a Technology Cluster in Argentina (IDB Working Paper No. IDB-WP-1382). Inter-American Development Bank. https://doi.org/10.18235/0004594 [accessed: 09.09.2025].

oversee seed funds or business-angel networks that support start-ups in a specific region. Access to finance and investors is vital for firm survival—particularly for innovative SMEs—during economic downturns.

Flexibility and adaptive capacity

Firms operating within clusters usually show greater operational flexibility and a better ability to adjust production profiles or target markets – an invaluable advantage during crises. This stems from a combination of factors: network connections, information flow, access to resources, and the innovative culture often found in clusters.

The literature highlights that clusters' adaptive capacity also arises from the diversity of actors and skills within the ecosystem. If one market segment declines, cluster firms can utilise complementary skills to collectively pivot towards another segment. For instance, in a textile cluster comprising fabric manufacturers, clothing design firms, and machinery producers, companies were able to jointly launch the production of masks and protective overalls during the pandemic – whereas a single textile company operating alone would likely struggle to manage the entire value chain of a new product[32].

It is important to remember, however, that membership in a cluster alone may not be enough. Effective cluster management and proactive organisational activity are vital. Cluster flexibility appears at both micro level (quick changes in production profiles by individual firms supported by the network) and macro level (keeping the entire ecosystem functioning by reallocating resources to where they are most needed). As a result, clusters can develop from crises, strengthened by new skills and products, whereas isolated firms may not survive.

Representation of interests and influence on policy

Clusters also serve as an important link between business and the state, a role that becomes especially vital during times of crisis. Cluster organisations unite dozens or even hundreds of firms, allowing them to effectively communicate their collective needs to government institutions. Instead of numerous individual voices, policymakers receive a coordinated message from the cluster (e.g., regarding necessary emergency measures, relief schemes, access to finance, or regulatory adjustments).

During the COVID-19 pandemic and subsequent disruptions to the supply chain, clusters actively communicated to governments the barriers that hindered business operations, such as obstacles to the cross-border movement of goods, and proposed suitable solutions. The European Commission utilised the information gathered by the European Clusters Alliance to

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[32] Puig, F., González-Loureiro, M., & Ghauri, P. N. (2021). Capturing the resilience of textile companies as a specific response of the fashion industry. Journal of Fashion Marketing and Management: An International Journal, 25(3), 463–481. https://doi.org/10.1108/JFMM-07-2020-0136 [accessed: 09.09.2025].

respond to supply chain breakdowns and redirect critical resources to where they were urgently needed[33]. Clusters proved to be an effective "early warning system" for disruptions in industrial ecosystems. Due to their proximity to the market, policymakers gained real-time insights into the condition of sectors and the needs of firms, particularly SMEs.

Equally important is the role of clusters in allocating support. Clusters can serve as operators of assistance schemes, selecting enterprises or projects with the highest potential to enhance resilience. A notable example is Interizon – the Pomeranian ICT Cluster – which acted as an operator of cascade grants within the DESIRE project. Through a simplified application process, it allowed SMEs to access funding quickly for developing innovative e-health solutions, thereby strengthening their capacity to respond to crises. Further details are provided in subsection 8.2.12 of this report.

In the longer term, cluster organisations help shape development policies by making sure that regional strategies, innovation plans, or energy-transition agendas reflect the specific needs of the local ecosystem. Across the EU, there is an increasing trend to assign clusters intermediary roles in implementing industrial policy (for example, clusters deliver EU-funded projects aimed at supporting the digital or green transition of SMEs). Consequently, clusters can boost systemic resilience – of entire sectors rather than just individual firms – by improving information flows and aligning public actions more closely with market realities.

6.3. Examples of clusters' effectiveness in crises and transformation

The examples below demonstrate how clusters across different regions worldwide have helped tackle three major challenges of recent years: the COVID-19 pandemic, geopolitical shocks (and the related supply chain crisis), and the green transition of the economy. These cases show that the resilience-building role of clusters is not just theoretical. In reality, clusters have consistently proven to be actors that enable many organisations to survive and adapt during periods of crisis.

COVID-19 pandemic – a test of the resilience of cluster networks

In the European Union, clusters played a vital role right from the early weeks of the pandemic. The European Commission urged industrial clusters to support crisis response efforts through the **COVID-19 Industrial Clusters Response Portal** – a dedicated forum on the European Cluster Collaboration Platform (ECCP)[34]. Through this portal, more than 1,100 support offers from

[33] European Clusters Alliance. (2020, 30 June). Industrial clusters need to be included in the European recovery plans. European Clusters Alliance. https://www.nca.cz/media/v3rktfkv/eca_common-declaration-recovery-plans-2020.pdf [accessed: 09.09.2025].

[34] https://www.clustercollaboration.eu [accessed: 09.09.2025].

companies were channelled to the European Commission via clusters[35]. On the forum, clusters exchanged information on shortages (for example, where masks or ventilators were lacking) and on solutions (which firms could supply them). Consequently, clusters served as a one-stop shop for public authorities, offering reliable information and practical proposals for action almost in real time. Additionally, as mentioned earlier, European cluster organisations (under the umbrella of the European Clusters Alliance) held daily crisis briefings, forming a pan-European rapid-response network. Clusters swiftly adapted the scope of their activities, becoming matchmaking hubs that linked demand with supply for essential medical equipment.

A similar pattern is seen in individual EU Member States. In Italy, the textile cluster in Prato coordinated hundreds of local workshops to start mass production of face masks when imports from Asia were suspended[36]. Another example of support can be seen in Poland's aviation cluster, Aviation Valley (Dolina Lotnicza) in Podkarpackie. During the pandemic, the cluster coordinated the production of protective face shields and ventilator components using 3D printers available in local companies and technical facilities schools[37]. Thanks to the cluster, companies that typically competed in the aerospace sector collaborated to address urgent hospital needs, which was broadly recognised as an example of regional innovation solidarity.

Another example of rapid adaptation was the Business Climate Barometer created by the Industrial Cluster Evoluma. By conducting regular surveys of business sentiment, the cluster offered dependable data on the state of the metal industry, utilised both by member firms and by the public authorities[38]. A further example is the Bydgoszcz Industrial Cluster – Bydgoszcz Tool Valley, which during the pandemic coordinated the production of personal protective equipment, organised a cooperation exchange, and provided training for companies, becoming a regional centre for crisis management[39]. These cases show that clusters not only promote competitiveness but also strengthen the resilience of their ecosystems against sudden shocks.

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[35] Engelmann, U. (2020). Clusters: strengthening resilience & supporting recovery [Presentation]. European Commission, DG GROW. European Alliance Against Coronavirus (EAAC). https://clustersalliance.eu/-cms/wp-content/uploads/2021/03/ulla_engelmanneaac_31-7final.pdf [accessed: 09.09.2025].

[36] WWD. (n.d.). From textiles to face masks: Faliero Sarti rethinks its strategies. WWD. https://wwd.com/accessories-news/hats-gloves-and-more/from-textiles-to-face-masks-faliero-sarti-rethinks-its-strategies-1203638767 [accessed: 09.09.2025].

[37] GazetaPrawna. (2020, 1 April). Podkarpackie: Firms from the technology park produce, among others, face shields and masks. https://www.gazetaprawna.pl/wiadomosci/artykuly/1465883,podkarpackie-firmy-z-parku-technologicznego-produkuja-min-przylbice-i-maseczki.html [accessed: 09.09.2025].

[38] Metal Processing Cluster. (29 May 2020). Synthesis of the Metal Processing Cluster Business Barometer (B-KOM) – May 2020. https://evoluma.pl/sites/default/files/2020-06/Synteza%20Barometr%20KOM%20-%20MAJ%202020%20r.pdf [accessed: 09.09.2025].

[39] BiznesCiti. (2020, 25 November). Bydgoszcz Industrial Cluster to support pandemic efforts. https://biznesciti.com/2020/11/25/bydgoski-klaster-przemyslowy-ma-pomoc-w-pandemii [accessed: 09.09.2025].

Asian examples also offer valuable insights. In China, where large industrial agglomerations of firms have long been studied as cluster structures, economists noted that regions with higher cluster density experienced smaller declines in the number of new firms and performed better overall during the pandemic[40]. This was attributed to the unique features of clusters: dense formal and informal networks, shared business communities (often originating from the same locality), and proximity to markets and suppliers. Mechanisms typical of Chinese clusters—such as mutual trade credit, sharing seasonal workers, and joint use of storage facilities—helped companies survive periods of disruption. The authors emphasise that these informal, network-based coordination mechanisms based on cooperation, risk-sharing, and spatial proximity constitute an important advantage that enables clusters to cope more effectively with shocks.

War in Ukraine

The Ukrainian defence cluster BRAVE1 serves as a clear example of how clusters can enhance economic and technological resilience during wartime. Launched in April 2023 by the Ministry of Digital Transformation of Ukraine, the cluster brings together the government, industry, and frontline users within a fast-paced innovation cycle: from prototype grants, through field testing and certification, to demo days and operational procurement. In practice, BRAVE1 has already connected approximately 1,000–1,600 firms and 1,600–3,500 projects, awarded hundreds of grants (totalling around USD 3–3.3 million in the initial programmes), and facilitated the rapid deployment of drone technologies, electronic warfare systems, and AI-based software on the frontline. Feedback from soldiers is transmitted to developers almost instantaneously, reducing development cycles and increasing the effectiveness of deployed technologies[41, 42]. Furthermore, the “Brave1 Market” – essentially an Amazon-style platform for military and technology providers – was launched, along with mechanisms that enable access for foreign investors and partners, thereby strengthening the ecosystem’s resilience through its capital and export aspects.

In 2025, BRAVE1 also launched the “Test in Ukraine” platform, aimed at organising and speeding up the testing of foreign defence technologies at Ukrainian proving grounds. This initiative boosts the transfer of know-how, investment, and innovative solutions, while diversifying supply chains and enhancing the resilience of the entire defence-industrial sector

[40] Dai, R., Mookherjee, D., Quan, Y., & Zhang, X. (2020). Industrial clusters, networks and resilience to the COVID-19 shock in China (NBER Working Paper No. 28000). National Bureau of Economic Research. http://www.nber.org/papers/w28000 [accessed: 09.09.2025].
[41] UBN. (2023, 27 April). Ukraine has launched the BRAVE1 cluster for the development of defence technologies. https://ubn.news/ukraine-has-launched-the-brave1-cluster-for-the-development-of-defense-technologies [accessed: 09.09.2025].
[42] Brave1. (n.d.). Cluster for support of defence tech developments in Ukraine. https://brave1.gov.ua [accessed: 09.09.2025].

system[43]. As a crisis-driven cluster model, BRAVE1 demonstrates that strong and well-coordinated clusters can quickly mobilise SMEs and start-ups, gather funding, develop standards, and, by integrating state demand with accelerated R&D cycles, effectively boost resilience across multiple areas levels:

- for member firms (access to finance, testing facilities, markets);
- for the cluster itself (critical mass of innovation);
- for the national economy (technological autonomy, export capacity, inflow of investment).

6.4. Geopolitical shocks and supply chain resilience

Recent years have also seen a series of geopolitical shocks that have disrupted global supply chains and threatened the economic security of states. These include the US–China trade war, Russia's aggression against Ukraine (which has, among other things, caused a resource and energy crisis in Europe), and increasing geopolitical tensions in key high-tech sectors such as semiconductors and critical raw materials. In these circumstances as well, clusters have proven to be effective tools for enhancing resilience, particularly by strengthening the independence of value networks within clusters and shortening supply chains.

For the European Union, geopolitical disruptions – such as shortages of semiconductors from Asia or limited access to critical materials – have prompted a re-evaluation of industrial policy. In 2021, the European Commission updated its Industrial Strategy, emphasising the resilience of 14 EU industrial ecosystems. One of the new tools introduced in this context was **Euroclusters** – cross-border alliances of clusters from different Member States, designed to support recovery and resilience goals. In September 2022, the first 30 Euroclusters were launched, involving 171 partner organisations from 23 countries and covering all key ecosystems (from health to advanced manufacturing)[44]. The aim of Euroclusters is, among other goals, to strengthen intra-EU value-chain linkages, decrease dependence on external suppliers, and enhance the resilience of strategic sectors. For instance, electronic, automotive, and energy clusters across Europe are expected to collaborate more closely by sharing expertise, jointly investing in missing production stages, and training the workforce. Consequently, the European supply chain should become less vulnerable to disruptions. Euroclusters are financed through the Single Market Programme, and their activities also include internationalisation (e.g., identifying

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[43] UBN. (n.d.). BRAVE1 has opened up opportunities for international defence tech companies to test their technologies in Ukraine. https://ubn.news/brave1-has-opened-up-opportunities-for-international-defense-tech-companies-to-test-their-technologies-in-ukraine [accessed: 09.09.2025].

[44] European Commission. (2022). 30 Euroclusters have been launched to implement the EU Industrial Strategy. Newsroom – Growth. https://ec.europa.eu/newsroom/growth/items/757849/en [accessed: 09.09.2025].

alternative markets outside the EU) and knowledge-sharing initiatives for firms outside the main cluster networks.

A strong example of cluster-driven resilience is Europe's automotive industry during the semiconductor shortage of 2021–2022. Automotive clusters—such as Silicon Saxony in Germany (a leading microelectronics cluster)—along with car-manufacturing clusters, created a dialogue platform between chip producers and automotive OEMs. This helped synchronise supply and demand, prioritise critical deliveries, and identify investment needs in Europe (including new semiconductor fabs, later supported through the EU Chips Act) initiative[45].

At the national level, a significant development was the establishment of **the Forum of Polish Automotive Clusters** (formalised in 2023), which unites the four most important cluster organisations in the sector: Silesia Automotive & Advanced Manufacturing, the Polish Automotive Group, the Eastern Automotive Alliance, and the Lower Silesia Automotive Cluster. This forum offers a unique platform for collaboration, fostering knowledge exchange through regular meetings and workshops, and facilitating joint strategic planning. In the context of enhancing economic resilience, the forum can serve as a key coordination mechanism for Poland's automotive sector – connecting businesses, research institutions, and public authorities. By presenting a unified voice and pooling resources, automotive clusters are better equipped to respond to crises (e.g., supply chain disruptions) and support the sector's green and digital transformation (see Chapter 7.4 for further details).

The issue of **supply security** and **dual-use technologies**[46] increasingly appears in EU cluster initiatives. For example, in June 2025 the "Clusters meet Regions" event held in Rzeszów (Poland) focused on regional resilience, with one of the main themes being the fast-growing aerospace and drone industries in the Podkarpackie region, including dual-use (civil–military) technologies[47]. Discussions focused on how clusters can support both defence-related objectives (e.g., integrating SMEs into defence-industry supply chains) and civilian development (e.g., diversifying production to cater to the rapidly growing civil drone market).

A good example is the activity of the Polish Automotive Group (PGM) cluster, which has recognised the potential of dual-use technologies in its sector. PGM supports its member companies in establishing links with the defence sector by organising B2B meetings, joint stands at defence trade fairs and undertaking advocacy efforts aimed at public institutions. PGM demonstrates that dual-use technologies are not limited to military applications; they can also

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[45] Based on data from: https://silicon-saxony.de [accessed: 09.09.2025].

[46] Dual-use technologies refer to products, technologies and solutions that can be used both for civilian purposes and in activities requiring heightened security – traditionally in the military, but also in other public services (e.g. police, border guard, fire services or emergency medical services).

[47] Further information, meeting agenda and presentations are available at: https://www.clustercollaboration.eu/content/clusters-meet-regions-rzeszow-poland [accessed: 09.09.2025].

support civil protection services, such as fire brigades, police or emergency rescue units. As a result, clusters are becoming not only instruments for enhancing competitiveness, but also strategic assets for national and societal security (see the cluster good practice in Chapter 8.2.7). Increasingly, they are also regarded as assets of economic security. EU authorities encourage technology clusters to collaborate in the development of key enabling technologies (e.g. microelectronics, cybersecurity, robotics) to reduce Europe's dependence on imports from third countries.

In the United States, the concept of supporting clusters for economic security has also become more prominent in recent years. The federal government – especially influenced by pandemic-related shortages of medical equipment and strategic competition with China – has started investing in **Regional Innovation Clusters (RICs)** focused on vital sectors. The US Small Business Administration (SBA) launched a dedicated funding programme for RICs aimed at strengthening local manufacturing clusters, rebuilding domestic capacity in key industries, and promoting reshoring by reducing supply chain dependencies chains[48]. Clusters in the US are expected to function as "network hubs for SMEs, concentrating resources to assist firms in navigating funding, procurement, and supply-chain opportunities" and to "match new technologies with industry needs".

In both the EU and the US, there is a clear trend towards strengthening clusters in sectors deemed essential for security (defence, semiconductors, critical raw materials, energy). Clusters promote the integration of SMEs into larger projects and programmes, thereby bolstering entire ecosystems. By fostering local and regional links, clusters diminish the risk of global supply disruptions – the more stages of the value chain available within a given cluster network, the greater the resilience to external shocks. It should be highlighted that such a restructuring of supply chains towards higher resilience is a long-term process requiring significant investment (e.g., in production capacity or technologies) and strong coordination at various levels.

Importantly, economic and security resilience extends beyond high-tech or defence sectors. A good example is the NUTRIBIOMED Cluster, which develops innovations in bioeconomy and healthy food. Through cooperation between firms and scientific institutions, the cluster enhances the region's capacity to meet essential needs such as access to functional foods, health-supporting supplements, and technologies for food preservation (see the cluster good practice in Chapter 8). This illustrates that clusters can be a vital part of the broader security

[48] Small Business Administration. (2025, 6 August). SBA announces new Regional Innovation Cluster funding to support domestic manufacturing. https://www.sba.gov/article/2025/08/06/sba-announces-new-regional-innovation-cluster-funding-support-domestic-manufacturing [accessed: 09.09.2025].

system, supporting regions in times of crisis in fundamental areas such as food, water, and health.

6.5. Green transition and sustainable innovation

The shift towards a climate-neutral and sustainable economy is another area where resilience and innovation go hand in hand. Moving to green technologies (renewable energy, electromobility, circular economy solutions) often demands radical innovation and may initially entail significant costs and risks. Clusters can serve a dual purpose in this context: firstly, they speed up the implementation of green innovations; secondly, they assist firms in reducing the risks linked to the transition, thereby bolstering their resilience to shocks such as volatile energy prices or environmental regulations.

The European Union increasingly views clusters as important actors in delivering the twin transition – green and digital. A number of EU-level initiatives explicitly support this objective, including the **Towards Green Transition** scheme under the ECCP[49], which offers clusters access to experts and training on greening industrial processes. One of the core tasks of the Euroclusters, mentioned earlier, is defined as “supporting the shift towards a greener and more digital economy” through joint implementation projects[50]. Clusters are understood here as intermediaries – connecting enterprises with research institutions and support programmes to ensure that new technologies (e.g. hydrogen technologies, energy storage, raw-material recycling) quickly diffuse among SMEs. This report[51], as well as the previous edition[52], describes numerous good practices that fall within this domain.

However, recent OECD analyses emphasise that **the green and digital transitions** alone are not sufficient. A third dimension is required – **the social transition**. Incorporating this dimension means that issues such as social cohesion, equality and inclusion must become integral components of economic and environmental policy. The OECD argues that neglecting this aspect may deepen inequalities and create adverse development cycles, in which social weaknesses inhibit both digital transformation and the green economy[53]. In this context,

[49] More information at: https://www.clustercollaboration.eu/in-focus/green/towards-green-transition-facility [accessed: 09.09.2025].

[50] European Commission. (2022). 30 Euroclusters have been launched to implement the EU Industrial Strategy. Newsroom – Growth. https://ec.europa.eu/newsroom/growth/items/757849/en [accessed: 09.09.2025].

[51] Including good practice examples from: Industrial Cluster Evoluma, Silesia Automotive & Advanced Manufacturing, Cluster of Innovative Technologies in Manufacturing, Mazovia Cluster ICT.

[52] Polish Agency for Enterprise Development. (2023). Benchmarking of Clusters in Poland – 2022 Edition. General Report (ed. M. Piotrowski). Warsaw: PARP. ISBN 978-83-7633-490-5. https://www.parp.gov.pl/storage/publications/pdf/2023.04.19.-Raport-ogolny---PL---korekta12082025.pdf [accessed: 09.09.2025].

[53] OECD. (2023). Towards a Triple Transition: Green, digital and social. OECD Publishing. https://doi.org/10.1787/094322ba-en [accessed: 09.09.2025].

clusters – as structures connecting businesses, academia, and support institutions – can play a central role in delivering this "triple transition". This involves not only enabling technological and eco-innovations but also creating mechanisms that include workers and local communities in the transformation process. Such an approach enhances both economic and social resilience, helping to prevent an asymmetric transition where certain firms or regions miss out instead of benefiting.

The 2024 Boston Consulting Group report "Are Economic Clusters Ready for the Green Transition?" suggests that governments should adopt a two-track strategy: "safeguard" and "spark". The safeguard strategy concentrates on helping existing clusters to adapt – supporting their development and reinforcing their resilience so they can continue to prosper under new conditions (e.g., an automotive cluster receiving support to assist firms in shifting towards electromobility).

The spark strategy concentrates on encouraging the development of new clusters in clean-tech sectors where emerging economic opportunities are appearing (e.g., hydrogen technology) clusters)[54].

Both strategies pursue two overarching resilience objectives:

- Preventing the decline of traditional industrial regions as a result of the transition;
- Harnessing emerging economic opportunities, while avoiding reliance on imported green technologies.

Many EU and national initiatives embody these principles. For example, Cluster Excellence Denmark (funded by the government until 2023) focused on enhancing cluster capabilities in sustainability, acting as a central hub for coordination and knowledge exchange for all Danish clusters[55]. Consequently, Danish clusters – spanning wind energy to bioeconomy – received structured support to adopt best practices and sector-specific sustainability standards. This type of meta-cluster functions as a platform for collaboration, coordination, and knowledge sharing across green initiatives, allowing the scaling-up of individual cluster achievements to the national level.

Another example is the **European Cluster Partnerships** funded under Horizon 2020 and continued in Horizon Europe. Through partnerships such as the European Circular Economy Hotspot Network[56] or Low Carbon Business Action[57], groups of clusters from different countries

[54] Daniel, C., Pande, V., Rafih, R., Morihara, M., Caines, C., & Zuzek-Arden, T. (10 May 2024). Are economic clusters ready for the green transition? Boston Consulting Group. https://www.bcg.com/publications/2024/supporting-economic-clusters-in-green-transition [accessed: 09.09.2025].
[55] Ibidem.
[56] https://hollandcircularhotspot.nl/network [accessed: 09.09.2025].
[57] https://lcbacanada.com [accessed: 09.09.2025].

jointly implement pilot projects on circular economy solutions, resource efficiency and emissions reduction. These initiatives show that clusters can test new models (e.g., industrial symbiosis, where one firm's waste becomes another's input) on a small scale and, once proven, spread them more widely across regions.

The examples above show that clusters can lower both the costs and risks of the green transition for individual firms, thereby boosting their resilience. For example, a firm may find it much easier to comply with new emissions regulations if the cluster offers targeted training and technological support. Similarly, if fossil-fuel energy prices rise (an economic shock), companies within an energy cluster that have invested together in a shared photovoltaic installation will be much less affected than those solely dependent on market-based electricity prices. In this way, green cluster initiatives – which also align with EU priorities – can have a direct and significant impact on economic resilience.

6.6. EU policies supporting clusters in resilience and transformation

The European Union has supported clusters for many years, but recent crises have added a new dimension to this support, focusing on strengthening resilience and promoting transformation. The main elements of EU policy in this area are outlined below.

- **EU Framework Programmes (Horizon Europe, COSME/Single Market Programme).** Horizon 2020 introduced dedicated instruments for clusters for the first time (e.g. *the European Cluster Excellence Programme*, *INNOSUP* actions for innovative clusters, and *Cluster facilitated projects for new industrial value chains*). Under Horizon Europe, support continues within the "Innovation Ecosystems" pillar, where clusters and innovation hubs can receive funding for international collaboration and capacity-building projects. In parallel, the Single Market Programme (the successor to COSME) funds **Joint Cluster Initiatives (Euroclusters)**, as discussed earlier. The objective of these initiatives is clearly outlined: to enhance the resilience of the EU's industrial ecosystems and to hasten the green and digital transitions.
- **European Cluster Collaboration Platform (ECCP).** The EU funds the operation of the ECCP portal, which acts as a central platform for over 1,400 cluster organisations across Europe. The platform became an essential tool during the crisis (through the COVID-19 forum) and afterwards – it now features a dedicated "Resilience" section, offering guidelines, case studies, and training materials on how to improve resilience clusters[58]. The ECCP also hosts regular EU Clusters Talks – webinars for clusters covering topics such as risk management, post-pandemic recovery, and the integration of Ukrainian refugees into local ecosystems. This may be seen as a form of "soft policy": knowledge-sharing and networking to strengthen the adaptive capacity of clusters.

[58] https://www.clustercollaboration.eu/in-focus/resilience [accessed: 09.09.2025].

- **Involving clusters in crisis management.** The European Commission has recognised clusters as partners in emergency management. Since 2020, representatives of the European Clusters Alliance have been invited to consultations on supply-chain initiatives (e.g., within the EU *Industrial Forum or during the development of the Single Market Emergency Instrument*). This demonstrates that the voice of clusters is considered when designing mechanisms for responding to future crises. Furthermore, several Member States have established national cluster contact points within their ministries of economy, with a mandate to collaborate with clusters specifically on resilience. For example, France has had a national coordinator for clusters since 2021, who, during the 2022 energy crisis, gathered information from clusters about energy-intensive firms at risk..
- **Funding for dual-use and defence-related projects**. Through the European Defence Fund (EDF) and other instruments, the EU has begun supporting networks of clusters whose solutions and products can be utilised in both civilian and defence sectors. One example is the EU KETs4Dual-Use project[59] – a consortium of high-technology clusters designed to assist companies with dual-use products and technologies in entering global value chains and scaling up. In this way, the EU aims to utilise clusters to bridge the gap between civilian sectors (e.g., consumer electronics) and defence sectors (e.g., advanced sensors), enabling innovation to flow between them and enhancing Europe's access to key technologies (e.g., advanced materials, photonics). The EU's 2023 Economic Security Strategy also emphasises the role of clusters in mobilising SMEs to support the broader security effort (e.g., defence components, stockpiling).
- **Focus on sustainable development.** EU cluster policy strongly aligns with sustainability objectives. Clusters participate in implementing the 2030 Agenda, for instance through European innovation partnerships in fields such as smart cities, clean transport, and resource efficiency. Many EU cluster calls grant extra points for elements like social inclusion, high-quality job creation, and carbon footprint reduction. This creates clear incentives for clusters to incorporate not only economic resilience but also social and environmental resilience into their strategies. For example, European Social Economy Clusters connect clusters with social enterprises, which, in the context of resilience, enhance social cohesion[60].
- A new trend: measuring "resilience" in cluster projects. In 2024, the Polish Agency for Enterprise Development published a report titled "Mechanisms for Strengthening

[59] https://www.clustercollaboration.eu/content/eu-kets4dual-use-20-project-successful-business-missions-uae-singapore-and [accessed: 09.09.2025].

[60] More information: https://www.clustercollaboration.eu/social-economy [accessed: 09.09.2025].

Economic Resilience in Times of Threat”, recommending that cluster projects should be assessed in terms of how effectively they enhance resiliencee.

Overall, EU cluster policy has shifted from relatively narrow support (focused mainly on innovation and competitiveness) towards a comprehensive approach where clusters are seen as partners in securing Europe’s economic future. This includes digital and green modernisation, as well as the ability to withstand crises and boost strategic autonomy. Financial support is complemented by coordination activities such as platforms, alliances, and knowledge-exchange forums. The EU increasingly encourages cross-border cooperation between clusters, rooted in the belief that a European network is stronger than the sum of individual national actors.

In Poland, similar patterns can be observed. There is a growing willingness among clusters to collaborate with one another, as illustrated by the Automotive Cluster Forum, cooperation between metal-sector clusters, and several other examples identified in the study. More information on these initiatives is provided in Chapter 7.4.

6.7. Selected results of the cluster coordinators’ survey

The benchmarking study of Polish clusters enabled the collection of data on their activities and capabilities, which can be evaluated in the context of resilience-building. Resilience was not assessed using a single direct indicator. Instead, it was defined as the combined effect of multiple factors that reflect a cluster and its members' ability to withstand, adapt, and continue developing under changing conditions. In other words, resilience is understood as the capacity to preserve the network's coherence and keep cluster operations ongoing despite disruptions, as well as the preparedness to introduce innovations and new business models in response to change.

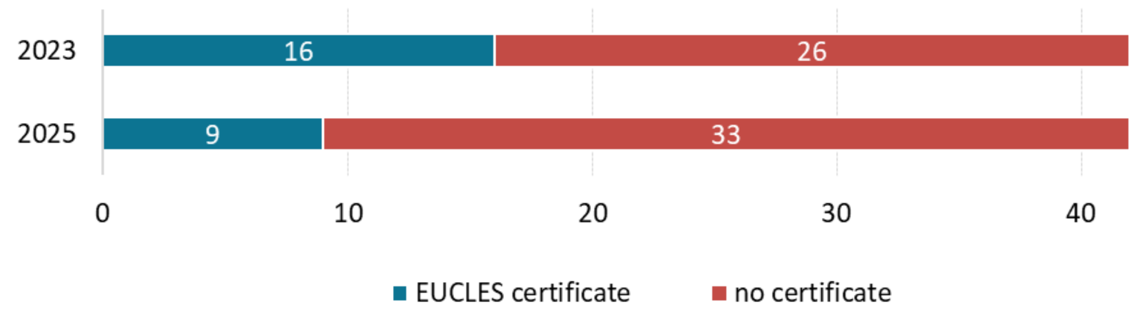
For the purposes of the study, resilience was assumed to arise from the maturity of a cluster and its capacity to respond to uncertainty. The analysis therefore concentrated on characteristics such as the existence of a long-term strategy, innovation ability, the quality of internal and external collaboration, diversification of funding sources, and the capacity to respond to sudden market or technological shifts. These elements were regarded as indirect indicators of resilience: the more developed and balanced a cluster is in these aspects, the greater its resilience to crises and environmental turbulence – and, consequently, the stronger its ability to support the resilience of its members.

Study findings – key trends and variations in the resilience of Polish clusters

- **Cluster growth and structure.** Most Polish clusters are experiencing strong growth, which is a positive sign of resilience. In the latest study, 34 out of 42 clusters showed increased membership, with an average of 15.6 more entities per cluster, amounting to a 15.3% rise in membership during 2022–2023. This growth trend is seen in both newer and more established clusters, highlighting their ongoing appeal despite recent economic challenges such as the COVID-19 pandemic and supply chain issues. A rising membership base enhances resilience by broadening the collaboration network, knowledge pool, and potential business partnerships within the cluster.
- A key indicator of maturity (and thus, indirectly, resilience) is the status of **the National Key Cluster (KKK)** awarded by the Ministry of Economic Development and Technology. Among the surveyed clusters, as many as 17 held KKK status, indicating that nearly 40% of the sample comprised clusters officially recognised as strategic and highly competitive. These clusters generally exhibit stronger management structures and greater overall potential – which is also reflected in their benchmarking results across most areas and sub-areas (e.g., R&D and innovation activity, collaboration with the environment, and internationalisation)..
- **European Cluster Excellence certifications**[61] are held by only a small proportion of clusters. Out of the 42 clusters studied, only 16 held a certification at the end of 2023, and by September 2025, this number had decreased to just 9. This suggests that only a select group of Polish clusters has achieved the highest European management standards, while a notable number have chosen not to renew their certification. Although this trend is not encouraging, the very presence of clusters with international excellence labels demonstrates that Poland does indeed host clusters with exceptionally strong operational capabilities – which may translate into above-average resilience. For the remaining clusters, this can serve as a benchmark and motivation to improve their organisational structures.

[61] This certification involves a fee, which may discourage some clusters. As an alternative, clusters may use the free self-assessment tool available on the PARP website (Cluster Management Standards), modelled on the Bronze Label audit: https://www.parp.gov.pl/component/site/site/clusterfy#wiedza [accessed: 09.09.2025].

Figure 41. Number of clusters with the EUCLES certificate at the end of 2023 and in 2025

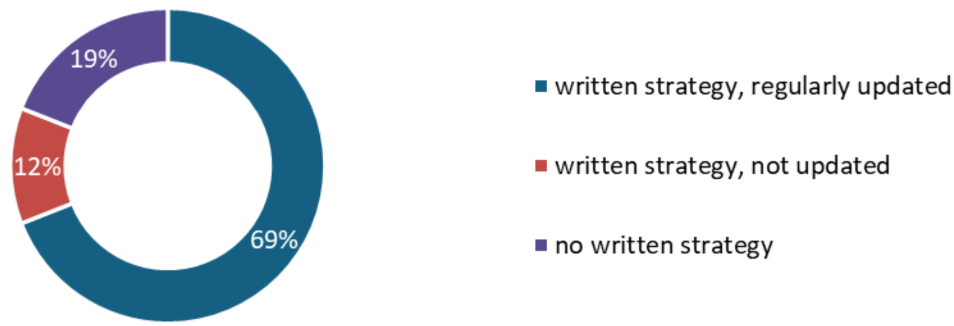


Source: own elaboration based on the cluster coordinators' survey (N = 42).

- **The financial health** of cluster enterprises was generally robust, serving as a positive sign of the overall resilience of networks. Data from a subset of 14 clusters suggested that, on average, approximately 74% of member firms either maintained or increased their sales revenue during the review period. This means only about a quarter of firms saw a decline in revenue. Given recent years marked by uncertainty, such as the pandemic and supply chain disruptions, this outcome demonstrates a certain level of resilience. It can be argued that cluster membership aided firms in navigating these challenging times by offering access to knowledge, cooperative opportunities, and support from the cluster coordinator. Naturally, financial performance varied across clusters – with high-tech clusters or those comprising larger entities showing a higher proportion of successful firms than sectors more severely impacted by the crisis, such as tourism or the broader quality-of-life industries. Nonetheless, the results point to a relatively stable financial condition among cluster firms, which remains a crucial aspect of resilience.
- Overall, the level of managerial maturity among Polish clusters can be considered moderate. On one hand, a significant number have developed key strategic documents (34 out of 42 clusters) and plan activities in core areas such as digitalisation and environmental sustainability. On the other hand, there remains a group of clusters that operate more on an ad hoc basis without a written strategy (8 clusters), or that do not update their existing strategy (5). This may be due to limited resources, as smaller clusters do not always have the administrative capacity to draft or revise strategic documents, or from a lack of awareness, since the importance of maintaining an up-to-date strategy is discussed in Chapter 4.

From a resilience perspective, this means that less mature clusters may struggle to respond swiftly and cooperatively to crises, whereas strategically managed clusters have predefined scenarios and objectives that support their continuity during disruptions.

Figure 42. Possession of a cluster strategy



Source: own elaboration based on the cluster coordinators' survey (N = 42).

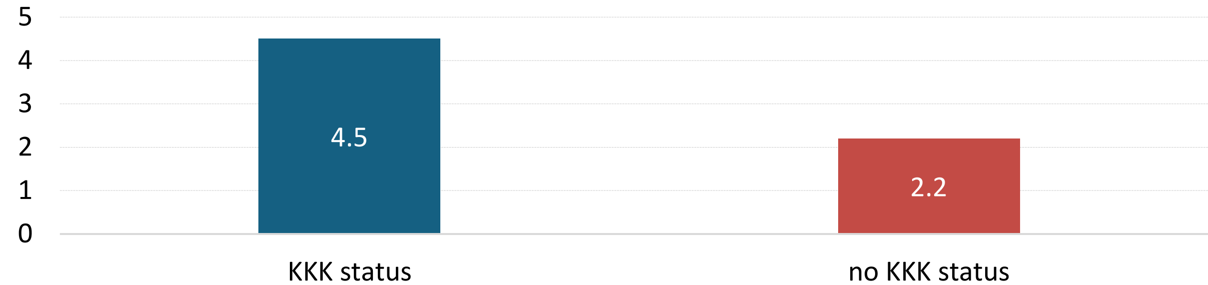
- **Managerial and strategic processes.** Professional management and a clear strategic focus form some of the key foundations of cluster resilience. The survey results reveal that Polish clusters have adopted development strategies to varying extents. A positive aspect is the relatively widespread inclusion of digital transformation: more than half of the clusters surveyed (23 out of 42) have a dedicated digitalisation strategy or incorporate digitalisation within their overall development plans. This demonstrates an awareness of the importance of digital tools and business models for the future – these clusters are investing in communication platforms, databases, and collaboration management systems that facilitate operations in a volatile, digital environment. Preparation for the green transition is somewhat less advanced: only 19 clusters have a strategy for the so-called green transition (either as a standalone document or embedded within the broader strategy), representing around 45% of the sample. An even smaller proportion mention having a comprehensive ESG strategy or its equivalent (CSR, CSV), with just 11 clusters, or roughly 26% of participants. This suggests that, although the concept of sustainable development influences the activities of many clusters, its formal integration into long-term strategies is still uncommon. For policymakers and cluster coordinators, this is a clear indication that efforts to develop plans for adapting to the green economy should be intensified – both due to increasing regulatory demands and emerging development opportunities (such as new business models in a low-emission economy). A lack of such strategies may, in the future, undermine a cluster's resilience, as energy and climate transition are expected to be among the primary challenges in the coming years.
- **Innovation and digitalisation of cluster activities.** The ability to generate innovation is a key factor in resilience, as innovative clusters are better equipped to adapt to changing

market conditions and technological advancements. The results show that innovative initiatives are being undertaken within Polish clusters, but the scale remains limited. On average, each cluster completed around 1.8 collaborative innovation or R&D projects during the survey period (defined as projects involving either the coordinator and at least two members, or at least three cluster members; two-party initiatives were not analysed). In practice, many clusters completed only one or two such projects, while some did not complete any. Only a small number managed to demonstrate a higher level of innovative activity. This suggests that the potential for expanding R&D collaboration is not fully utilised. It is notable that as many as 28 clusters (two-thirds of the sample) maintained at least one active cooperation agreement with research or educational institutions, with an average of approximately 6–7 such agreements per cluster. While partnerships with the scientific community are being established, they do not always lead to a higher number of joint innovation projects. Barriers may include limited R&D funding, lack of experience in forming consortia, or the long timeframes required for innovation projects to produce results..

- **Technology transfer**, meaning the adoption of new technologies by members facilitated by the cluster, is also not widespread. Such activities were reported by 15 clusters, indicating that more than half of the networks did not report any instances of formalised technology transfer during the period under review. In clusters where transfers did occur, the scale was moderate (with an average of 5.7 transfers per active cluster). This confirms that while Polish clusters serve as platforms for cooperation, their role as intermediaries in innovation deployment could be further strengthened. Enhancing this function (for example, through programmes supporting technology audits, innovation brokerage, or joint projects) would undoubtedly improve resilience across the entire ecosystem.
- A positive trend is the **increasing speed of digitalisation** within clusters. Cluster coordinators reported that their members are adopting various IT systems to support different stages of business activities (production, logistics, sales, communication, etc.). On average, about 7–8 different IT systems are used across a cluster's value chain (out of nine specified in the survey questionnaire). This suggests that cluster enterprises are largely utilising modern digital tools, which enhance efficiency and flexibility. The more digital technologies are integrated into a cluster, the easier it becomes to operate remotely, analyse market data, or coordinate members' processes – all of which are vital during lockdowns or communication breakdowns..

- **Collaboration within the value chain** was also examined. The surveyed clusters reported cooperation across roughly three out of seven stages of the value chain (e.g., joint development work, related component production, joint marketing), which is a relatively low figure. On one hand, this indicates that companies within clusters do not limit themselves to informal information exchange, but instead engage in operational collaboration across several consecutive stages of value creation. On the other hand, the average number of stages does not permit full value chain integration. To some degree, clusters with National Key Cluster (KKK) status stand out, with an average of 4.5 stages, while in clusters without this status, the figure is significantly lower at 2.2.

Figure 43. Collaboration in the value chain by possession of Key National Cluster (KKK) status

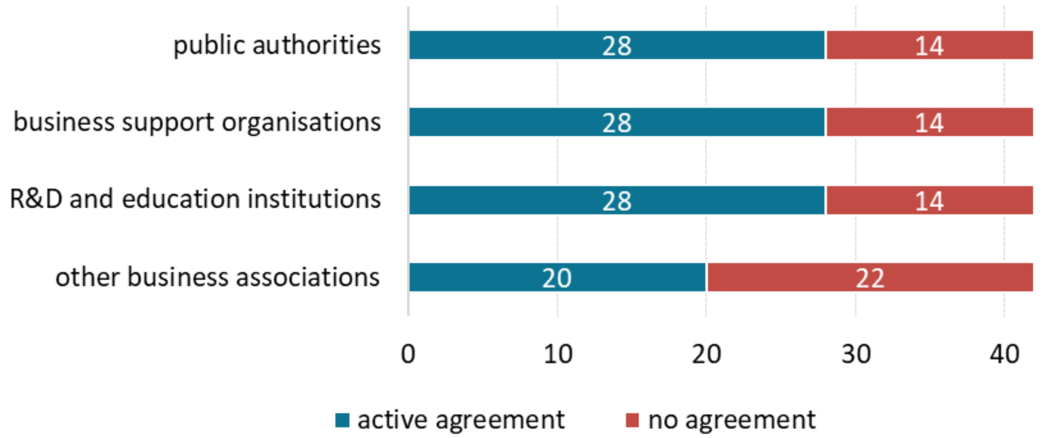


Source: own elaboration based on the cluster coordinators' survey (N = 42).

Clusters should aim to strengthen collaboration along their value chains. Such integration improves resilience – clusters become internally cohesive ecosystems where partners can depend on one another during disruptions (e.g., one member can quickly compensate for shortages affecting another within the supply chain). Naturally, the level of integration varies: in sectors such as automotive or aerospace – where supply chains are extensive – cooperation usually covers more stages, whereas in some service-oriented clusters, it is often limited to specific stages (e.g., marketing and promotional activities). Nonetheless, the average of 3.1 stages shows that network-based production and service linkages are an important aspect of how clusters operate in Poland.

- A high level of cooperation with institutional partners is also one of the key factors shaping the contribution of clusters to resilience (including at the sectoral level, as discussed earlier). Polish clusters are actively expanding networks beyond their membership base. Twenty-eight clusters have at least one active agreement respectively with public authorities, business support organisations, or research and education institutions. Slightly fewer – twenty clusters – have declared active agreements with other business associations.

Figure 44. Clusters with an active agreement with particular categories of partners



Source: own elaboration based on the cluster coordinators' survey (N = 42).

On average, each cluster maintains around 21 active cooperation agreements with external partners such as local government units, business support institutions (e.g., regional development agencies), industry organisations, and even other clusters. An extensive network of linkages shows that clusters act as hubs, integrating local economic ecosystems. Strong relationships with local authorities can translate into support for cluster initiatives (e.g., joint infrastructure or training projects). Contacts with agencies and business support organisations facilitate access to advisory services, funding, and promotion. Collaboration between clusters, in turn, supports the exchange of good practices and the implementation of larger, supra-regional projects. Clusters that are well embedded in their environment therefore have better "safety buffers" and access to resources during crises – making them more resilient.

- Clusters in Poland are increasingly going beyond purely business objectives and engaging in **activities that benefit the socio-economic and natural environments**. Nearly 62% of the surveyed clusters (26) reported undertaking initiatives with a positive social impact. Examples include various CSR initiatives, activities aligned with environmental, social, and governance (ESG) criteria, or projects based on the concept of Creating Shared Value (CSV). Likewise, 26 clusters initiated efforts to enhance the business environment for their members – such as economic lobbying, participation in regulatory consultations, or establishing industrial zones and investment clusters. On average, each cluster carried out about three such initiatives during the reporting period. These activities show that clusters in Poland are adopting a more proactive role as advocates for sectoral and regional interests, helping shape the broader environment in which they operate. This, in turn, strengthens systemic resilience: a robust cluster sector contributes to a more favourable business climate for all entities within the ecosystem.

- **Environmental engagement** is also noteworthy. Thirty-four clusters (81% of those surveyed) reported engaging in activities to enhance the natural environment. These actions take various forms – from ecological awareness and educational initiatives, through the implementation of technologies that reduce industry's environmental impact, to participation in research projects on clean technologies. Importantly, these are not one-off efforts: clusters implemented more than six different types of pro-environmental actions on average, reflecting a systematic approach. This level of ecological activity indicates a growing awareness of sustainable development among Polish clusters. It also directly affects resilience: clusters that adapt early to the green transition are less exposed to regulatory risks (e.g., tightening emissions standards) and better prepared for shifts in customer and investor preferences. Furthermore, environmental initiatives are often linked to innovation (e.g., the deployment of new green technologies), enhancing the cluster's capacity to adapt to new regulations or commercialise new solutions. The question remains regarding the quality and added value of some of these initiatives. An analysis of selected examples suggests that some activities are relatively simple and do not directly contribute to building members' resilience (e.g., they are not technology-oriented).
- **Internationalisation and international expansion** are another vital aspect linked to resilience. Many Polish clusters show a strong advantage – active participation in international markets. According to the study, thirty-four clusters (81% of the sample) provide services that support internationalisation. A typical cluster offers around five different types of support, such as joint exhibition stands abroad, trade missions, export advisory services, partner searches overseas, or training on entering foreign markets. Conversely, the situation is less positive for thirteen clusters where only a minimal number of members (fewer than ten) have benefited from such services. This support is especially important for SMEs – as indicated by the member survey results – which often lack the resources to explore foreign markets independently. Thanks to clusters, these firms can overcome entry barriers collectively, thereby increasing resilience by diversifying sales geographically. The data confirms that cluster firms are active in numerous foreign markets: on average, firms in a single cluster sell their products or services in around 33 countries. This reflects extensive global connections across various forms of export (direct exports, sales through intermediaries or partners). A broad geographical presence means that a decline in demand in any one market is less likely to be critical for the entire cluster, as firms can redirect sales elsewhere. Consequently, clusters active internationally are more resilient to local economic or political shocks..

- It is worth noting that **outward investment** (e.g., establishing subsidiaries or branches abroad) is limited to a smaller number of clusters. Nineteen clusters (around 45%) reported that their members had engaged in foreign investments over the past two years. On average, this involved fewer than three such investments per cluster in this group. However, the existence of such cases indicates that some Polish clusters include firms with international ambitions (or members of global groups). For the cluster, this offers access to new resources, markets, and valuable international experience, enhancing the resilience of the entire network (e.g., through knowledge transfer from foreign markets or protection against risks in the domestic market).

The study results show that Polish clusters have many traits that support resilience, though some areas still need improvement. Their **main strengths** include broad cooperation networks and a high level of internationalisation. Clusters are actively growing their membership, which expands their resources and contacts. Most maintain strong links with their external environment – including local authorities, institutions, and international partners — making support and expertise more accessible. In practice, this means that when a crisis occurs (whether economic or social), these clusters can respond more quickly (thanks to their ties with local government) or find alternative markets (through their international networks).

Market diversification through export activity is a crucial factor supporting the resilience of Polish clusters against economic shocks. Among the clusters analysed, some members operated in several dozen foreign markets, greatly reducing the risk of depending on the economic cycle of any single country. Nearly half of the clusters (19) reported their members' presence in at least 20 foreign markets. Based on the collected data, the average number of export markets exceeded 32 across all surveyed clusters, with the most internationalised cluster reaching 131. This extensive geographical diversification helps to sustain business continuity and revenue flows even amid declining demand in certain markets, regulatory changes, or supply chain disruptions. Furthermore, clusters active on international markets tend to engage more easily in cross-border cooperation and international projects, which enhances their resilience and capacity to adapt to global crises.

Another positive trend is the gradually increasing level of strategic awareness. Over half of the clusters (23) have incorporated digital transformation into their overall strategies. Nineteen clusters have also included provisions on the green transition. As a result, a significant proportion of clusters are proactively preparing for future technological and climate-related challenges rather than responding only under pressure. Coupled with the numerous environmental and social initiatives undertaken by the majority of surveyed clusters, this creates an ecosystem increasingly aligned with the model of sustainable and responsible development. This is crucial for long-term resilience – clusters that care for their environment enjoy higher levels of trust among communities and stakeholders and are better positioned to adapt to regulatory changes (for example, climate-related requirements).

Weaker areas and issues needing improvement mostly relate to **the operational and innovation maturity** of parts of the cluster landscape. The relatively small number of joint R&D projects and limited scale of technology transfer indicate that the potential for collaborative innovation is still underused. Clusters might require additional incentives or support (financial or organisational) to involve firms and research organisations more actively in joint development efforts. For policymakers, this signals that programmes supporting cluster innovation should remain a key way to enhance resilience. Clusters that do not develop innovation capabilities risk losing competitiveness over time, which will also limit their resilience to technological change.

Strategic planning in the realm of social impact (e.g., ESG, CSR, or CSV) also needs reinforcement. Only 11 clusters have formalised social strategies, suggesting that the rest may operate reactively, without a clearly defined direction. Given ongoing regulatory developments and increasing societal expectations, inadequate preparation in this area poses a risk – organisations that are not adapted to new requirements might gradually become marginalised or excluded from business partnerships. Therefore, strengthening strategic planning and expanding the number of clusters with dedicated ESG strategies should be a priority, allowing clusters and their members to build resilience against future social, environmental, and regulatory challenges.

The overall resilience level among Polish clusters is generally rising but remains uneven. The most advanced clusters (often those with KKK status or international excellence labels) show high resilience due to extensive networks, strong internationalisation, active pro-innovation and pro-environmental initiatives, and strategic management. Less mature clusters, although they are also growing and engaging in cooperation, may need support to develop specific capabilities such as professional management, strategic planning, and R&D initiatives. Based on the study results and ongoing dialogue with the Polish cluster community, it can be recognised that these structures are learning from recent experiences and adapting to new challenges, while fostering promising cooperation practices. The main strength of clusters lies in their ability to bring many entities together around shared goals—an ability especially valuable during crises. With continued development in maturity and conscious risk management, Polish clusters have the potential to become key pillars of the country's economic resilience in the coming years.

At the same time, this report highlights several areas requiring improvement that directly affect the capacity of clusters to build resilience. A significant proportion of structures still lack updated development strategies (around 31% of those surveyed), which hampers intentional risk management and the setting of priorities in the face of sudden changes. Weaker results were also observed in the areas of financial and infrastructural resources – with median scores of 0.11 and 0.14 respectively – indicating that many clusters lack a sufficiently stable foundation to ensure continuity of operations. In addition, the relatively low level of internationalisation and the limited number of cooperation agreements with R&D institutions and external partners restrict the ability of clusters to draw on diverse sources of knowledge and support. This demonstrates that although the fundamental basis for resilience – cooperation and integration – is strong, many clusters still require reinforcement in strategic planning, financial capacity, and international connectivity in order to respond effectively to future shocks.

Clusters can also leverage existing good practices as inspiration to develop their own services that support resilience-building. A notable example is the Resilience 2030 initiative carried out by the Silesia Automotive & Advanced Manufacturing cluster, which aims to strengthen the capacity of enterprises (particularly SMEs) to adapt and grow amid economic, technological, and environmental volatility (see Chapter 8.2.4 for further details). The service employs a seven-step resilience adaptation process, including needs diagnostics, change mapping, implementation of digital tools, and automation and robotisation of processes. This approach shows that clusters can become key partners in fostering long-term resilience for companies and entire ecosystems, while providing inspiration for other organisations across the country.

7. Inter-cluster cooperation

7.1. Introduction

In the face of global megatrends – including the twin transition (digital and green), the increasing complexity of value chains, and the growing need to build economic resilience – traditional models of competition are giving way to advanced forms of networked collaboration. Within this context, clusters are evolving from local engines of innovation into strategic nodes within global knowledge and value networks. While their capacity to stimulate productivity and innovation is well established, their real potential today lies not only in internal dynamics but increasingly in strategic inter-cluster partnerships.

Inter-cluster collaboration – understood as intentional and structured interaction between distinct ecosystems – is becoming an essential tool for achieving critical mass, combining complementary capabilities, and addressing challenges that exceed the capacity of individual firms, regions or even nations.

This chapter aims to analyse the phenomenon of inter-cluster cooperation by combining theoretical foundations with practical examples from both mature European markets and the emerging Polish ecosystem.

7.2. Foundations of inter-cluster cooperation

Understanding the nature and mechanisms of inter-cluster collaboration requires placing this phenomenon within theoretical frameworks rooted in economics, management studies, and sociology. A cluster, in Michael Porter's classical conception, is a dynamic ecosystem where competitive and cooperative forces coexist, creating a unique environment for innovation. Its strength comes from advantages such as access to a specialised labour force, knowledge diffusion, and the development of supporting infrastructure industries[62]. Inter-cluster collaboration extends this logic beyond a single ecosystem's boundaries. It involves deliberate, purposeful, and often formal interactions between at least two different clusters, designed to create synergies and benefits that cannot be achieved individually. From this viewpoint, clusters stop functioning as isolated ecosystems and instead become nodes within a broader national and international network, through which resources, knowledge, and value flow.

The theoretical foundations of this phenomenon are multidimensional[63]. **Network theory** views such partnerships as the creation of strategic linkages whose structure and strength determine

[62] Porter, M. E. (1990). The competitive advantage of nations. New York: Free Press.

[63] Sölvell, Ö., Lindqvist, G., & Ketels, C. (2003). The Cluster Initiative Greenbook. Stockholm: Ivory Tower.

the capacity to generate innovation[64]. **Social capital theory**, in turn, emphasises that trust, reciprocity and shared norms constitute the foundation of effective collaboration, without which formal agreements remain merely symbolic[65]. **The resource-based view** interprets cooperation as a strategic mechanism for accessing complementary, unique resources and competencies of partners, while **the triple helix model** – integrating business, science and public administration – often provides the organisational framework for such partnerships[66].

Inter-cluster collaboration can take various forms, which can be categorised along two main axes – intra-sectoral and cross-sectoral.

- **Intra-sectoral collaboration** involves partnerships between clusters operating within the same sector, often situated in different regions or countries. Its primary aim is to combine capabilities to enhance the competitiveness of the entire sector at national or international levels. Motivations include, among others, joint development of R&D activities focused on breakthrough technologies, the creation of standardised regulations, the exchange of best practices, and collaborative efforts in third-country markets. Such alliances enable reaching the critical mass needed to compete with global leaders and to influence industrial policy.
- **Cross-sectoral collaboration** connects clusters from different, often distant, sectors – for example, ICT with medicine or aerospace with composite materials. It is seen as a source of breakthrough innovation, as entirely new products, services, and markets emerge at the intersection of diverse knowledge and technology areas. This form of cooperation addresses complex challenges, such as digital and green transformation, which require holistic, integrated solutions, and is closely linked to the idea of smart specialisation.

The effectiveness of collaboration depends on the partnership models and operational mechanisms adopted. These models range from **informal networks** based on personal relationships to **formalised structures**, such as project consortia or joint legal entities. Regardless of the model, cooperation relies on a set of concrete mechanisms: **structural** (e.g. joint working groups), **operational** (joint R&D projects, business missions, technology platforms) and **relational** (activities aimed at building trust and social capital).

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[64] Powell, W. W., & Grodal, S. (2005). Networks of innovators. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), The Oxford handbook of innovation (pp. 56–85). Oxford: Oxford University Press.

[65] Putnam, R. D. (2000). Bowling alone: The collapse and revival of American community. New York: Simon & Schuster.

[66] Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. Research Policy, 29(2), 109–123.

The ultimate success of a partnership relies on the synergy of key factors: a shared vision and clear objectives, a high level of trust, effective governance, the complementarity of partners' resources, stable funding, and a supportive institutional environment. The ability to overcome barriers and nurture these factors determines whether inter-cluster collaboration becomes an effective development tool or remains an untapped opportunity.

7.3. International experiences

An analysis of mature cluster ecosystems in Europe demonstrates that the success of inter-cluster collaboration is the result of a deliberate, long-term support policy and the strategic approach adopted by cluster organisations themselves. The European Union has established advanced institutional frameworks that actively stimulate and fund transnational and cross-sectoral partnerships, viewing them as key instruments for implementing the EU Industrial Strategy. At the centre of this system is the **European Cluster Collaboration Platform (ECCP)**, which functions as a knowledge hub, matchmaking tool and the operational arm for programmes such as **Euroclusters**. The Euroclusters initiative, with a budget of EUR 42 million, has financed 30 transnational partnerships aimed at strengthening value chains, supporting innovation for strategic autonomy and accelerating the green and digital transition across 14 key industrial ecosystems[67]. It is also worth noting earlier initiatives, including cluster partnership projects focused on supporting SME internationalisation in non-EU markets (European Strategic Cluster Partnerships for Going International – ESCP-4i, operating between 2021–2024) and mobilising interregional investments in smart specialisation areas (European Strategic Cluster Partnerships for Smart Specialisation Investments – ESCP-S3 since 2018). The measurable outcomes of these programmes, such as B2B meetings organised and business projects launched, confirm their high effectiveness.

Cross-sectoral collaboration offers particularly strong potential, generating innovation at the interface of different fields. One example is the PIMAP+ partnership (Photonics for Advanced Manufacturing Plus), bringing together six clusters from France, Sweden, Portugal, the Czech Republic, Italy and Finland. These clusters represent areas such as photonics, advanced manufacturing, metalworking and the aerospace industry. Another project, CE4BIG (Cluster Excellence for Business, Innovation and Growth in the Health Sector), connected healthcare-related clusters from France, Germany, Belgium and Poland (LifeScience Kraków Cluster), focusing on knowledge transfer and strengthening SME capabilities in acquiring international partners. These initiatives demonstrate that strategically combining distant areas of expertise can be an effective way to open new markets and create innovative value chains.

[67] As at 30 September 2025.

7.4. Analysis of inter-cluster cooperation in Poland

As part of the benchmarking study, cluster coordinators were asked whether they held an active cooperation agreement with other domestic clusters (as at the end of the reference period, i.e., end of 2023). An affirmative response was given by 26 clusters (62% of the surveyed structures). The average number of agreements per cluster was 2.3 (among those clusters that declared such cooperation). This figure is significantly inflated by three clusters (declaring 21, 15 and 12 agreements respectively). It is worth noting that the median value is 1 agreement (meaning at least half of the clusters hold only one such agreement).

The experts gathered additional information from the 26 cluster coordinators mentioned earlier regarding the types of partners and the nature of collaboration. The key findings from the analysis are outlined below, considering the distinction between intra-sectoral cooperation, cross-sectoral cooperation, cooperation within government and regional agency initiatives, and collaboration with other business associations (without cluster status). The analysis, based on data provided directly by coordinators, may not be entirely comprehensive, as it does not cover all Polish clusters and some did not provide detailed information.

Intra-sectoral collaboration

- **The automotive industry** in Poland offers a prime example of advanced, multi-level intra-sectoral cooperation. Its foundation is the **Forum of Polish Automotive Clusters** – a unique platform uniting four organisations: Silesia Automotive & Advanced Manufacturing, the Polish Automotive Group, the Eastern Automotive Alliance, and the Lower Silesian Automotive Cluster. The agreement, formalised in 2023, established a mechanism for regular meetings and workshops aimed at exchanging experience and crafting joint strategies. The Forum's activities have swiftly resulted in tangible outcomes. A meeting with representatives of the Ministry of Economic Development and Technology in May 2025 served as an opportunity to initiate a consolidated dialogue with the national government. A unified industry voice enabled the effective presentation of proposals concerning updates to cluster policy, the certification system, and financial support for coordinators. Additionally, the meeting facilitated the formation of strategic cooperation with the Łukasiewicz Research Network, providing member companies with access to advanced research infrastructure.
- **The medical sector** also exemplifies a model of collaboration between clusters. As early as 2016, an agreement was made between the MedSilesia Cluster and the Municipality of Lublin – a coordinator of the Lublin Medicine Cluster – the LifeScience Kraków Cluster, the "Medycyna Polska" Association – recipient of the MedCluster in Tarnów, and Data Techno Park Sp. z o.o. in Wrocław – the coordinator of the national institutional e-Health Cluster. Collaboration among medical clusters mainly involves activities to integrate the sectoral environment and enhance the innovation capacity of

organisations within the fields of medicine and health technologies. According to the agreement, the **Medical Clusters Council** was established as a platform for cooperation and knowledge sharing among coordinators. This collaboration also includes organising joint sectoral events, such as conferences, workshops, and training sessions, designed to improve management standards and strengthen professional cluster structures. An example of this is the preparation and presentation of a session on innovative medical devices at the Life Science Open Space.

- **The metal and machinery industry** also highlights intra-sectoral cooperation, although informal, which has been ongoing since around 2020. The Industrial Cluster Evoluma, the Lubuski Metal Cluster, the Bydgoszcz Industrial Cluster Tool Valley, and the CINNOMATECH Association (Cluster of Innovative Manufacturing Technologies) carry out joint information and promotional activities for their members, aim to network companies to close value chains, and ensure member involvement in industry events organised by cooperating clusters. They also collaborate within the Sectoral Skills Council, which is discussed later in this chapter. The Lubuski Metal Cluster also engages in bilateral cooperation with other sector clusters, including the Radom Metal Cluster under a cooperation agreement from 2013, and the METALIKA Cluster for Industry under an agreement from 2020. This cooperation aims to facilitate knowledge and best-practice exchange, jointly organise industry events and conferences, promote the metal industry and manufacturing technologies, establish B2B relations between cluster members, support internationalisation and interregional cooperation, and pursue other joint initiatives.
- An example of intra-sectoral collaboration within a narrow group of basalt-based products or technologies is the agreement between the Polish Construction Cluster and the Polish Basalt Technologies Cluster (a cluster operated by institutes of the Łukasiewicz Research Network). One of the aims and potential outcomes of this cooperation is the transfer of innovative basalt solutions and technologies, as well as composites using them, to the construction industry.

Cross-sectoral collaboration

- Some clusters have built **extensive cross-sector cooperation** networks with other clusters. An example is the activities of the Polish Construction Cluster, which works in broad and varied collaboration with different cluster environments. Alongside the Silesian NANO Cluster, it co-organises the InterNanoPoland event, promoting innovation and sustainable development in the construction sector. The Polish Construction Cluster also partners with other cluster communities – including the Eastern ICT Cluster "Informatyka Podkarpacka", which is also a member of the Polish Construction Cluster, and the Circular Economy and Recycling Cluster, with which it jointly organises events under the Polish Circular Forum, including a panel dedicated to circular construction. The Cluster also works with INTERIZON – the Pomeranian ICT Cluster – within the project Podlaskie Industry 4.0, developing support services for companies in the areas of digitalisation, automation and process robotics. Through these initiatives, the Polish Construction Cluster actively contributes to linking different sectors of the economy and promotes innovative and sustainable solutions in construction.

- The Sustainable Infrastructure Cluster collaborates with the Polish Cluster of Composite Technologies in applying modern materials to infrastructure. As a result of this partnership, a joint conference was organised in 2023 to promote cooperation between businesses, clusters, and scientific institutions from Poland and Ukraine in developing joint projects and business initiatives.
- The Polish Automotive Group Cluster and the Industrial Cluster Evoluma have established cooperation aimed at exchanging knowledge and experience, including topics related to the defence industry and participation in events organised by each partner.
- The Łódź ICT Cluster, the North-South Logistics and Transport Cluster, and the "LODZistics" Employers' Association collaborate in organising joint events, projects, and the mutual promotion of initiatives.
- The Cluster of Innovative Manufacturing Technologies, the Modern Packaging Cluster (represented by the Polish Chamber of Packaging), and the Employers' Association Business Centre Club launched cooperation in 2023 in the form of a round table for business support institutions. This serves as an example of collaboration with an entity that represents and acts for its members without cluster status – a type of cooperation also discussed in the final part of this chapter. The round table initiative aimed to create a platform for dialogue among key players of the Polish economic ecosystem, support innovation policy, accelerate the green and digital transition, develop workforce skills, and enhance advocacy activities in the legislative sphere. The outcomes included defining short- and medium-term goals, preparing a cooperation plan, establishing expert groups, launching support tools, and planning the creation of an organisation serving as a centre for knowledge exchange.
- The cooperation between the West Pomeranian Chemical Cluster "Green Chemistry" Association and the Southern Wielkopolska Food Cluster, initiated in 2021, was informal. It involved coaching activities and the exchange of best practices to boost member engagement and enhance their activities. The cooperation also included efforts to implement joint network-based initiatives.
- The West Pomeranian Chemical Cluster "Green Chemistry", the West Pomeranian ICT Cluster, and the METALIKA Cluster for Industry collaborated in 2022 as part of a study conducted for the Future Industry Platform Foundation.

- The Lubuski Metal Cluster collaborates with three other clusters in Poland across different sectors (in addition to the previously described sectoral cooperation), both formally and informally. The Cluster works with the West Pomeranian Maritime Cluster based on a Letter of Intent from 2018, with the Polish Composite Technologies Cluster based on a Letter of Intent from 2021, and with the West Pomeranian Chemical Cluster "Green Chemistry" Association without formal agreements. The cooperation includes, among others: exchanging knowledge and best practices, organising joint events, promoting the metal industry and manufacturing technologies, supporting internationalisation, and establishing B2B relations between members.
- The collaboration between the North-South Logistics and Transport Cluster and the Polish Educational Cluster, which began in 2017, aims to support the development of both clusters through knowledge sharing, exchanging experiences, and identifying areas of synergy in education, logistics, and transport.
- An example of collaboration within composite technology, which features both intra-sectoral and cross-sectoral traits, is the activity of the Polish Composite Technologies Cluster. Its partners include Silesia Automotive & Advanced Manufacturing, the South Poland Cleantech Cluster, the Greater Poland ICT Cluster, the Lubuski Metal Cluster, and indirectly, the Silesian NANO Cluster (through the NANONET Foundation). However, simply being recognised as a partner does not automatically prove that there is ongoing cooperation between the clusters.

Collaboration within public-sector initiatives:

- Collaboration between clusters within the national **Sectoral Skills Councils** system, developed by PARP. This nationwide system acts as a dialogue platform for businesses, educational institutions, and public authorities, identifying skills needs across different sectors and guiding changes in education. PARP plays a key role in coordinating the system, offering both substantive and organisational support, and linking Council recommendations with labour market and education policies at the national level. Examples of collaboration within the Sectoral Skills Councils include:
  - **Sectoral Skills Council – Chemical industry**. The project is carried out by the West Pomeranian Chemical Cluster "Green Chemistry" Association. One of the challenges for the Council was to establish a platform to promote Industry 5.0 developments within the chemical sector. The LifeScience Kraków Cluster was also engaged in the Council's activities. The Council operated from 2019 to 2024 and, among its main tasks, supported the vocational education system through four recommendations that enabled companies in the chemical sector across Poland to provide training to improve employee skills and qualifications.

  - **Sectoral Skills Council – Metal and Machinery Industry**. The organisation and management of this Council was entrusted to the Industrial Cluster Evoluma. Among the organisations involved in defining skills needs and forecasting future trends in the sector are the Lubuski Metal Cluster, the CINNOMATECH Innovative Manufacturing Technologies Cluster Association, and the Bydgoszcz Industrial Cluster Tool Valley.
  - **Sectoral Skills Council – Aviation Industry**. The Council comprises leading aviation clusters in Poland: the Aviation Valley Association, the Silesian Aviation Cluster, the Lublin Advanced Aerospace Technology Cluster, the Greater Poland Aviation Cluster, and the Lower Silesian Aviation Cluster.

- Cross-sectoral collaboration within the development of **regional strategies and participation in entrepreneurial discovery processes (EDP)**:
  - An example is the collaboration in the **Podkarpackie Region**, involving the following clusters: the Eastern Automotive Alliance, the Aviation Valley Association, the Eastern Poland IT Companies Cluster, the Unmanned Systems Cluster, the Podkarpackie Renewable Energy Cluster and the POLIGEN Plastics Processing Cluster.
  - A similar area of collaboration concerned the verification and adoption of regional smart specialisations in the **West Pomeranian Region**. In 2022–2023, the following clusters were involved: the West Pomeranian Chemical Cluster "Green Chemistry" Association, the West Pomeranian ICT Cluster Association, the METALIKA Cluster for Industry and the West Pomeranian Maritime Cluster.
  - In **Małopolska**, so-called Specialisation Platforms have been created as spaces for collaboration and knowledge exchange among key stakeholders of the Małopolska Smart Specialisations (MIS). Their aim is, among other things, to facilitate the entrepreneurial discovery process (EDP), which involves the joint identification of technological, innovative, and social development pathways for the region. Three Małopolska Key Clusters operate within these structures: the Sustainable Infrastructure Cluster, the Polish Composite Technologies Cluster, and the LifeScience Kraków Cluster.
  - In the **Podlaskie region**, The Polish Construction Cluster and the Industrial Cluster Evoluma collaborate on the Voivodeship's partnership project "Regional Capacity-building Project – EDP", where they jointly enhance the innovation ecosystem through networking, smart specialisation observatories, research and analyses, study visits, and activities linking science with business. Within this project, the Polish Construction Cluster is responsible, among other things, for eco-innovation, while the Evoluma Industrial Cluster oversees the metal and

machinery sectors, co-creating RIS3 development pathways alongside other partners.

- Collaboration between the MedSilesia Cluster and the Silesian Nano Cluster is a close partnership based on the joint implementation of a project under the **Regional Specialised Observatory Network in the Silesian Voivodeship**[68]. The two clusters unite their abilities in exchanging knowledge and analysing technological trends relevant to regional innovation development, and this collaboration is especially vital within the Medicine Observatory, where MedSilesia acts as the leader. This allows for effective integration of the skills and experience of the medical and nanotechnology sectors.

Collaboration with other business associations (without cluster status)

- Most of the agreements identified in the study are neither strictly intra-sectoral nor cross-sectoral. An example is collaboration with the **Polish Clusters Association (ZPKP)** – an organisation perceived by some structures as a kind of "meta-cluster", whose members are clusters themselves (therefore the agreements reported by coordinators refer to cluster membership in ZPKP). It is worth emphasising that more than 40 clusters cooperate within ZPKP, both formally and informally. The activities undertaken aim to professionalise cluster operations, strengthen the collective voice of clusters in interactions with public administration (including influence on cluster policy), promote the idea of clustering as such, and expand the knowledge and skills of cluster coordinators. Cooperation with ZPKP is an example of an effective model of cluster integration at national level. It enables clusters not only to increase their influence as partners for central and regional administration, but also to build a coherent, professional and more visible representation of the cluster movement in Poland.
- Cluster cooperation also involves organisations that represent businesses but do not hold cluster status.
  - An example is the cooperation of the Innovative Manufacturing Technologies Cluster CINNOMATECH with the Employers' Association Business Centre Club and the Employers' Association Polish Maritime Technology Forum. The Baltic Sea and Space Cluster also participates in this partnership. The partnership concentrates on activities in social dialogue related to adaptability—defined as the ability of enterprises and sectors to respond flexibly to economic, regulatory, and technological changes. The collaboration aims to expand the network with new sectoral insights (maritime industries) and to emphasise the importance of adaptability as a key factor in green and digital transformation efforts.

[68] More information available at: https://ris.slaskie.pl/pl/so-ris-krotko-o-sieci-obserwatoriow.html [accessed 09 September 2025].

Consequently, the network's core develops a cross-sectoral character, increasing its potential impact on public policy and innovation support.

- The Innovative Manufacturing Technologies Cluster CINNOMATECH also collaborates strategically with the Business Centre Club Employers' Association, engaging in sectoral dialogue on implementing the circular economy (CE) and the green transition in ways that are feasible for companies. This partnership has led to the creation of the sectoral Employers' Association "Green Business Responsibility Initiative" (IZOB), which standardises approaches to regulation, reporting, and implementation, and offers substantial arguments for BCC's communication with policymakers. IZOB also engages in dialogue with other organisations (e.g., the Polish Clusters Association) and submits sectoral CE recommendations to the Social Dialogue Council within BCC structures, while BCC membership allows companies to participate in expert bodies and co-develop public interventions. More details on this cooperation are included in Chapter 8, where it is presented as a cluster good practice example.

7.5. Summary

An analysis of Polish experiences in inter-cluster collaboration highlights several conclusions regarding its level of development, strengths, and gaps. The Polish cluster landscape shows significant dynamism and an ability to adapt to global trends, including those related to fully harnessing the potential of network-based cooperation.

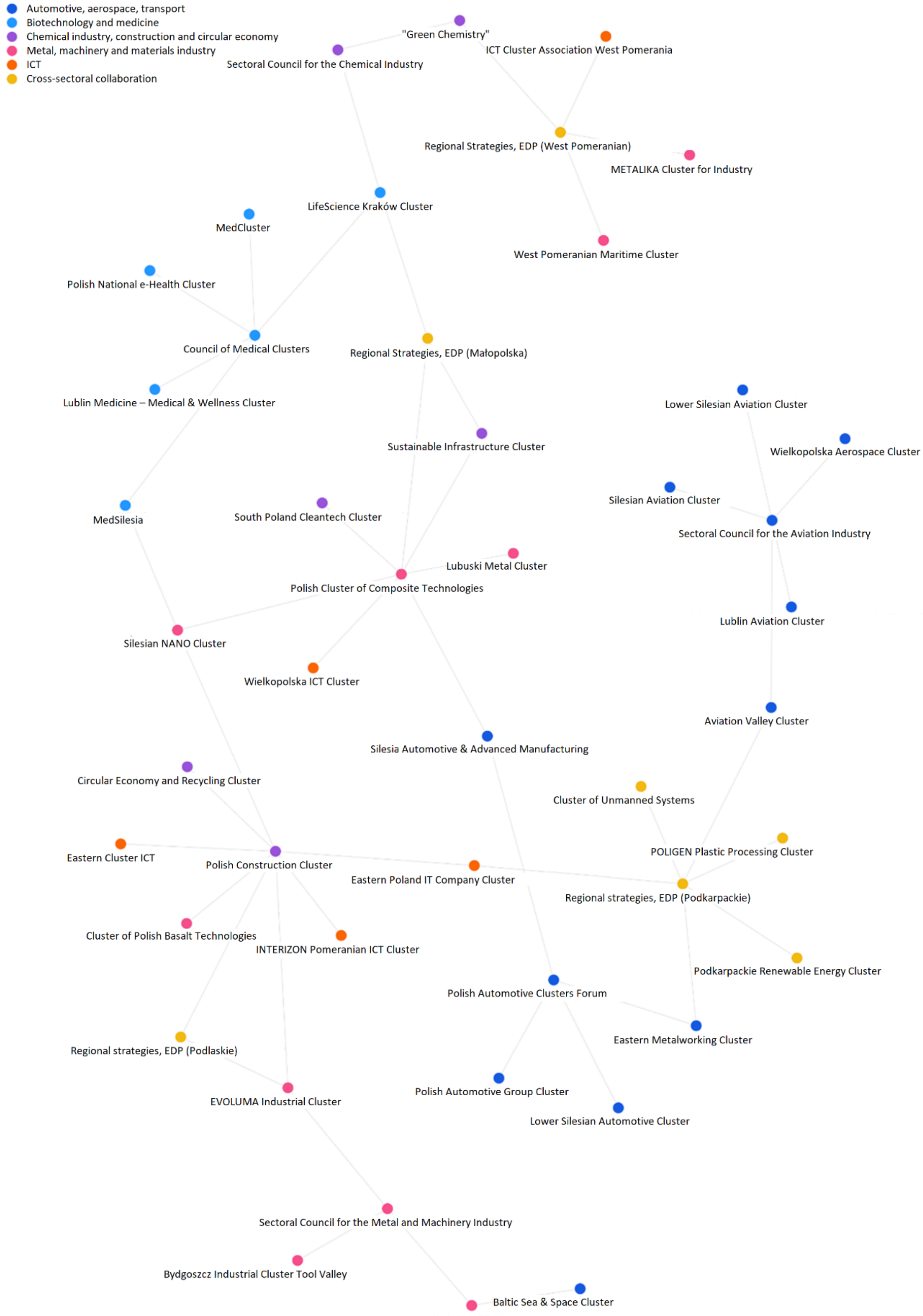
One of the most encouraging findings is the increasing strategic maturity of Polish clusters, as demonstrated by the example of the automotive sector. The creation of the Forum of Polish Automotive Clusters is fully comparable with leading European practices, where national federations and sectoral platforms play a crucial role in consolidation and structured dialogue with public authorities.

The analysis of collaborations between clusters reveals certain patterns in both their direction and motivation. Sectoral cooperation, involving clusters from the same or related sectors (e.g., automotive, medical, or metal and machinery), mainly aims to strengthen sectoral competitiveness, consolidate business environments, exchange experiences, and jointly develop sectoral policies. Such partnerships often focus on creating new products and technologies, establishing common standards, or improving the quality of vocational education within a specific domain. Cross-sectoral cooperation, on the other hand, occurs at the intersection of various areas of the economy such as ICT, construction, chemical industry, logistics, or education – and often results in the development of new solutions, services, and business models (e.g., addressing the needs of digital and green transformation).

Relations with public institutions, especially regional self-governments, form another significant area of cooperation. These partnerships are generally strategic and focus on joint regional development planning, defining smart specialisations, participating in entrepreneurial discovery processes (EDP), and enhancing skills within Sectoral Skills Councils. Collaboration with other business associations (such as employer organisations or sectoral chambers) aims to build economic representation, strengthen social dialogue, and increase the visibility of clusters as partners in public policy.

The following figure shows a visualisation of the linkages identified in the previous subsection. For clarity, some cluster names have been simplified to their common forms, as have the names of Sectoral Skills Councils. The term “Regional strategies, EDP” refers to collaboration between groups of clusters and regional authorities within, among other things, the system of Regional Smart Specialisations and entrepreneurial discovery processes (EDP).

Figure 45. Visualisation of described examples of collaboration among Polish clusters



Source: own elaboration based on the cluster coordinators' survey (N = 42) and desk research.

The analysis of inter-cluster collaboration also uncovers several gaps and challenges. While intra-sectoral cooperation in Poland – particularly in the automotive industry – has reached an advanced stage, cross-sectoral collaboration seems to be at an earlier phase of development compared to comprehensive, EU-funded projects such as PIMAP+. Polish examples, like cooperation between an educational cluster and a logistics cluster, are valuable but often bilateral and smaller in scale. Poland lacks prominent, multi-party partnerships that connect technologically distant sectors (e.g., photonics, biotechnology, ICT, aerospace) to form entirely new value chains and boost the participation of Polish entities in global markets (similar to initiatives like WaterCampus). This may be due to the limited availability of major national funding programmes supporting such activities, in contrast to EU initiatives like Euroclusters (which, however, target mature and well-established structures).

In inter-cluster collaboration, financial stability and governance models are especially important because they influence the ability of clusters to initiate and maintain long-term partnerships. In countries with well-established cluster ecosystems, such as Germany or the Nordic nations, inter-cluster cooperation often relies on stable funding structures sourced from diverse revenue streams – including membership fees and joint market projects. This approach not only ensures the smooth operation of individual clusters but also facilitates long-term project planning and the creation of joint thematic platforms. Conversely, in Poland, the heavy dependence on cyclical, project-based public funding means that inter-cluster cooperation tends to be short-term and reliant on available support programmes. Consequently, it is challenging to develop sustainable mechanisms for coordination and knowledge exchange, as well as to cultivate the skills necessary to manage complex networks of cross-sectoral partnerships.

8. Good practices in cluster functioning

8.1. Introduction

One of the elements of the cluster benchmarking study was the identification of good practices – exemplary solutions that enable outstanding effectiveness and efficiency in carrying out activities and achieving the cluster's development objectives. It was assumed that good practices must be applicable in other clusters (the attribute of transferability and learning), and therefore their identification and selection were undertaken with a view to their potential implementation in other cluster structures. The selection of good practices followed several stages: initially, the authors identified potential practices based on a review of cluster activities and data from coordinator surveys, after which they were verified during in-depth individual interviews (IDI), allowing the descriptions to be enriched and enabling an assessment of their real significance and level of advancement. Practices qualified for inclusion in the report had to meet a number of criteria listed below.

- innovation/novelty of the solution applied;
- effectiveness and efficiency of the solution applied;
- systemic character and durability of the solutions implemented in the cluster;
- flexibility and potential for adaptation;
- universality, i.e. the possibility of applying the solution in another cluster, including those from a different sector;
- efficiency, optimal use of the cluster's available resources;
- potential for the practice to be applied in situations of abrupt change (e.g. the COVID-19 pandemic, the war in Ukraine, legal disruptions or other sector-specific crises).

Particular attention was paid to good practices implemented in eight selected sub-areas, which largely determine the development of cluster structures (as they relate to organisational maturity, the development of collaboration and innovation within the cluster, and internationalisation). These include:

- Market activity
- Cluster digitalisation
- Innovation activity
- Development of collaboration within the cluster
- Collaboration with the external environment
- Impact on the natural environment
- Influence on shaping external conditions
- Exports and pro-export activities

8.2. Good practices of Polish clusters

8.2.1. LifeScience Kraków Cluster: an integrated support model for life science start-ups in Małopolska

Good practice areas (primary and additional)

Development of collaboration within the cluster

Innovation activity

Market activity

Cluster digitalisation

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

Despite having a well-developed innovation ecosystem, the Małopolska region continues to face challenges related to the low number and limited quality of innovative start-ups compared with Western Europe, including those in the life sciences sector[69]. Regional diagnostics, carried out regularly in cooperation with the regional authorities, identified three key barriers underlying this situation: insufficient market readiness of projects, a shortage of early-stage competences among innovators, and limited access to investors and business partners. In response to these challenges, the LifeScience Kraków Cluster – acting as a collaboration platform for enterprises, scientific institutions, public bodies and business support organisations – launched initiatives aimed at strengthening the innovation competences of Małopolska's residents, accelerating the commercialisation of life science projects, developing lasting links between start-ups, science and business, and increasing both the number and quality of projects reaching investors and industry experts.

The combination of activities such as multilateral collaboration, acceleration, education, networking and promotion – with a strong emphasis on cooperation within the cluster and

[69] The life sciences sector is an area of the economy encompassing a wide range of industries and subsectors related to research and applications in the fields of life and health. It includes, among others, biotechnology, medicine, healthcare services, pharmaceuticals, medtech, bioinformatics, food technologies and nutraceuticals, as well as the bioeconomy.

among its members – constituted the cluster's response to the need to build an effective, integrated support system for young companies and innovators. A key factor behind the success of these initiatives was the alignment of the cluster's activities with regional smart specialisations and the involvement of public and international institutions (e.g. EIT Health). This has enabled the development of an environment conducive to innovative and entrepreneurial activity in the field of health and quality of life.

Description of the good practice

The LifeScience Kraków Cluster acts as an integrator and facilitator of cooperation, developing an acceleration model for start-up projects in the life sciences sector that combines education, mentoring, networking and promotion. The initiative fosters an ecosystem that supports the development of innovative companies by facilitating access to investors, enabling market validation and ensuring that projects are effectively prepared for market entry. This activity is carried out within the framework of the LifeScience Innovation Accelerator. The accelerator programme is based on the Swedish Innovation Readiness Level (IRL) model and offers thematic workshops, individual support from experts representing various fields, as well as pitching and networking sessions focused on real market needs, customer cooperation, appropriate business models and the ability to work with investors and partners. These activities are implemented in collaboration with companies, institutions and investors affiliated with the cluster.

The Swedish IRL model used by the cluster was developed by the National Institute of Technology[70] as a tool for assessing the readiness level of innovations created by start-ups and young innovative companies. The scale was inspired by the widely recognised TRL (Technology Readiness Level) scales but incorporates a broader context of implementing ideas in business practice. IRL serves to diagnose the stage of development of start-up solutions together with the business ecosystem surrounding them. Importantly, the IRL scale encompasses not only technological aspects but also business models, market potential, team capabilities, intellectual property protection and preparedness for internationalisation. Its purpose is therefore to determine how ready a start-up is to enter the market and scale its solution, rather than simply whether the prototype works.

A key component of the accelerator programme is its connection to real challenges reported by companies and institutions in the health sector.

A distinctive element of the accelerator – strengthening cooperation within the cluster – is the Life Science Startup Scene, a series of small events aimed at facilitating knowledge transfer and practically connecting innovators, investors and experts. The final event of the Startup Scene

[70] More information is available at: https://www.kth.se/en [accessed: 09.09.2025].

takes place during the Life Science Open Space (LSOS) conference – one of the most important industry events in Poland – where start-ups present their solutions to investors and experts in MedTech, HealthTech and Digital Health, thereby enhancing cooperation and increasing the cluster's national and international visibility.

Start-ups can further develop their activities within the cluster's thematic groups (Special Interest Groups – SIG), which focus on selected thematic areas. These groups bring together experts, entrepreneurs and institutions interested in collaboration in a given field, for example SIG Active Healthy Ageing (SIG AHA), which supports active and healthy ageing by combining the potential of science, entrepreneurship, healthcare and the region's spa and wellness resources.

The Swedish acceleration model was tested specifically within SIG AHA. Activities under SIG AHA were based on three pillars:

- Building awareness: the AHA group identified key challenges faced by older adults, such as long-term healthcare, social isolation or housing adaptation;
- Activation: selected problems, defined as concrete challenges (e.g. polypharmacy or digital exclusion), were presented to participants of the AHAthon, which mobilised innovators to work intensively on solution proposals;
- Acceleration: the best solutions received support according to the Innovation Readiness Level model, with the aim of increasing the likelihood that "fresh" ideas succeed on the market.

An additional element of the programme, enhancing collaboration opportunities, is the AHA Innovation Map[71], which identifies and describes more than 70 regional initiatives addressed to seniors. Created through collaboration among cluster members, the map serves as a guide to relevant innovation activities and helps identify specific innovators worth partnering with, thereby increasing the application potential of these projects.

It is also worth noting that since 2022 the cluster has served as the EIT Health hub in Poland, providing start-ups with access to European support programmes and further strengthening the regional innovation ecosystem.

Effects of implementing the good practice

The activities of the LifeScience Kraków Cluster are based on sustained collaboration both with its members and with a wide range of stakeholders, as well as on the integration of multiple projects into one broad yet coherent "cluster programme". Within this programme, start-ups are developed not only by experts but also through close cooperation with other members. The proposed start-up support model is one of the components strengthening the regional

[71] More information is available at: https://www.kth.se/en [accessed: 09.09.2025].

innovation ecosystem, in which start-ups play a particularly important role. For this reason, the Cluster invites other organisations supporting the start-up community to participate in its initiatives, thereby helping to build stronger connections that transcend thematic silos.

The acceleration model, which applies a methodology developed and validated in Scandinavia, has the potential to become widely adopted and to evolve into a standard across the broader innovation environment. As a result, actors in the region – regardless of sector – begin to speak the same language when discussing the innovation support process. In the longer term, initiatives such as the AHA! Innovation Accelerator help young companies develop the capabilities needed to create market-ready products and services. They also build soft skills, including team-building, pitching, negotiation and intellectual property protection, which collectively enable them to organise cooperation more effectively with the market, industrial partners and investors.

The impact is also visible in cooperation with local government authorities, which receive better support in fulfilling their systemic tasks. This is particularly relevant in the context of challenges such as an ageing society, public health or environmental protection.

The role of EIT Health Poland Representative enables the LifeScience Kraków Cluster not only to support local start-ups but also to integrate them into the European innovation ecosystem. Beyond access to funding, start-ups gain access to knowledge and international networks, which strengthens the cluster's international reach and enhances cross-border collaboration among its members. As a result, Małopolska has consolidated its position in the field of social and technological innovation for healthy ageing, and the cluster's collaboration and operational model now serves as a benchmark for other regions and initiatives across Europe.

The benefits for the cluster coordinator are also multidimensional. Initiatives such as the SIG groups help members build lasting relationships, exchange knowledge and jointly develop solutions that address real market needs. The AHA area, in particular, illustrates how cooperation between cluster members and local authorities is systematically deepened, and how the number and quality of jointly undertaken activities supporting economic development continue to grow. Experience and trust on both sides strengthen over time, opening the way to new areas of collaboration and new opportunities. The good practices developed within the AHA area are set to be applied in other fields that are key to the Regional Smart Specialisation Strategy.

Possibility of applying the good practice elsewhere

The model developed by the LifeScience Kraków Cluster can be successfully adapted by other clusters, regardless of their sectoral specialisation or region of operation, as an example of effective cooperation-building both within the cluster and among its members.

The key components that can be implemented in other environments include:

- An acceleration model for start-ups integrated into a broader development programme;
- The creation of thematic Special Interest Groups (SIGs), enabling systematic and in-depth collaboration among cluster members in key development areas, for example those aligned with a region's Smart Specialisations;
- The organisation of regular open events (pitching sessions, hackathons, thematic breakfasts) that foster a culture of collaboration and stimulate innovation;
- An Innovation Map as a tool integrating cluster members and facilitating the identification of partners for joint projects;
- Strong anchoring of activities in real market needs through cooperation with companies, public institutions and the local community;
- Collaboration with international networks enabling the import of modern start-up support methods, such as hackathons, which can be adapted to local needs.

Thanks to its modularity and scalability, this practice can be implemented in both mature and emerging innovation ecosystems. It can also serve as a model for clusters seeking to strengthen member integration, support start-up development, and contribute to tangible social and economic change in their region.

Commentary

The approach developed by the LifeScience Kraków Cluster demonstrates that effective support for start-ups requires an integrated model combining acceleration and networking activities with ongoing collaboration across the institutional and business environment. It is important to analyse the specific challenges and barriers to innovation development in the region, but in order to implement practical tools that address these challenges, they must be linked with other activities. Only then can cluster activities translate directly into results for programme participants and outcomes for the entire ecosystem. This is a long and complex process, shaped by many iterations of trial and error, yet one that is worthwhile because it enables the introduction of systemic – rather than ad hoc – solutions. It is advantageous when there is room for such experimentation, for example through pilot programmes. This enhances both the quality of activity and the mutual trust among participants. In such circumstances, the developed operating model becomes flexible and scalable at regional level. This in turn makes it an attractive solution for other regions seeking to professionalise support for innovators. Through consistent action, it is possible to exert a real influence on the quality and maturity of the innovation ecosystem, including the start-up environment, as well as on building the cluster's expert position in the region.

Kazimierz Murzyn, President of the Management Board, LifeScience Kraków Cluster Foundation

8.2.2. Digital Creative Cluster: "Knowledge Surfers" – accelerator for digital education creators

Good practice areas (primary and additional)

Market activity

Cluster digitalisation

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Impact on the natural environment

Influence on shaping external conditions

Exports and pro-export activities

Objective and context for introducing the good practice

The COVID-19 pandemic significantly accelerated the digitalisation of education, particularly in the areas of remote learning and e-learning. Many small and medium-sized enterprises, especially those operating in the development services sector, were suddenly faced with the need to adapt rapidly to the new reality, often without the necessary resources, competences or awareness of available technological solutions. This revealed a competence gap in designing modern online courses, creating engaging educational materials, and conducting effective marketing and sales activities through digital channels.

The Digital Creative Cluster, operating within the creative and educational sectors, sought to address these needs by developing a proprietary acceleration programme that not only provided knowledge but also offered practical support in creating scalable educational products and digital business models. In the era of the content creator economy – where an increasing number of individuals build their brand, influence and income streams through the creation of valuable content, from courses and newsletters to online communities – new support models are needed that integrate education, technology and entrepreneurship.

The programme was designed as a response to a broader trend, namely the growing number and importance of knowledge creators and micro-education businesses within the digital economy.

Description of the good practice

The Digital Creative Cluster, managed by the cluster coordinator (Digital Creative Cluster sp. z o.o.) in cooperation with the Digital Knowledge Observatory Foundation, established the "Surferzy Wiedzy" (Knowledge Surfers) accelerator – a programme supporting SMEs as well as individual educators and experts looking to grow their business based on knowledge and modern technologies. The programme combines education, practice, technology and business support, making it an effective and scalable model for the rapidly developing market of educational content creators.

Its implementation draws on resources available within the cluster (experts, technology partners, the Digital Space studio, the LearningSpace platform) as well as public support instruments, including de minimis aid. This reduced entry barriers and increased accessibility for a broad group of participants, including individuals without prior experience in running online education businesses.

The programme is a 12-week intensive acceleration pathway. Participants begin by designing an online course: defining the target audience, educational and business objectives, course structure, formats and scenario. Next, with support from mentors and experts, they produce concrete educational materials (e.g. video recordings, quizzes, graphics, micro-exercises) and test them in the user environment (Proof of Concept, PoC). The final stage focuses on marketing, sales, communication, and preparing for market launch and course scaling.

What distinguishes "Surferzy Wiedzy" on the Polish market is its consistent focus on commercialisation and internationalisation. The programme does not limit itself to theoretical considerations – its goal is to create an educational product that can be successfully launched on the market and generate revenue. The best projects are showcased during Demo Day and industry conferences attended by publishers, investment funds and commercial partners from the EdTech sector.

The "access to finance" component is a crucial part of the accelerator. Top participants can benefit from fundraising consultations and present their projects to investors (including at conferences and Demo Day).

For the most promising projects, the cluster coordinator offers extended support, including further incubation, matchmaking with publishers, and advisory services in commercialisation and business scaling. These elements significantly increase participants' chances of achieving a meaningful market presence – not only as content creators but as EdTech entrepreneurs.

Internationalisation is another important element of the programme. The programme creators make every effort to ensure that participants are able to successfully release and publish their courses in foreign markets. To this end, modern technological tools and platforms supporting multilingual content and localisation processes are used. The cluster believes that this approach can generate tangible returns on investment in educational product development.

Effects of implementing the good practice

To date, across five editions of the "Surferzy Wiedzy" programme, more than 400 educational projects have been submitted – ranging from online courses to thematic platforms and tools supporting adult skills development.

The pathway relaunched after the pandemic, dedicated specifically to teachers and individual educators, attracted exceptionally high interest. More than 85% of accepted participants completed the entire acceleration process, confirming both the effectiveness of the adopted model and the real value of the support provided.

The programme has contributed to the development of digital competences within the SME sector and educational communities, enhancing their competitiveness in the rapidly expanding e-learning market. At the same time, it has strengthened the cluster's position as a competence centre for educational innovation and as a partner supporting the professionalisation of knowledge creators.

The main challenges included:

- Engaging participants in an online format;
- Convincing SMEs to invest time and resources in developing their own educational products;
- Ensuring high-quality mentoring within a short and intensive programme duration.
- These challenges were overcome through:
- Individualised development pathways;
- Cohort-based learning and strengthening the sense of community;
- Intensive mentoring and expert support across various disciplines;
- A strong focus on practical outcomes and a tangible final product that participants can implement and sell.

Possibility of applying the good practice elsewhere

The model applied in the "Surferzy Wiedzy" accelerator demonstrates how a cluster can provide tangible support for the development of digital competences and educational innovation by combining practical activities, technology and a collaborative environment. The programme not only imparts knowledge but also enables its practical application and transformation into a scalable product. It may therefore serve as a reference point for other clusters planning to develop ecosystems that support entrepreneurship, digital development and modern education. Clusters can draw inspiration from its structure, methodology and needs-driven approach, tailored to participants' real challenges and the evolving digital landscape.

Key elements for adaptation include developing an acceleration programme based on identified sectoral needs and the resources available within the cluster. Promoting the creation of knowledge-based products using modern educational technologies is of particular importance. Equally crucial is providing space for collaboration and networking. Regular industry events such as Q&A sessions or cohort meetings foster the exchange of experience and the building of lasting relationships within the innovation community. A hybrid training model – combining online and offline learning – increases the programme's accessibility and flexibility. The practical application of acquired knowledge is supported by the implementation of a blended learning approach, combining theory with practice, online learning with workshops and individual mentoring. Support in promotion and product deployment is also essential. Activities should not end at the educational stage; participants need access to tools, partnerships and knowledge required to build a market offer, manage sales and scale their ventures.

It is also recommended to promote participants' success stories through the publication of case studies, interviews and implementation stories. Such activities strengthen the cluster's brand and inspire further individuals and organisations to take action. Organising events at which projects are presented to investors is a universal way of increasing the visibility of innovations and can be applied in any sector. In addition, to reduce participation costs and increase programme accessibility, it is worthwhile to use financing mechanisms such as de minimis aid.

Commentary

We believe that Poland's digital education sector has the potential to join the global league – just as the Polish video games industry has done. We have the experts. We have the talent. We have the technologies. Now we are building systemic support that allows these potentials to spread their wings and realise their full market value. As a cluster, we have a genuine opportunity to succeed.

Elżbieta Obrębowska, Cluster Manager, Digital Creative Cluster

8.2.3. Mazovia Cluster ICT: Space Bridge Fund & ECN S.A. – synergistic ecosystem supporting start-ups and green energy

Good practice areas (primary and additional)

Innovation activity

Market activity

Development of collaboration within the cluster

Collaboration with the external environment

Impact on the natural environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The good practice responds to the real needs of start-ups and SMEs that have innovative ideas but lack capital and access to implementation infrastructure, as well as to the strategic regional challenges identified by the cluster regarding effective technological development, economic digitalisation and energy modernisation. The activities undertaken under this practice facilitate the commercialisation of technologies by financing early-stage development and supporting the implementation of innovative energy solutions. At the same time, they contribute to the region's economic development by strengthening the innovation ecosystem and supporting the transfer of green technologies.

An essential element of this good practice is its social dimension, particularly in relation to the activities undertaken by the cluster's special-purpose vehicle, ECN S.A. These initiatives help reduce pollution, lower energy costs for residents and raise ecological awareness within society. As a result, they improve the quality of life in local communities, enhance citizen engagement in pro-environmental processes and create conditions conducive to the region's sustainable development.

Description of the good practice

The Mazovia ICT Cluster has developed a model for supporting innovation through the creation of specialised, dedicated structures: the venture capital fund Space Bridge Fund and the special-purpose vehicle ECN S.A. The fund, established as a public–private partnership under the BRIdge Alfa scheme (Operational Programme Smart Growth 2014–2020, European Regional

Development Fund), fills the capital gap for innovative technologies in the areas of artificial intelligence, the Internet of Things, the space sector and the green transition. Meanwhile, ECN S.A. enables the implementation of innovative energy systems based on renewable energy sources (RES). Together, these initiatives align with Mazovia's climate objectives and strengthen the region's geopolitical energy security through local RES systems and autonomous energy sources. Both entities provide financing, development and deployment support for breakthrough technologies in high-tech sectors, particularly green technologies. The combination of these initiatives creates a comprehensive ecosystem that supports the growth of innovative entrepreneurship and accelerates technological and green transformation.

Space Bridge Fund offers high-risk financing for start-ups and young technology companies implementing R&D projects. Start-ups gain access to early-stage capital, which accelerates their growth and enables them to scale innovations onto international markets. Project assessment includes, among other aspects, a detailed analysis of innovation potential, business and financial models, target markets, previous achievements, team competences and intellectual property protection. Importantly, the project selection process is not limited to cluster members but is open to all potential beneficiaries meeting formal criteria, allowing the fund to select the most promising initiatives.

ECN S.A., the cluster's special-purpose vehicle, enables the implementation of innovative energy systems based on renewable energy sources. ECN S.A. is carrying out the project "Combined Heat and Power Plant in a Local Energy System" in Sokołów Podlaski, financed by the National Centre for Research and Development (NCBR) under a pre-commercial procurement scheme. The project involves developing an innovative system for producing and storing RES-generated energy to support the self-balancing of local electricity systems. Between August 2021 and March 2022, the company successfully completed Phase I of the project, achieving first place in the NCBR ranking, which enabled continuation in Phases II and III. The mission of ECN S.A. is to enhance the autonomy and energy security of local communities by connecting local energy producers and consumers. This aligns with Mazovia's climate objectives and strengthens the region's geopolitical energy security through local RES-based systems and autonomous energy sources.

Effects of implementing the good practice

Both initiatives – Space Bridge Fund and ECN S.A. – form a synergistic model for supporting green innovation, spanning the entire pathway from financing (VC fund) to practical implementation (special-purpose vehicle). This model fosters integration between scientific, business and local government environments by offering:

- High-risk financing: Space Bridge Fund effectively fills the capital gap in a context of limited private investment in Poland, particularly for early-stage start-ups, supporting the development of innovative technologies, including those related to the green transition. The fund has assessed more than 400 projects, of which 21 received financing totalling PLN 25 million. This enabled start-ups to accelerate growth, achieve market validation and scale to international markets. Without such support, many innovative ideas would never have been realised.
- Implementation of solutions: ECN S.A. transforms research outcomes into concrete products and systems, such as RES-based solutions for distributed energy, including the combined heat and power plant project in Sokołów Podlaski.
- Cross-sector collaboration: Both structures connect entrepreneurs, researchers and local governments, strengthening technology transfer and building know-how. The cluster effectively engages local authorities by demonstrating added value for communities, such as lower energy costs and increased investment opportunities for municipalities.
- Development of team competences: The implementation of the Space Bridge Fund project contributed to strengthening the cluster team's competences in project evaluation, the preparation and assessment of investment agreements, and advisory services for start-ups – forming a lasting asset for future initiatives. Experience gained through these activities enables the team to advise cluster members effectively on securing public funding, developing robust business models, scaling operations and internationalisation. As a result, cluster members – especially start-ups and SMEs – benefit from professional support in preparing funding applications, negotiating with investors and drafting investment agreements. Moreover, the acquired competences allow the team to support members in market validation and innovation scaling.

As a result, the cluster has strengthened cooperation between science, industry and local government, creating model solutions for distributed energy and high technologies, while the coordinator has enhanced its capabilities and expanded the scope of its activities.

Possibility of applying the good practice elsewhere

Effective innovation support and the development of an entrepreneurship-friendly ecosystem require a broad set of activities which, in the case of the Mazovia ICT Cluster, have been embedded within a coherent model. This model is built on two key pillars:

- Securing public and private funding to establish and operate an investment fund, thereby enabling the provision of high-risk financing for start-ups and young technology companies at an early stage of development. The benefits include, among others, accelerated commercialisation of technologies, enhanced competitiveness of enterprises on international markets and the development of innovative economic sectors;
- Creating dedicated structures, such as special-purpose vehicles, which make it possible to support projects from the conceptual stage, through financing, and ultimately to implementation.

The key success factors include the identification of sectoral challenges – such as capital gaps, the need for digitalisation or the energy transition – and the establishment of strategic partnerships with public institutions (e.g. NCBR, government ministries, PFR Ventures[72]) and international networks (e.g. EU funding instruments). These partnerships ensure access to capital, expert knowledge and foreign markets.

This model can be effectively implemented by other clusters, particularly those operating in technology areas with high deployment potential. The conditions for success include strong engagement of local stakeholders, access to know-how and a coherent strategic vision. Equally important is building trust with local authorities by demonstrating clear added value, such as reduced energy costs, improved infrastructure, attracting investment to the region, raising environmental awareness and enhancing the quality of life for local communities.

Commentary

Mazovia ICT Cluster intends to continue its activities, building on the experience and competences gained through the implementation of the Space Bridge Fund and ECN S.A. projects. Our team, strengthened with new skills, is ready to provide even more effective support for innovative entrepreneurship and to further enhance the competitiveness of our cluster members.

Artur Radzio, Member of the Presidium, Mazovia ICT Cluster

[72] PFR Ventures is a fund-of-funds manager which, together with private investors, business angels and corporates, invests in venture capital and private equity funds.

8.2.4. Silesia Automotive & Advanced Manufacturing: resilience in practice – how Resilience 2030 supports transformation and competitiveness

Good practice areas (primary and additional)

Innovation activity

Market activity

Development of collaboration within the cluster

Collaboration with the external environment

Impact on the natural environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The Resilience 2030 service was developed in response to growing instability in the economic and technological environment driven by global trends and risks such as digitalisation, the green transition, geopolitical shifts, and health and climate crises. Increasing pressure on innovation, energy efficiency and supply chain resilience means that micro, small and medium-sized enterprises (SMEs) require a new approach to development.

The aim of the Resilience 2030 service is to support companies in building organisational resilience, understood as the ability to adapt, survive and grow in conditions of volatility and uncertainty. The service is not limited to the automotive sector; its principles are universal and primarily targeted at the SME sector. Resilience 2030 is currently in the research and development phase, enabling its testing and refinement in cooperation with enterprises.

Description of the good practice

The service focuses on identifying areas requiring adaptation and developing a strategy for change. Its foundation is a seven-step process for adapting a resilience strategy, guiding companies through the consecutive stages of building resilience.

The service includes a needs diagnosis – an analysis of processes, organisational structures and the business environment; change mapping – the identification of actions that increase resilience, such as automation, optimisation or investment in human capital; and implementation support – consultancy and training that help guide change in line with the European Green Deal and Industry 4.0.

An entry point to the service is the Resilience 2030 workshop, which introduces participants to global trends and risks, familiarises them with the seven-step adaptation model, and allows them to test the service within the context of their own company.

The model consists of:

- Identifying threats and assessing digital maturity, including classifying processes in terms of their digitalisation potential;
- Reviewing strategy and verifying the business model with regard to digitalisation objectives and alignment with the smart factory concept;
- Identifying areas that do not meet intended objectives and mapping processes;
- Selecting methods and tools to address identified gaps, including choosing appropriate digital modules (e.g. Manufacturing Execution System – MES, Warehouse Management System – WMS);
- Implementing corrective actions through automation, robotisation and the integration of quality, logistics and energy systems;
- Evaluating and analysing the impact of implemented actions, including real-time monitoring (dashboards, key performance indicators, digital audits);
- Embedding effective practices using the Kaizen approach and system-generated data, and ensuring continuous improvement based on analysis results.

Participants receive access to the Resilience 2030 e-handbook. The service adopts a holistic approach to the organisation, encompassing risk management, human capital, energy efficiency, stakeholder relations, financial management, brand value and access to finance.

Effects of implementing the good practice

Implementing the Resilience 2030 service enables companies to manage risk and undertake strategic planning more effectively. It improves the understanding of customer and investor needs and supports increased loyalty, reduces staff turnover and enhances employee engagement. It also promotes the perception of the company as an employer of choice, generates energy and resource savings, strengthens brand value and improves access to financing.

By developing the competences of leaders and teams, enterprises increase their flexibility and adaptive capacity, which translates into greater operational security, competitiveness and innovativeness. At the same time, Resilience 2030 contributes to the modernisation of production and reduces dependency on fluctuations in labour costs and resource availability, thereby strengthening supply chain resilience.

Possibility of applying the good practice elsewhere

The Resilience 2030 model can be successfully adopted by other clusters, particularly those supporting the SME sector, regardless of industry. Clusters, as platforms for cooperation between business, science and public administration, possess unique potential in strengthening economic resilience.

Examples of activities that can be undertaken within similar services include:

- conducting technology and environmental readiness audits;
- delivering workshops based on the seven-step adaptation model;
- creating regional ecosystems for collaboration and knowledge exchange;
- supporting green and digital transformation;
- developing the competences of managerial staff and leaders;
- initiating cross-sectoral collaboration, for instance between industry, IT and energy.

In this way, clusters can strengthen local and national resilience, contributing to the development of a modern and sustainable economy.

It is also worth noting that, in crisis situations, Resilience 2030 can be used as a tool enabling companies to maintain business continuity and mitigate the effects of a crisis. The service functions as a "survival and development manual" for SMEs – from situational analysis, through action planning, to implementation and training. It helps not only to minimise losses but also to identify new avenues for growth in uncertain environments, making companies more flexible, independent and competitive.

Commentary

The Resilience 2030 service is currently being developed within research and development activities, which allows it to be tailored to the diverse needs of enterprises. The Resilience 2030 workshops aim to familiarise participants with global risks and trends, the seven-step resilience adaptation process, and the practical application of methods and tools within a company. The benefits of the workshops include a deeper understanding of the impact of global trends on the company, access to a tested model for building resilience, and the possibility of piloting the service within one's own organisation. The service is not limited to the automotive sector; its principles are universal and primarily targeted at the SME sector. Resilience 2030 supports the creation of resilient organisations that manage risk and finances more effectively, strengthen relationships with customers and investors, reduce turnover and increase productivity, improve energy efficiency, and achieve higher market value and stronger customer loyalty.

Łukasz Górecki, Director, SA&AM Cluster

8.2.5. Polish Cybersecurity Cluster #CyberMadeInPoland: from education to legislation – strengthening cyber-resilience in Poland

Good practice areas (primary and additional)

Collaboration with the external environment

Market activity

Cluster digitalisation

Innovation activity

Development of collaboration within the cluster

Impact on the natural environment

Influence on shaping external conditions

Exports and pro-export activities

Objective and context for introducing the good practice

In recent years, the increasing volume and sophistication of cyber threats has posed growing challenges for both the public and private sectors. Particularly acute issues include staffing shortages in the cybersecurity sector, low awareness of risks among local government units (LGUs) and SMEs, difficulties in keeping pace with legal and regulatory changes, and the need to build cooperation between the public, private and education sectors. In this context, knowledge, competences and adaptive capacity have become essential not only for organisations but also for society as a whole. The ability to respond to incidents, mitigate their impact and quickly return to operational capacity constitutes the foundation of digital resilience.

#CyberMadeInPoland Cluster, as an organisation bringing together enterprises, institutions and experts in the cybersecurity sector, has responded to these challenges by developing an ecosystem for collaboration, education and legislative support. The cluster's activities directly translate into increased competences, higher levels of security and regulatory compliance, while simultaneously strengthening the digital resilience of organisations and society in the face of contemporary cyber threats.

Description of the good practice

#CyberMadeInPoland Cluster actively works to systematically raise the level of cybersecurity in Poland. Through educational, advisory and stakeholder-integration activities, the cluster builds the digital resilience of organisations at strategic, operational and technological levels. Local governments constitute a key target group: through cooperation with the cluster, they gain access to workshops, IT security audits and support in developing and implementing information security policies.

One of the cluster's flagship initiatives is the #CyberMadeInPoland Academy, a training programme bringing together leading experts and companies from the Polish cybersecurity sector offering free training tailored to the rapidly changing technological and regulatory environment.

Furthermore, as part of the Digital4Security project (funded by the Digital Europe Programme), the cluster is collaborating with around 30 partners from across Europe to develop a pan-European cybersecurity curriculum. The project aims to train a new generation of specialists, thereby addressing labour shortages and supporting the development of human capital – a key component of system and organisational resilience. Through such activities, the cluster strengthens competences particularly among LGUs and SMEs.

The cluster also implements the AGH Cyber Campus initiative, aimed at both beginners (students, enthusiasts) and advanced users, enhancing digital resilience from the earliest stages of education. The programme's agenda is designed around the most current needs of the target group and the latest cybersecurity trends.

In addition, the Marketplace tool provides users and clients with a comprehensive knowledge base of cybersecurity products and services offered by Polish companies associated with #CyberMadeInPoland, specialising in systems, data and infrastructure protection. This tool helps organisations identify tailored solutions. It is particularly valuable for local governments, as it facilitates market analysis during the preparation of tenders or requests for proposals.

Given the dynamic nature of cyber threats, continuous adaptation to new realities is essential. Monitoring legal changes is therefore crucial for organisations seeking to protect their data effectively. In response to the implementation of the NIS2 Directive, the cluster launched a series of online meetings with experts discussing regulatory requirements and sharing implementation practices. A comprehensive implementation guide was also developed, including a presentation of Polish cybersecurity products and services, supporting organisations in their transformation and enhancing operational resilience.

The cluster is also actively involved in legislative processes by coordinating the preparation of joint positions by its members for public consultations, including on the Act on the National Cybersecurity System[73]. It prepares proprietary reports on the state and potential of the Polish cybersecurity sector, identifying opportunities and barriers for its development. These reports serve not only as up-to-date analyses but also as promotional tools showcasing the sector's innovations and strategic development pathways. The cluster maintains close communication with relevant ministries on matters of importance for Poland's digital security, for Polish enterprises, and for the development of the national cybersecurity sector.

Moreover, the cluster is expanding its service offer for member companies, supported by EU funding under the project "Development of #CyberMadeInPoland Cluster's offer in the area of digital transformation and internationalisation". This project includes two key services: a new service and a significantly improved one. The first is an advanced market and competition analysis supporting companies in implementing and scaling innovations in cybersecurity. The second service is the "Member Zone" digital platform, designed to facilitate collaboration, knowledge-sharing and dissemination of good practices among cluster members. The project also includes an internationalisation component, covering participation in trade fairs, establishing relations with foreign partners and training in international promotion. Its result will be the strengthened position of #CyberMadeInPoland Cluster and the Polish cybersecurity sector. The project also supports the implementation of national and European priorities in digital transformation, innovation and cross-sector cooperation, including in an international context.

Effects of implementing the good practice

The activities of #CyberMadeInPoland Cluster contribute to the systematic development of digital resilience among a broad group of stakeholders – from local government units and SMEs to individuals entering cybersecurity careers. Educational and integrative actions result in increased awareness of risks, enhanced competences and improved incident response capabilities. Cluster tools, such as the Marketplace featuring Polish security solutions, enable swift responses to rising cyber threats. In the event of a crisis, LGUs, SMEs or public institutions can quickly identify and deploy suitable protection systems.

Through legislative support and participation in consultations, the cluster helps organisations implement regulations effectively and develop systems that comply with standards. The cluster's public consultation statements and market reports help shape future regulations and sectoral development strategies. These reports also support organisational planning in

[73] For example: https://cybermadeinpoland.pl/polski-rynek-cyberbezpieczenstwa-2023-2028 [accessed: 09.09.2025].

uncertain conditions, highlighting areas requiring urgent attention. This enables decision-making based on current data rather than assumptions.

Across all these activities, the cluster contributes to the professionalisation of the cybersecurity market and the promotion of Polish solutions both domestically and at the European level, strengthening the strategic resilience of the national cybersecurity sector against future challenges.

Possibility of applying the good practice elsewhere

The good practice implemented by #CyberMadeInPoland demonstrates how a cluster can effectively influence the regulatory, educational and business environment. It is a model approach to building digital resilience through education, competence development and cross-sector collaboration. Implementing such a model strengthens the cluster's position as an expert community.

#CyberMadeInPoland shows that clusters can be not only community integrators but also partners for public institutions, businesses and society in areas such as combating cyber threats. They can support the creation of better regulation, a safer market and a more informed society, becoming the voice of the sector in key matters while preparing their members for upcoming changes.

Commentary

The cybersecurity market is exceptionally dynamic, fragmented and highly competitive, which makes it difficult to create joint initiatives even in the face of rising threats. The strength of #CyberMadeInPoland lies in the fact that we have managed to build trust and genuine cooperation among dozens of companies, public institutions, universities and international organisations – both in Poland and abroad. We are particularly proud of initiatives such as the #CyberMadeInPoland Academy, our market analysis report and a wide range of promotional activities that combine education, regulatory support and international promotion of Polish solutions. Together, we help Polish companies expand abroad – from organising trade missions and joint stands at international fairs to facilitating access to European R&D projects – demonstrating that cooperation enhances the competitiveness of all cluster members.

Łukasz Gawron, CEO, #CyberMadeInPoland Cluster

8.2.6. MedSilesia Cluster: MedSilesia Innovation Showroom – model supporting innovation in the silver economy sector

Good practice areas (primary and additional)

Collaboration with the external environment

Market activity

Innovation activity

Development of collaboration within the cluster

Influence on shaping external conditions

Objective and context for introducing the good practice

The MedSilesia Cluster, which brings together enterprises, research institutions and business environment organisations, works to build innovative ecosystems in the medical sector. One of the cluster's areas of activity is the development of solutions dedicated to older adults, their carers and physiotherapists. Medical devices – such as rehabilitation equipment, diagnostic tools or technologies supporting everyday functioning – can be designed to improve the quality of life of older people, support their independence and facilitate the work of carers. In the context of an ageing population, which represents both a challenge and an opportunity for the economy, MedSilesia recognises the growing importance of the silver economy. Older adults constitute an expanding market segment, and their needs in healthcare, rehabilitation and technologies supporting daily living align with the products and services developed by cluster members. The good practice presented by the MedSilesia Cluster responds to these challenges, supporting older people and stakeholders in the medical sector while strengthening the position of the MedTech sector in the region.

Description of the good practice

MedSilesia – Innovation Showroom (MIS)[74] is an innovative ecosystem designed to provide effective, integrated support for older adults – and more broadly for anyone requiring

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[74] This activity is implemented as part of the "SmartMed" project under the European Funds for a Modern Economy Programme, Priority II: Innovation-Friendly Environment, Measure 02.17: Development of Cluster Services for Companies. More information is available at: https://medsilesia.com/wspolpraca_i_projekt/smartmed [accessed: 09.09.2025].

assistance in everyday activities. It is a space dedicated to companies, start-ups, local authorities, NGOs and institutions operating in the field of medical technologies, enabling:

- Presentation of new technological solutions;
- Testing medical devices in near-real conditions;
- Product validation following the Tb4i (test before invest) model – early identification of technological, ergonomic and usability challenges;
- Consultations with end users through Customer Talks (CT) – gathering feedback from older adults, carers, physiotherapists and patient organisations to align solutions with real needs;
- Preparation for commercialisation and market deployment in the MtM (market to market) approach – assessing market potential and the scalability of solutions;
- Strengthening collaboration within and beyond the cluster community.

The Showroom forms part of a broader set of cluster initiatives supporting senior policy, including preparations for the implementation of the planned national Senior Voucher, which aims to subsidise part of the care costs for older adults.

Another important component is the Silver Economy thematic group, operating within the Sectoral Competence Centre. The group brings together enterprises, healthcare providers, manufacturers of medical devices and research institutions. Its activities include:

- Training and seminars on the role of digital technologies in care for older adults;
- Practical workshops for seniors (e.g. wound care, operation of medical devices, using digital health applications);
- Awareness-raising campaigns and community initiatives on health and digital literacy;
- Participation in national and international conferences on senior policy and MedTech innovation.

MIS plays an integrative role in the MedTech ecosystem, facilitating cooperation among enterprises, research institutions, senior organisations and local authorities, and enabling the development of comprehensive solutions supporting medical innovation and improving the quality of life of patients and older adults.

It also supports education and the development of digital and health competences of seniors and carers through the implementation of an online knowledge base, and enables modular innovation development – from pilot demonstrations to the scaling of validated solutions.

In addition to the physical showroom, the online platform COIN supports collaboration among members by enabling knowledge exchange, sharing case studies and publishing reports and analyses.

The cluster also monitors the development of senior policy in Poland, follows legislative processes, reviews government documents and tracks developments within the Ministry of Health. It also publishes legal and MedTech-related materials on the silver economy at: www.naukadlabiznesu.pl.

Effects of implementing the good practice

The implementation of the MedSilesia Innovation Showroom enables MedTech companies, start-ups and research institutions to design, test and validate solutions dedicated to older adults in conditions closely resembling real-world environments. Key effects include:

- Improved quality and usability of products thanks to early identification of technological, ergonomic and usability issues;
- Shorter time-to-market and reduced implementation costs;
- Better alignment of solutions with the needs of older adults, their carers and physiotherapists;
- Integration of the MedTech community and strengthened cooperation among enterprises, research institutions, senior organisations and local authorities;
- Increased digital and health literacy among older adults and their carers;
- Strengthening senior policy and the silver economy, including preparedness for effective implementation of the Senior Voucher, through the development and testing of solutions that may be financed under this future scheme.

The Showroom also enables the cluster coordinator to consolidate resources and activities, plan further work and systematically build the cluster's capacity in this important social area.

MedSilesia anticipates cooperation with the wider cluster community, positioning the Showroom as a space for cross-sector collaboration among businesses, academia, local authorities and civil society organisations. Thanks to the active involvement of end users, the Showroom becomes not only a venue for demonstrating technology but also a source of inspiration for creating solutions tailored to real societal needs. This approach facilitates the transfer of good practices, the initiation of joint R&D projects and the building of cross-sector partnerships, strengthening the entire innovation ecosystem.

This model is particularly beneficial for clusters rooted in local ecosystems and cooperating with local governments and businesses from the silver economy, rehabilitation and care sectors. It does not need to be limited to MedTech clusters – it may also apply to clusters in healthcare, care services, tourism or medical tourism, including municipalities hosting care institutions (both public and private).

The key beneficiaries of MedSilesia Cluster's solutions include older adults and other care recipients, as well as formal and informal carers. It is important to emphasise the relevance of the cluster's activities for local governments, which are already partly responsible for providing senior care – a public task that will become increasingly significant in light of demographic trends. Given the limited availability of human resources (professional carers, family carers and volunteers) and the growing demand for care services, future effectiveness will largely depend on organisational and technological innovations. For privately run care homes, MedSilesia's knowledge base offers an accessible tool for acquiring information about available improvement pathways that can enhance the quality of care, improve working conditions for staff, optimise resource use and potentially reduce per-capita service costs.

In social terms, this practice contributes to tangible improvements in the quality of life of older adults and supports carers and physiotherapists by facilitating access to modern medical technologies. In economic terms, MIS strengthens the innovativeness and competitiveness of the regional MedTech sector, both domestically and internationally.

Possibility of applying the good practice elsewhere

The MedSilesia Innovation Showroom (MIS) model can be successfully adopted in other regions, particularly where close cooperation with end users is essential for testing, validating and developing products. By combining technical infrastructure, R&D&I facilities and a partnership network linking business, academia, patient organisations and public administration, MIS provides a universal framework for supporting innovation. Key elements of the model include:

- Technical infrastructure and R&D&I facilities;
- A network of partnerships across business, academia, patient organisations and public administration;
- A user-centric approach – designing solutions that are intuitive, safe and affordable.

Potential areas of application include:

- Senior care and the silver economy – designing and testing technologies supporting daily functioning of older adults;
- Telemedicine and e-health – validating devices and digital applications in realistic user environments;
- Rehabilitation and home care – testing robotic equipment, assistive devices and monitoring tools;
- The wider MedTech sector – shortening product development cycles, reducing innovation costs and minimising investment risk.

The flexible infrastructure of the Showroom allows spaces to be adapted to the needs of specific projects and target groups. The Tb4i, CT and MtM components provide comprehensive support – from concept validation, through user testing, to commercialisation. The cluster can also support innovators in preparing materials and documentation required for investor engagement. MedSilesia also sees opportunities for cooperation with clusters from various sectors. The Showroom should be regarded as a cross-sector collaboration space for a wide range of stakeholders.

Commentary

Activities related to senior policy and the planned implementation of the Senior Voucher will be clarified once the legislative process has concluded. Until then, within the Showroom and complementary initiatives, the cluster is focusing on developing solutions that could be included under this future scheme, ensuring preparedness for their rapid deployment. The cluster is systematically preparing to take on this new role in order to set standards and guide the development of senior care.

Izabela Czeremcha, Cluster Manager

8.2.7. Polish Automotive Group Cluster (PGM): integrating the automotive and defence sectors to strengthen economic resilience

Good practice areas (primary and additional)

Influence on shaping external conditions

Market activity

Cluster digitalisation

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Impact on the natural environment

Exports and pro-export activities

Objective and context for introducing the good practice

The Polish Automotive Group (PGM), which brings together nearly 100 Polish suppliers from the automotive sector, represents companies manufacturing a wide range of parts, components and accessories used both in new vehicles and in aftermarket products. These firms employ advanced technologies and meet the highest quality standards, such as IATF 16949, ISO 9001, ISO 14001 and AQUAP.

Against the backdrop of Poland's current geopolitical situation, the cluster recognised that the automotive industry – with its mature competences, technologies and manufacturing capabilities – can play a crucial role in strengthening economic and defence resilience. Many automotive solutions may be deployed for both civilian and military purposes, making them relevant for dual-use applications.[75]

[75] Automotive-sector solutions – such as components, technologies and accessories – are used not only by the military, but also by other public services including the police, ambulance services, fire brigades and crisis-management authorities.

At the same time, PGM identified structural barriers limiting access to defence supply chains. Although numerous member companies possess the capabilities needed for defence-related production, procedural obstacles – such as rigid technical specifications or limited flexibility in public procurement – often prevent their participation. The cluster therefore undertook actions that directly address the needs of its members, while supporting the strategic interests of the state in the context of changing geopolitical conditions. The overarching objective was to offer business support to cluster members whilst strengthening Poland's role in the defence sector by harnessing domestic technological potential.

Description of the good practice

The Polish Automotive Group (PGM) is actively strengthening the position of the automotive sector in the context of geopolitical, environmental and technological challenges. One of the key opportunities at present is the growing integration with the defence sector. The cluster's activities have an economic dimension (increasing the participation of firms in strategic industries), a political dimension (influencing defence-industry policymaking) and a societal dimension (enhancing national security). PGM has adopted a proactive approach, going beyond the traditional role of a cluster coordinator and becoming an active contributor to industrial policy. The cluster supports its members in establishing relationships with the defence industry, as demonstrated by, among others:

- Appointing an adviser to the PGM board for defence cooperation and establishing a dedicated working group on the defence sector;
- Participating in events and meetings dedicated to defence industries, while advocating for wider inclusion of dual-use technologies originating from automotive companies;
- Organising B2B meetings with potential defence-sector clients, such as JELCZ, ROSOMAK, AUTOSAN, PIT-RADWAR and General Dynamics Land Systems – the manufacturer of ABRAMS tanks;
- Coordinating collective stands at key trade fairs (e.g. the International Defence Industry Exhibition in Kielce and the EUROSATORY defence exhibition in Paris) and promoting the technological capabilities of Polish companies at national and international events.

PGM's activities also include strategic advocacy at the legislative and institutional levels, involving engagement in dialogue with public institutions such as the Ministry of National Defence, the Ministry of Economic Development and Technology, the Polish Armaments Group and the Polish Investment and Trade Agency. The cluster provides an important voice (including during meetings of the Sejm Committee on Economy and Development) on opportunities for integrating Polish companies into national defence programmes as partners with established competencies in the automotive sector and in dual-use technologies. In public debates, the cluster highlights the experience and capabilities of PGM member companies, which possess the know-how, certifications and technological capacity required to deliver contracts for the defence sector, as well as the role of the automotive industry as a key domain for dual-use technology development.

PGM also alerts policymakers to important procedural and regulatory barriers that hinder the ability of private Polish companies to access defence supply chains. These include constraints arising from rigid technical specifications and the lack of recognition of positive test results as grounds for authorisation to tender. The cluster calls for greater flexibility in how public institutions assess the potential of private firms, which would facilitate their integration into defence programmes and support a systemic, partnership-based public–private dialogue conducive to the development of dual-use technologies. PGM's activity is therefore a model example of advocacy that supports the development of a knowledge- and technology-based economy, in which the industrial sector not only responds to policy directions but also co-creates the state's strategic development pathways.

For several years, PGM has actively participated in industry events such as the International Defence Industry Exhibition in Kielce, where member companies have repeatedly been able to present, at a shared stand, their potential to engage in production and maintenance projects for a range of defence-related equipment, including solutions that could significantly strengthen the capabilities of the national defence sector. The cluster has also taken part in events such as the Eksplobalis conference organised by the Military Institute of Armoured and Automotive Technology; Defence24Days 2025 – the largest and most important security and defence forum in Central Europe; the scientific and technical conference "Autonomous Vehicles – Challenges and Opportunities for the Economy and National Defence"; and the Clusters Meet Regions event dedicated to the role of clusters in enhancing regional competitiveness (including participation in a panel discussion on dual-use technologies). Such events offer opportunities to expand networks, explore new technologies and showcase the capabilities of Polish automotive (and other) suppliers for the defence sector..

The topic of engaging automotive companies in defence projects is also addressed within the Forum of Polish Automotive Clusters, which brings together PGM, Silesia Automotive & Advanced Manufacturing, the Eastern Automotive Alliance and the Lower Silesian Automotive Cluster. This cooperation promotes knowledge exchange and strengthens the sector's visibility.

In parallel, PGM cooperates closely with the Evoluma Industrial Cluster, which is also active in defence-related initiatives. This inter-cluster collaboration forms part of the good practice, demonstrating the value of joint action among Polish clusters.

Effects of implementing the good practice

The implementation of this good practice has generated significant benefits for both member companies and the wider economic ecosystem.

Thanks to the cluster's efforts to integrate the automotive sector into defence supply chains, companies have gained greater visibility and new opportunities to enter strategic markets that were previously difficult to access. The establishment of the defence working group, B2B meetings and participation in key industry fairs has enhanced the recognition of Polish automotive firms among defence-sector stakeholders and public institutions. As a result, cluster members have strengthened their competitive position by presenting their technological capabilities and readiness to undertake defence-related production.

At the systemic level, PGM has reinforced the role of the automotive industry in national debates on the future of defence, advocating for broader inclusion of private enterprises in national armament programmes. Through its advocacy activities, the cluster has brought procedural and regulatory barriers – hindering firms' access to defence procurement – into discussions with policymakers. This has initiated a public–private dialogue that is gradually encouraging greater flexibility among public institutions in assessing the potential of Polish automotive companies.

The cluster's active presence at major events has also enhanced the image of Poland's automotive sector as a provider of dual-use technologies capable of supporting both military and civilian innovation. For the cluster itself, this visibility creates opportunities to attract new members and implement further initiatives which, in the long term, contribute to strengthening Poland's economic and technological resilience.

Collaboration with other clusters operating in the same or related fields demonstrates that knowledge exchange and coordinated action can enhance the competitiveness and overall potential of the entire sector.

Possibility of applying the good practice elsewhere

This good practice demonstrates that clusters can respond to the real needs of their members by expanding their role from traditional activities (e.g. supporting innovation, linking business with science) to more strategic functions. PGM strengthens the competitive position of its members in strategic sectors and contributes to the resilience of supply chains – an approach that can inspire other clusters seeking to support national security and strategic industries.

By design, clusters have the capacity to act as representatives of entire industries at national level, coordinate large-scale projects and engage in dialogue with public authorities. Active participation in legislative processes and public consultations helps articulate the interests of member companies and shape policy directions. For clusters, such involvement increases their strategic relevance and strengthens their ability to attract new members, develop new services and implement more ambitious initiatives.

To adopt a similar model, clusters should identify and engage with public institutions responsible for sectoral regulations, map key barriers limiting members' access to strategic markets and systematically communicate these challenges to decision-makers. Pointing out procedural obstacles – particularly in public procurement – can catalyse reforms facilitating access to strategic projects.

This model of cooperation with government, based on dialogue and co-creation of strategic solutions, can be adapted across sectors in response to global challenges such as regulatory changes, supply chain disruptions or geopolitical risks. The essential factors are strong industry engagement and the ability to respond swiftly to changing conditions.

This practice can serve as an inspiration for clusters in various sectors, illustrating that combining members' competencies with strategic national priorities strengthens both competitiveness and resilience.

Commentary

PGM's activities demonstrate that a cluster can become a credible partner for public administration and major industrial organisations, provided it is able to articulate the collective voice of its member companies in a coherent and structured manner. We are proud to have created a platform for dialogue in which Polish private automotive firms are increasingly recognised as reliable partners for the defence industry. The initial challenge lay in overcoming barriers to entry – individual companies found it difficult to reach key decision-makers or large contractors. Thanks to the strength of the cluster, these barriers are gradually being dismantled. We believe that this experience can serve as an inspiration for other clusters seeking to align the capabilities of their members with the needs of strategic sectors of the economy.

Bartosz Mielecki, Managing Director, Polish Automotive Group (PGM)

8.2.8. Cluster of Innovative Technologies in Manufacturing CINNOMATECH: Green Transformation Package – modular tool for SMEs moving towards the circular economy

Good practice areas (primary and additional)

Impact on the natural environment

Market activity

Cluster digitalisation

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The impetus for developing the Green Transformation Package (GTP) stemmed from signals received from cluster members and industry experts collaborating with the cluster. Market practice increasingly revealed mounting cost pressures (energy, materials), evolving client and supply-chain requirements, and the need to streamline processes and data to improve efficiency and ensure compliance with ESG[76]/CSRD[77] principles. Stakeholder needs were identified through research, including consultations carried out by the cluster coordinator (e.g. as part of the development of the new BPNA[78] product Business Process Nature Assessment and GRAss[79] Green Readiness Assessment), as well as through surveys and demand analyses on green-transformation support services among SMEs. It is worth emphasising that as many as 81.3% of cluster members declared a need for support in the direction of the Circular Economy

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[76] Environmental, Social, and Governance (ESG) – a framework for assessing a company's performance across three key dimensions: environmental impact, social responsibility and corporate governance.

[77] Corporate Sustainability Reporting Directive (CSRD) – an EU directive on corporate sustainability reporting which requires companies to disclose more detailed and structured information relating to sustainable development.

[78] Business Process Nature Assessment (BPNA).

[79] Green Readiness Assessment (GRAss).

(CE)/ESG, while the level of knowledge in these areas proved to be low, confirming the scale of the implementation gap on the enterprise side.

The market context was further reinforced by requirements imposed by large companies within supply chains, which – by implementing CSRD/ESRS – transfer part of their environmental expectations onto suppliers. For cluster members, this has meant that green-transformation practices are no longer optional, but have become a prerequisite for market participation.

At the same time, companies expected pragmatic solutions enabling them to reduce energy and material costs, organise processes and data, and use CE as a productivity lever (minimising waste, recycling/reuse, and designing for circularity). A high entry threshold for green transformation was identified, both in terms of cost (implementation and maintaining CE-related development as a cost centre within the company) and knowledge (despite technological readiness, there was no mechanism to trigger a behavioural shift necessary to begin implementation).

These conditions shaped the overarching objective of the GTP, which is not environmental protection for its own sake, but rather sensible, profitable and measurable development aligned with socio-economic and environmental change, while simultaneously meeting the expectations of clients and regulators.

Description of the good practice

The cluster designed the Green Transformation Package (PZT) in a modular format, starting with an audit and readiness assessment, followed by process mapping, and concluding with implementation and ICT tools.

Developed by the Cluster of Innovative Manufacturing Technologies, the package constitutes a practical instrument supporting rational, profitable and measurable business development, particularly for SMEs. Its foundations lie in the principles of the Circular Economy (GOZ) and encompass five key areas:

- Systemic transformation – from linear to circular. A shift in economic thinking from the “take–make–dispose” model towards a circular economy that reduces raw material and climate pressures and establishes a framework for sustainable productivity.
- Regulations and public policies – the framework for transformation. Monitoring changes (EU taxonomy, national legislation and government initiatives supporting the transition towards GOZ), which define the operating conditions for enterprises and set future standards of competitiveness in domestic and international markets.
- Implementing circularity in business models. At the micro level, firms adjust their operational strategies to circularity requirements by developing new business models (e.g. product-as-a-service, eco-design, reverse logistics, industrial symbiosis), re-using materials and managing product life cycles more efficiently.

- Financing and economics of GOZ activities. Assessing life-cycle costs and benefits, and creating financial models that allow measurable improvements in profitability, while leveraging available instruments – including EU funds – to reduce risk and shorten investment payback time.
- Business benefits – competitiveness and efficiency. The circular economy can be used as a lever for reducing energy and material costs, improving processes, strengthening competitive position, and preparing firms for rising expectations in international markets and among customers.

The PZT was developed as a modular support system enabling companies to enter the green transformation pathway in a systematic and economically viable way. It consists of several complementary modules, including:

- Green Transformation Readiness Assessment combined with Business Process Nature Assessment. A framework that integrates operational and environmental perspectives, enabling firms to simultaneously enhance economic efficiency and pursue sustainability objectives.
- Competency programmes ("Learn how to implement sustainable solutions in business!") delivered in partnership with Aurelius Academy, combining thematic training with practical application. The use of simulation games enables companies to model implementation scenarios, plan resources and manage production schedules in a controlled environment without disrupting ongoing operations.
- Collaboration facilitation and R&D project development. Knowledge exchange between cluster members supports the initiation and implementation of joint R&D projects, enabling organisations to pool competencies and resources to accelerate deployment.
- Strategic partnerships. Owing to its close relationship with the Business Centre Club Employers' Association (ZP BCC), the cluster conducts sector-focused dialogue aimed at developing a shared strategy for implementing GOZ and green transformation in a business-viable manner. This cooperation led to the creation of the sectoral Employers' Association – the Initiative for Green Corporate Responsibility (IZOB), which standardises approaches to regulation, reporting and implementation at sector level. The relationship is symbiotic: IZOB, as a specialist employers' association, provides substantive expertise underpinning ZP BCC's communication with government bodies, while the advocacy successes of ZP BCC strengthen companies affiliated with both organisations. IZOB also conducts dialogue with other industry bodies such as the Polish Clusters Association and works within ZP BCC to prepare sectoral recommendations related to GOZ for submission through this umbrella organisation, which is a member of the Social Dialogue Council. Membership in ZP BCC also offers opportunities to

participate in expert committees, engage with policymakers and put forward recommendations regarding public-intervention priorities[80].

During implementation, the cluster encountered several key challenges, all of which were successfully addressed. One major challenge was encouraging firms, especially SMEs, to engage in the green transformation process. Initially, companies displayed limited awareness and conservative attitudes stemming from a lack of understanding of the circular economy and the persistence of stereotypes. Changing these attitudes unlocked the potential for further action.

Another challenge concerned securing suitably qualified sector-specific GOZ experts. Organisationally, constraints included limited resources and fragmented data. Many cluster members had overstretched staff and insufficient tools due to day-to-day pressures, and lacked a coherent overview of processes and reliable, structured data required for planning. Initial audits revealed the need for instruments that not only diagnosed the current state, but also organised information and prioritised actions. The solution was to combine the Green Transformation Readiness Assessment with the Business Process Nature Assessment into a unified framework that evaluated business processes and environmental readiness simultaneously. This enabled companies to quickly identify high-impact actions generating immediate savings in energy, materials or labour time, while also standardising reporting via a unified platform.

A further challenge involved investment uncertainty and concerns about return on investment. Green transformation investments were perceived as risky due to unpredictable economic impacts, especially amid fluctuating energy and raw material prices. Consequently, the PZT was implemented modularly: beginning with small pilot and demonstration projects (PoC), followed by scaling of validated solutions. The cluster provided advisory support on tax incentives, grants and funding instruments, allowing companies to make decisions based on robust financial data.

Finally, a critical obstacle was the competency gap and lack of practical workforce preparedness, requiring new skills ranging from circular production planning to the use of

[80] Operational example: Based on the Act of 28 April 2022 on the rules governing the implementation of tasks financed from European funds in the 2021–2027 financial perspective, ZP BCC – as a recognised social dialogue organisation – holds the authority to agree with public administration the shape of interventions financed from EU funds. In 2023, a ZP BCC representative, in dialogue with PARP, submitted recommendations for the “Circular Economy – It Pays Off” competition (FERS), which resulted in the adoption of the Annual Action Plan with defined criteria and the subsequent launch of the call. This delineation of roles ensures a full 360° evaluation cycle. BCC, conducting sectoral dialogue with the cluster, identifies employers’ needs in the area of the Circular Economy (GOZ), while the ZP BCC representative participates in consultations on the financing mechanism for transformation activities in enterprises. PARP, in turn, is responsible for running the competition and for the operational implementation of the mechanism. Afterwards, ZP BCC monitors its execution, systematically gathering and analysing feedback from businesses on the effectiveness of the solution. As a result, public policy is better aligned with the needs of the business community and implementation risks are reduced.

modern digital tools and reporting systems. Many firms lacked personnel who could combine technological expertise with an understanding of environmental regulations and project economics. This challenge was addressed through training and workshop programmes delivered via the Aurelius Academy, alongside the cluster's decision to introduce new educational tools for resource optimisation and GOZ implementation within a "safe laboratory" setting.

Effects of implementing the good practice

The implementation of the GTP has delivered numerous benefits that may inspire other clusters to pursue similar initiatives:

- Reduction of operating costs and improved resource efficiency – by completing the full GTP cycle, enterprises can achieve tangible economic and operational gains. It is estimated that optimising equipment operating parameters, implementing waste heat recovery systems and modernising power supply units can reduce energy consumption in production processes by 8–15%. At the same time, through better production planning, the introduction of Circular Economy (CE) measures (e.g. re-use of production waste, designing components for recycling) and minimising material losses, companies may reduce raw-material wastage by 5–12%. These results position the GTP not merely as a regulatory compliance tool, but as an initiative delivering measurable improvements in profitability and productivity.
- Streamlining processes and data – the framework linking operational and environmental perspectives enables companies to improve economic efficiency while meeting sustainability objectives. This integrated approach allows firms to gain a coherent picture of their operational and environmental processes. Organising data exposes the areas with the greatest losses and untapped reserves, enabling prioritisation and swift implementation of corrective actions.
- Strengthening workforce competences – the training programmes delivered under Aurelius Academy were created in response to rising requirements in safety and compliance, the need to accelerate digital transformation and growing pressure to implement CE-aligned solutions. Their purpose is to rapidly and measurably improve employees' skills across production, services and administration so that AI technologies can genuinely support efficiency and operational resilience. The cluster also plans to introduce a new educational simulation – MasterFactory – enabling employees and managers to practise correct decision-making in "dry-run" production planning. These simulations allow participants to understand, in a controlled setting, how their decisions affect process performance and costs. As a result, participants are better equipped to understand the relationship between operational efficiency and environmental

requirements, which increases acceptance and active involvement in transformation processes.

- Shorter time-to-market for innovations – the use of the cluster network to develop prototypes within the member environment shortens the journey from concept to finished solution by 30–40%. Examples such as the Stellar two-phase cooler (Moltres Energy) or the waste-heat recovery unit (C-Tech) demonstrate that local collaboration between manufacturing and R&D firms creates a genuine competitive advantage. Cluster members including Brookvent, Moltres Energy and C-Tech highlighted the difficulty of producing high-quality prototypes quickly, particularly without production scale and when specialised components were required. The cluster coordinator leveraged its network to connect firms with complementary resources, enabling prototype development internally, reducing both time and costs.
- Strengthening the market position of the cluster and its members – the implementation of the GTP reinforces the position of the Cluster of Innovative Manufacturing Technologies as an initiator and coordinator of sector-wide change. The standards and cooperation model developed within the GTP provided the foundation for establishing IZOB, an employers' organisation aimed at standardising approaches to green transformation, CE and ESG reporting at sectoral level. As a result, practices developed within the cluster can be applied beyond the region, supporting affiliated companies in building competitive advantage and increasing their credibility with clients, investors and business partners.
- Improved access to finance – companies using the GTP may receive comprehensive support in preparing grant applications and utilising tax incentives such as the Innovation Relief or the R&D Relief. In many cases, external funding – including EU funds – was secured, substantially shortening payback periods and reducing investment risk associated with implementing green technologies. By linking modernisation plans with dedicated financial instruments, enterprises were able to make more confident investment decisions based on realistic budgetary capabilities. This, in turn, accelerated implementation and enabled fuller realisation of CE and energy-efficiency goals.

The outcomes above demonstrate that green transformation can be not only a necessity, but also a source of tangible profit.

Possibility of applying the good practice elsewhere

The experience gained in designing and implementing the GTP can serve as a valuable reference point for other clusters, illustrating how to identify market needs and translate them into practical tools that support sustainable development. The GTP was designed to be modular and scalable, which enables straightforward adaptation across different industries and regions. Key components – business process diagnosis, assessment of readiness for green transformation, financing pathways and training programmes – may be implemented individually or as a full package, depending on enterprise needs.

This model can be replicated in industrial sectors (e.g. metal and machinery, energy, processing) as well as in technical services or logistics. Particularly valuable is the combination of process analysis, skills development and financial instruments, which makes the GTP not only a technological tool but also a strategic one.

Cooperation with the newly established Employers' Association – the Initiative for Corporate Green Responsibility (IZOB) – enables further standardisation of procedures and indicators, allowing the model to be implemented by other sectoral and regional clusters and ensuring comparability of results on a national scale.

The GTP may become a benchmark for economic environments seeking practical, economically viable green-transformation solutions that combine cost efficiency, circularity and long-term organisational resilience.

Commentary

The development of the Green Transformation Package was a natural step arising from market observations and the real needs of cluster members. We succeeded in combining three elements that are often treated separately – robust process diagnosis, practical competence development and access to financial instruments. One of the main challenges was engaging SMEs, which often operate with limited staff and financial resources, making it difficult to simultaneously run day-to-day operations and implement changes. The key to success was a phased approach based on "quick wins" and tangible cost benefits, which quickly increased acceptance of the entire process.

The GTP has become a platform for cooperation and standardisation benefiting both cluster members and other organisations through the Employers' Association – the Initiative for Corporate Green Responsibility (IZOB).

Similar initiatives can accelerate transformation across many sectors, provided they strike a pragmatic balance between ecology and economics – precisely as this model was designed to do.

Grzegorz Piecek, Chair of the Audit Committee, Cluster of Innovative Manufacturing Technologies, President of the Board, Employers' Association IZOB

8.2.9. Industrial Cluster Evoluma: industry transformation in line with the Organisation 5.0 concept

Good practice areas (primary and additional)

Cluster digitalisation

Market activity

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

In the face of dynamic market, technological and geopolitical change, both the cluster coordinator and its members recognised the need for tools that would support digital collaboration and promotion more effectively than traditional solutions. They also identified a need to strengthen competences related to securing financial support. Conventional forms of communication – such as exchanging offers via e-mail – proved insufficient given the growing scale of operations and the increasing complexity of the cluster's business environment. At the same time, there was no system-level tool facilitating access to knowledge on technological partners, members' resources and competences, or available funding opportunities.

In parallel, the cluster recognised the need to prepare and support companies in their transition towards the Organisation 5.0 model, focused on sustainable development, innovation, and social and environmental resilience.

The cluster coordinator responded to these challenges by concentrating efforts on building an ecosystem of competences and digital tools that support members not only in their day-to-day operations, but crucially – in their broader transformation journey.

Description of the good practice

The good practice developed by the Evoluma Industrial Cluster consists of comprehensive support for digital collaboration, competence development, and industrial transformation through integrated operational and educational activities. In response to the real needs of its members, the cluster has implemented modern digital tools.

One of these solutions is the e-RFQ platform, which automates quotation and procurement processes, enabling companies to create technological profiles, manage contact history, and increase the efficiency of cooperation. The previous process – based on e-mail exchanges – was time-consuming and inefficient, especially given the high number of enquiries[81]. The digital e-RFQ platform has streamlined this workflow, including through the possibility of concluding NDA agreements[82], thereby increasing transparency and the effectiveness of procurement processes. As a result, cluster members gained easier access to reliable business partners and strengthened their competences in digital commerce, supply-chain management and effective B2B communication.

In parallel, the cluster created a virtual catalogue of members and strategic partners. This interactive space enables companies to present their offering, supports promotion, strengthens B2B relationship-building and fosters trust within the cluster ecosystem. It has become a practical tool for initiating cooperation and increasing market visibility.

Another key digital instrument is e-PKD – the Cluster Guide to Grants, an intuitive and personalised tool tailored to the needs of cluster members and strategic partners. It supports companies – particularly SMEs – in navigating public funding schemes. Cluster experts curate dedicated funding opportunities at regional, national and EU levels, including commercial sources, creating a unique and needs-based knowledge resource. The tool increases the success rate of funding applications without the need to engage external consultants, while the Evoluma coordinator's office provides additional support in implementing selected actions. This offering combines expertise from regional, national and EU levels, making it a unique solution on the market.

An important element of the good practice is the long-term partnership with the science and research sector, exemplified by SmartCOM[83] – the DEMOLAB Competence Centre, established jointly with Bialystok University of Technology. This modern laboratory enables practical training of future and current industrial staff for Industry 5.0 directly at the university. It

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[81] In the traditional model, the cluster attempted to match buyers with suppliers by receiving a request for quotation from the buyer, distributing it among cluster members, and subsequently collecting and forwarding expressions of interest. The e-RFQ platform fully automates this process. The buyer uploads a request for quotation (validated by the administrator), which becomes visible to potential suppliers, who can then submit their bids and proposed prices. The quotation and contracting process takes place without the involvement of the cluster coordinator. The coordinator's role is limited to acting as the administrator of the platform.

[82] Non-Disclosure Agreement – a confidentiality agreement.

[83] The project was implemented under the Smart Growth Operational Programme 2014–2020, Sub-measure 2.3.7 Development of the potential of Key National Cluster coordinators, co-financed by the European Regional Development Fund, in the years 2021–2023. More information is available at: https://evoluma.pl/projekty/smartkom-centrum-kompetencji-klastra-obrobki-metali [accessed: 09.09.2025].

supports the development of technical skills across the full career cycle – from school pupils and students to industrial employees and those seeking retraining. Events such as the VR Welding Hackathon promote modern, practice-oriented educational methods, developing digital and engineering competences among young people.

The initiative was inspired by the University Vice-Rector for Industry Cooperation, who sought to create a dedicated space on campus equipped with technology supplied by industrial partners. The concept was embraced by industry, which developed the initial laboratory concept based on CNC technologies, with the Evoluma cluster coordinator acting as project lead. In subsequent phases, the lab was expanded with solutions in robotics, 3D printing and augmented-reality welding. The laboratory covers two separate spaces, enabling the parallel development of competences required by the sector.

This model demonstrates that close cooperation between academia and industry can effectively build a modern, resilient and sustainable competence ecosystem.

Effects of implementing the good practice

The activities undertaken by the Evoluma Industrial Cluster demonstrate how to support the day-to-day functioning of members effectively and pragmatically – not only through networking, but also by developing concrete, scalable digital tools tailored to real operational needs. These tools integrate the industrial environment with the education sector and modern technologies. The digitalisation of quotation processes and company cataloguing significantly enhances the efficiency of communication and collaboration within the cluster, reducing the time burden and information chaos associated with traditional offer exchange. Solutions such as the e-PKD guide strengthen members’ competences in securing funding, particularly among SMEs, thereby increasing their development prospects. Meanwhile, collaboration with the science sector, including the DEMOLAB Competence Centre, enables practical and systemic skills development in modern technologies, addressing labour-market needs and supporting the transition towards Industry 5.0.

The Evoluma Industrial Cluster pursues its objectives in a strategic and long-term manner, building a solid foundation for digital and organisational transformation within the industrial environment, promoting the principles of sustainable development and shaping a resilient, adaptive ecosystem. This also contributes to positioning the cluster as a body that provides comprehensive support to businesses, effectively responds to their needs, and maintains long-term cooperation with the science sector.

Possibility of applying the good practice elsewhere

The good practice developed by the Evoluma Industrial Cluster may serve as an inspiration for other clusters wishing to actively support the transformation of the economy, education and labour market in line with the Organisation 5.0 concept. At the same time, it is fully scalable and can be replicated across other clusters. The e-RFQ platform, virtual catalogue, e-PKD guide and competence centres such as DEMOLAB are universal tools that can be adapted to the specific needs of different sectors and regions. Cluster engagement in ecosystem-building activities, including cooperation with higher education institutions, brings benefits to both clusters (and their business members) and universities. It is therefore crucial to foster partnership-based relationships between cluster coordinators and universities, jointly aiming to attract and educate future employees and students.

Dedicated funding for cluster coordinators makes it possible to move beyond traditional operational models. At the current stage of cluster development in Poland, the optimal approach appears to be public-sector funding complemented by commercial capital, given the innovative nature of these solutions and the still relatively low level of social trust compared with more developed economies.

The key to success lies in the openness of all stakeholders to joint needs assessment, trust-building and cross-sector cooperation. Important for further development is also the consistent promotion of the solutions created – both domestically and internationally – and the search for additional opportunities to scale the cluster's potential.

Commentary

Naturally, any process change or development of dedicated IT tools involves certain risks, technical errors, validation challenges and adjustments to employees' working habits. However, this direction is irreversible, particularly in the context of data processing and network-based management that characterises a cluster. The volume of data and the speed of processing required are substantial, and such solutions are indispensable in today's dynamic environment and ongoing transformation. As a cluster leader, we must adopt an agile approach and keep pace with the process changes occurring among our members and clients.

The added value is that these tools are scalable. We are already in discussions with another cluster regarding a sublicence for the e-RFQ platform or the integration of their members into our system. I believe other clusters may also consider such solutions to save time and resources by using ready-made products.

Janusz Poulakowski, Chief Operating Officer, Evoluma Industrial Cluster

8.2.10. Circular Economy and Recycling Cluster: coalition for plastics recycling, value chain integration and recyclate market development

Good practice areas (primary and additional)

Impact on the natural environment

Market activity

Cluster digitalisation

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The good practice implemented by the Circular Economy and Recycling Cluster was initiated in response to specific challenges faced by the SME sector in Poland – namely legislative gaps related to the circular economy (CE), the lack of support instruments, including the absence of standards, all of which hinder the development of the secondary raw materials market and the adoption of sustainable solutions. At the same time, the cluster recognised that the 2019 Circular Economy Roadmap[84] required updating to better reflect a cross-sectoral perspective, including the industrial and construction sectors, and to support SMEs in their transition. The existing document did not sufficiently account for the needs of the industrial and construction sectors, eco-design, recycling technologies or investment requirements. It also lacked concrete milestones and implementation pathways.

Another challenge identified by the cluster was the low level of awareness and readiness among SMEs to undertake CE transformation. Internal cluster research showed that only around 3–3.5% of SMEs were prepared to implement CE principles. It therefore became clear that tools and guidelines were needed to support this group of businesses in their transition.

[84] CE (circular economy) – an economic model aimed at minimising waste and keeping products, materials and resources in use for as long as possible. It is based on reuse, repair, recycling and the recovery of raw materials, contributing to sustainable development and environmental protection.

SMEs face the daily challenges of the green transformation, requiring intensive and often complex organisational adjustments. In working with companies on their shift towards CE, it became evident that training and competence-building were essential – both for employees and management staff. Even the most well-designed CE strategies are effective only when they are understood and supported by employees, who shape and operationalise organisational change on a daily basis. At the same time, EU sustainability goals and rising energy costs are forcing businesses to transform their models, yet without regulatory support and clear standards, SMEs struggle to transition effectively towards a circular economy model.

Description of the good practice

The Circular Economy and Recycling Cluster has, for many years, adopted a holistic approach to CE. It implemented a comprehensive good practice consisting of a multi-layered support system for the transition towards a circular economic model. Its activities directly address key challenges such as legislative gaps in CE, low SME awareness, the need to develop the secondary raw materials market and derived products, and the need to align national strategies with EU objectives (e.g. CEAP 2020[85]).

Responding to the dynamic changes and challenges outlined above, the cluster became involved in developing a framework document setting out the foundations for a new Circular Economy Roadmap for 2025–2030. The document aims to define directions for the development of the circular economy, with particular emphasis on the needs of SMEs, eco-design, automation and recycling. In order to formulate recommendations for the new Circular Economy Roadmap and build consensus around the need for systemic change, the cluster – during its flagship event, the Polish Circular Forum – created a unique platform for dialogue between representatives of the European Commission, the national government, local authorities, academia and industry.

At the same time, the cluster delivers training cycles for company management teams under the Manager Academy for Transformation, offered in two thematic areas – circular and digital. The Manager Academy for Transformation is a programme of certified courses that supports enterprises in transitioning to a circular economy model, digital transformation and low-emission operations. The Academy combines hands-on knowledge based on real implementations with theory and modern management methods, preparing companies to meet the challenges of today’s economy. The training courses focus on key areas, including legislation, new business models, circular innovations, eco-design, life cycle assessment, business modelling and risk management. Thanks to its three pathways – Change Manager,

[85] CEAP 2020 (Circular Economy Action Plan) – the EU Action Plan for the Circular Economy, adopted on 11 March 2020 by the European Commission.

Green Transformation and Expert – the programme develops competencies not only among managerial staff but also within teams and specialist roles.

The Manager Academy for Digital Transformation covers, among other topics: new business models in Industry 4.0 and digitalisation financing, legal aspects and cybersecurity, Industry 4.0 leadership competencies, and study visits to "factories of the future". Participants engage in workshops, brainstorming sessions and examine proven case studies, enabling them to connect theoretical concepts with real market challenges.

Meanwhile, the goal of the Manager Academy for Circular Transformation is to prepare companies to achieve low-emission performance, resource efficiency and sustainable development. Participants learn, among other skills, how to calculate a carbon footprint, develop emission-reduction strategies and implement eco-design principles. As a result, companies can not only reduce their environmental impact but also gain competitive advantages – for example through easier access to funding, lower operational costs, or meeting ESG reporting requirements. The Academy programmes also support the creation of circular innovations and new business models that open opportunities for additional revenue streams and savings.

The use of the ProGOZ[86] (circular transformation) and ProINNO (digital and innovation transformation) services enables companies to achieve measurable outcomes – from reducing environmental charges to increasing raw-material efficiency. This is particularly important for SMEs, which most often require support in their transformation processes. Through the Manager of Transformation Academy, they gain practical tools and knowledge essential to addressing the challenges of circularity, digitalisation and change management.

Cluster members also participate in working groups such as the KIS-7 Working Group, the European Commission Working Group for updating the BAT[87] reference document for the surface treatment of metals and plastics (STM BREF[88]), and the Committee on Sustainable Management of Mineral Resources of the Polish Academy of Sciences. This enables them to

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[86] More information: Benchmarking of Clusters in Poland – 2022 Edition. General Report, available at the Polish Agency for Enterprise Development website: https://www.parp.gov.pl/component/publications/publication/benchmarking-klastrow-w-polsce-edycja-2022 or via the Cluster website: https://klasterodpadowy.com/portal [accessed: 09.09.2025].

[87] BAT (Best Available Techniques) – the most effective and technologically advanced methods of carrying out economic or industrial activities that are available and feasible to implement within a given sector, while at the same time minimising negative environmental impacts.

[88] Surface Treatment Using Organic Solvents – Best Available Techniques Reference Document – a reference document on Best Available Techniques (BAT) for surface-treatment processes using organic solvents. It is developed as part of the EU's information-exchange system on BAT (the so-called Sevilla process) and serves as the basis for setting emission standards and environmental conditions for installations covered by Directive 2010/75/EU on industrial emissions (Industrial Emissions Directive).

influence the development of standards and regulations at national and European levels. The outcomes of these activities include increased SME awareness of CE, the development of circularity standards – such as the cluster's own KNR GREEN[89] standard – and the initiation of systemic cross-sectoral dialogue supporting the creation of new regulations and support mechanisms for the circular transition. This initiative strengthens the position of Polish companies in delivering sustainability objectives and builds supply-chain resilience by promoting recycling and eco-design.

Furthermore, the cluster initiated the establishment of a broad partnership – the Coalition for Plastics Recycling – bringing together stakeholders from the entire plastics value chain in Poland: suppliers, processors, recyclers, companies placing goods in plastic packaging on the market, as well as representatives of academia and civil-society organisations. The Coalition's areas of interest include: increasing recycling-plant processing capacity; expanding the capacity of processors to incorporate recycled plastics; improving the recyclability of packaging; expanding the recyclate market; and ensuring coherent and effective national and EU legislation that provides fair competitive conditions for different material groups in line with single-market rules. Coalition members work together to identify and analyse barriers to the development of plastics recycling in Poland and to propose actions necessary to remove them in order to rapidly increase recycling rates.

Effects of implementing the good practice

The presented good practice demonstrates how a cluster can move beyond its traditional integrative function and become an active participant in legislative, educational and strategic processes supporting the transformation not only of its members, but of the entire sector. The key success factors include cross-sector collaboration, competency-based support for companies and a proactive approach to shaping regulations and standards.

The good practice developed by the Circular Economy and Recycling Cluster has generated a wide range of tangible outcomes at the level of enterprises, the sector and national transformation strategies.

Most importantly, the cluster contributes to raising the awareness and preparedness of SMEs for implementing circular-economy (CE) principles, particularly through educational activities delivered under the Academy for Transformation Managers. Through courses and training programmes, managers acquire concrete skills in sustainable development, digitalisation and

[89] The first Polish recycling certification standard, addressed to recyclers operating across seven industries: textiles, metallurgy, paper, wood, glass, chemicals and plastics.
More information is available in Benchmarking of Clusters in Poland – 2022 Edition. General Report https://www.parp.gov.pl/component/publications/publication/benchmarking-klastrow-w-polsce-edycja-2022 or at https://klasterodpadowy.com/portal [accessed: 09.09.2025].

change management, which directly support the adoption of innovative and more efficient business models within companies.

At the same time, through its active participation in expert and advisory groups at both national and European level, the cluster has a direct influence on the development of CE-related regulations and policies. The development of the assumptions for the new Circular Economy Roadmap 2025–2030 – prepared through broad stakeholder dialogue initiated during the Polish Circular Forum, and subsequently taken up by the Ministry of Economic Development – is one of many examples of the cluster's impact on the policy environment.

Another important outcome is the establishment of the Coalition for Plastics Recycling, which brings together the entire plastics value chain and works to eliminate barriers hindering the development of the recyclate market in Poland. The Coalition focuses on building shared positions and legislative proposals centred around expanding recycling capacity. Notably, the cluster has succeeded in gathering the leading sectoral organisations, including representatives of plastics processors, recyclers, and companies placing plastic packaging on the market.

Collectively, these actions strengthen the legislative and institutional conditions necessary for the green transition, enhance the competitiveness of Polish enterprises and contribute to building resilient and sustainable supply chains.

Possibility of applying the good practice elsewhere

Clusters seeking to effectively implement transformation-supporting and policy-shaping initiatives may consider the following actions:

- Building inter-cluster synergies – clusters increasingly deepen and expand their specialisations, allowing one cluster to benefit from the services and know-how of another, instead of duplicating efforts and resources. A good practice is to foster synergies between clusters and make use of their growing resources.
- Identifying key needs and regulatory gaps – clusters should conduct systematic analyses (e.g. member surveys, workshops, consultations) to uncover challenges and determine which regulatory barriers or unmet needs impede development and transformation. Subsequently, existing legislation should be assessed to identify areas requiring change.
- Organising cross-sector events – to develop shared strategies and recommendations, clusters may organise events bringing together industry, academia and public administration. An example worth emulating is the Polish Circular Forum. Clear objectives should be set (e.g. developing a transformation strategy), key stakeholders invited and a programme designed to support knowledge exchange. Following the event, conclusions and recommendations should be compiled into a report and submitted to relevant institutions.

- Engaging with public and international institutions – active participation in working groups, committees and dialogue platforms at national and EU level allows clusters to influence emerging policies and regulations. Clusters should identify appropriate bodies – such as ministerial working groups, government agencies or EU expert panels – nominate representatives and consistently participate, sharing insights and proposals. Joint projects or cooperation agreements can further strengthen the cluster's position.
- Developing educational programmes – initiatives such as the Academy for Transformation Managers help upgrade managerial and operational competences, supporting transformation across sectors. Training programmes should be tailored to member needs – for instance, workshops on change management, innovation or circularity – and may involve external experts, universities or specialised training providers.
- Monitoring and communicating results – clusters should regularly evaluate the impact of their actions and communicate achievements to members and external partners. This strengthens credibility and encourages further collaboration. Reporting can take the form of publications on the cluster's website, social media updates or conference presentations highlighting how cluster activities have contributed to changes in policies, regulations or business competences.

Commentary

A further reflection of the cluster's strategic direction is its name change – from the more narrowly focused Cluster of Waste Management and Recycling to the more comprehensive Circular Economy and Recycling Cluster.

Katarzyna Błachowicz, Vice-President of the Board, Circular Economy and Recycling Cluster

8.2.11. NUTRIBIOMED Cluster: strengthening Poland’s food security through innovation and cooperation

Good practice areas (primary and additional)

Influence on shaping external conditions

Market activity

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Impact on the natural environment

Objective and context for introducing the good practice

The NUTRIBIOMED Cluster aims to raise awareness of the importance of high-quality Polish food for the health and wellbeing of the population, promote domestic farmers, processors and food-innovation companies, shape trends that support Polish agriculture, and disseminate knowledge about the risks associated with poor food quality. A key objective is also to strengthen the country’s food self-sufficiency – an issue that has gained particular relevance following the outbreak of the Russian–Ukrainian war and the resulting potential threat to national security.

This challenge is becoming increasingly significant not only in Poland but worldwide, in the context of the climate crisis, geopolitical shifts and disruptions in global supply chains. At the same time, the cluster’s activities aim to support the transition of agriculture towards more sustainable models based on natural raw materials and modern technologies.

The good practice developed by the NUTRIBIOMED Cluster, coordinated by Wrocław Technology Park (WPT), offers a model example of a comprehensive approach to strengthening Poland’s food security.

Description of the good practice

The cluster seeks to act as a guardian of Poland’s strategic food self-sufficiency through a wide range of activities. It operates a multi-level support model (covering infrastructural, research, technological and educational dimensions) which integrates agricultural, biotechnological, scientific and medical communities with the overarching goal of enhancing national food security. This is particularly important given global challenges such as climate, geopolitical and supply-chain crises.

NUTRIBIOMED initiates cooperation with agricultural advisory centres, farms and local producers, offering not only market access but also support in product and process innovation. The cluster's operations include the use of advanced technologies for food-safety monitoring, compliance with EU requirements, biotechnology and innovative packaging systems, all of which directly improve the health standards of food products.

Another pillar of activity is technology transfer and enterprise support. The cluster provides companies with access to WPT's Experimental Facility – a research and production environment where firms can test innovative processes and accelerate product commercialisation. The Facility is equipped with specialist lines for extraction, preservation, packaging and testing of supplements and functional foods. This gives SMEs access to high-quality infrastructure without incurring significant investment costs. Businesses operating within WPT's Experimental Facility are able not only to develop top-quality products using modern technologies, but also to expand their knowledge of process and technology design. This significantly enhances their expertise, competitiveness and credibility in the eyes of business partners. The wide range of available equipment and flexible configuration options make testing and subsequent implementation of production technologies easier, faster and more efficient.

The cluster also supports the development of food products that not only nourish but also provide preventive health benefits, responding to the needs of an ageing population and the rise of lifestyle diseases. NUTRIBIOMED conducts research on products designed for individuals affected by cancer, dementia and Alzheimer's disease.

In addition, through R&D activities and collaboration with universities, the cluster supports the development of functional foods and nutraceuticals. The primary focus is on cooperative production of a new generation of health-promoting food, based on natural raw materials and offering high competitiveness due to guaranteed safety. By emphasising domestic agricultural resources and their application in nutraceutical and supplement production, the cluster reduces dependence on imports. Meanwhile, the promotion of natural raw materials and the use of eco-friendly packaging supports the transition to more sustainable agriculture.

At the same time, the cluster's coordinator conducts extensive educational activities, including regular webinars, conferences and practical workshops devoted to HACCP, GHP, GMP systems[90], technological innovation and food law. These support knowledge transfer in safe food production, modern processing methods and digital technologies (IoT, automation, bio-

[90] Hazard Analysis and Critical Control Points (HACCP) – Analiza Zagrożeń i Krytyczne Punkty Kontrolne; Good Hygiene Practice (GHP) – Dobra Praktyka Higieniczna; Good Manufacturing Practice (GMP) – Dobra Praktyka Produkcyjna.

based packaging). NUTRIBIOMED encourages food producers to adopt advanced technologies for preservation, extraction and packaging, strengthening both competitiveness and supply-chain resilience. The cluster also manages implementation and investment projects and applies for funding for innovative research and development initiatives.

The cluster is likewise active in exploring the future of food, particularly in forecasting how agricultural land can be used more efficiently to produce food while reducing environmental impacts and maximising societal benefits. It also supports the emergence of a new generation of agriculture dedicated to enhancing quality of life, human health and environmental protection.

This operating model enhances not only the safety and quality of food products but also the strategic food self-sufficiency of Poland. At the same time, it responds to contemporary challenges such as climate change, rising food prices, global supply-chain risks and evolving public-health needs.

As a result, NUTRIBIOMED strengthens the national food-security system and simultaneously builds Poland's strong position in the markets for functional foods, dietary supplements and biomedical preparations. This approach not only increases the country's resilience to crises but also contributes to improving the quality of life and health of the population.

Effects of implementing the good practice

Implementation of this good practice by the NUTRIBIOMED Cluster contributes to strengthening Poland's food security by expanding domestic production, shortening supply chains, reducing dependence on imports and introducing modern technologies and quality standards (including HACCP, GMP and GHP). The cluster's activities support the development of sustainable agriculture and the food industry, promoting the production of functional foods and biosupplements based on natural raw materials. The cluster supports the development of next-generation food products derived from natural ingredients, reducing the use of chemical additives and ensuring the sustainable utilisation of resources.

Through cooperation with universities and the implementation of R&D activities, the cluster facilitates the transfer of knowledge from science to business. As a result, SMEs gain access to expertise, testing capabilities and product commercialisation pathways, which in turn strengthens their competitiveness. Health-oriented education and training activities enhance workforce skills and build the sector's intellectual capital. The cluster strengthens local supply chains, supports knowledge transfer and actively secures funding for R&D projects, thereby increasing economic resilience to health, environmental and geopolitical crises and promoting Poland's position as a producer of modern, high-quality food products.

Concrete solutions implemented by the cluster may serve as inspiration for clusters in other sectors that also aim to advance sustainable development.

Possibility of applying the good practice elsewhere

The NUTRIBIOMED Cluster's model of operation provides an example that can be effectively adapted by other clusters in Poland, particularly in the context of strengthening resilience to crises such as pandemics, natural disasters, climate-related disruptions, geopolitical instability or supply-chain interruptions.

By integrating a broad group of stakeholders – including representatives of academia, industry and public administration – and by supporting local supply chains, innovation and education, clusters can create mechanisms that mitigate the risk of disruptions to production and services, while simultaneously enhancing regional sovereignty and competitiveness, which is of strategic importance for both the economy and society in times of threat.

This practice highlights the need for a comprehensive approach, combining multiple activities and sustained engagement.

From a societal perspective, the NUTRIBIOMED practice shows that cross-sector collaboration enables the creation of safe, high-quality food products while simultaneously supporting public health and environmental protection, thereby contributing directly to the well-being of local communities.

Through these activities, the coordinator strengthens its own resilience, that of its members, and of the wider community, preparing all stakeholders to ensure safety in crisis situations. Clusters that build the resilience of their members are better positioned to respond to emerging challenges and capitalise on new opportunities. Developing organisational resilience reinforces the stability of companies and enhances their credibility in the eyes of customers, partners and investors, who increasingly value the ability to manage risk effectively.

Commentary

Thanks to its nationwide reach, modern infrastructure and a strong base of experienced experts, the NUTRIBIOMED Cluster has become an ideal environment for developing innovative projects and building resilience among all stakeholders. Any innovator, company or individual with an idea for a new product can come to us and – together with our technologists – develop a formulation, test it and then manufacture it on our technological lines. Through the cluster's activities, they can also build a crisis-resilient organisation and, through their operations and products, contribute to ensuring food security in Poland.

Anna Bednarska, Management Board Plenipotentiary for the Cluster

8.2.12. INTERIZON Pomeranian ICT Cluster: cascade grants in practice – support for SMEs and internationalisation

Good practice areas (primary and additional)

Innovation activity

Market activity

Development of collaboration within the cluster

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

Interizon – the Pomeranian ICT Cluster – has implemented a good practice based on the distribution of cascade grants under the international project DESIRE (Development of E-Health Solutions Improving Resilience in Europe), carried out between 2022 and 2025. Project documentation emphasised that the COVID-19 pandemic exposed weaknesses in healthcare systems and demonstrated the importance of rapidly introducing innovative digital solutions.

DESIRE was therefore designed to support SMEs in the ICT and e-health sectors so that they could respond to health, social and economic crises and adapt their business models to sudden changes in the external environment.

The initiative also arose from the need to provide micro, small and medium-sized enterprises with simple and effective access to funding instruments that support innovation, particularly in the field of e-health and ICT technologies. Member companies often struggle to obtain financing directly from EU programmes, which are administratively complex. The aim was not only to overcome barriers associated with accessing EU funds – requiring substantial administrative and organisational capacities – but also to strengthen the resilience and adaptive capacity of member companies, enable them to expand internationally and open the cluster to new opportunities for international cooperation.

Description of the good practice

The DESIRE project was designed according to the logic of resilience – strengthening the capacity of companies and entire ecosystems to withstand shocks and crises. Cascade grants awarded to enterprises support the development of new digital products and services in the healthcare sector, which in turn increases the ability of medical systems and economies to respond in emergency situations. The mechanism combines two components:

- Direct financial support, i.e. funding for the development of innovative digital solutions in the e-health sector;
- A voucher worth EUR 10,000 for advisory services, selected either from the project's catalogue or externally (subject to approval from the project supervisor).

This support included services related to entering foreign markets as well as technological, R&D and marketing consultancy. As a result, companies were able not only to develop new products but also to prepare internationalisation and export strategies. Several beneficiaries signed agreements with foreign partners, confirming the practical value of the export-oriented support.

At the same time, participating enterprises gained easier access to financing, reducing the dependence of SMEs on single sources of support. Companies also benefited from consultations and training, which strengthened their organisational and digital capabilities, making them more resilient to market and technological shocks. In practice, the objective is not solely to support innovation, but to increase the adaptive capacity of SMEs and of the entire cluster ecosystem under conditions of uncertainty.

The implementation of the project required establishing international partnerships, as consortia in programmes such as Horizon Europe or Euroclusters are composed of institutions from multiple countries. To act as a cascade-funding operator, Interizon entered collaboration structures with foreign clusters, research organisations and business-support institutions. In this way, DESIRE also became a tool for the internationalisation of the cluster and its members.

In practical terms, Interizon acts as the operator of funds, organising open calls and distributing resources among interested companies. Under DESIRE, thirty-five grants of EUR 30,000 each were foreseen. The application process was deliberately simplified to lower the entry barrier for enterprises. In addition to financial support, the cluster also provides further services such as webinars and advisory support on risk management and business continuity planning. Interizon is responsible for the evaluation and selection of projects, signing contracts and monitoring and settling the implementation of activities, which reinforces its role as an entity professionally managing public funds.

Effects of implementing the good practice

The results of this good practice are multidimensional. Companies gained access to relatively small grants which, however, were sufficient to carry out tests, prototypes and market research – often acting as a stepping stone towards larger projects (Horizon Europe, EDIH, NCBR). This support has directly contributed to increased innovativeness and adaptive capacity among beneficiaries. Some of the supported firms successfully commercialised their products and launched export activities, drawing on the advisory services financed through the vouchers.

The project also enabled cluster members to participate in events, matchmaking sessions and cooperation networks, all of which facilitated access to foreign markets and international partners. The outcomes of the project (i.e. the results of the companies' grant-supported activities), including new e-health solutions and service prototypes, have been showcased at the European level, enhancing the visibility and competitiveness of companies from the Pomerania region.

Interizon, as the coordinator, not only gained experience in applying European project-management standards, but also developed the capacity to operate as a financing institution – managing the entire funding process from start to finish. This included establishing rules, selecting projects for funding, monitoring implementation and carrying out financial settlement. As a result, the cluster has strengthened its institutional capacity, evolving into not only a more effective platform for cooperation and networking, but also a genuine financial intermediary and a source of expertise in resilience management. This good practice demonstrates that Polish clusters can go beyond networking and promotion to become active operators of European funds.

An important result was also the development of the Interizon coordinator's internal competences in international project participation and financial-procedure management, which further strengthens the cluster's stability and credibility.

At the same time, the implementation of the project involved several significant challenges. One of the main difficulties was building and coordinating an international consortium, which required reconciling different procedures and organisational cultures among partners. Additionally, Interizon had to develop effective procedures for grant distribution and financial settlement, including transparent rules for calls, project evaluation and monitoring, all aligned with the stringent requirements of the European Commission. Another challenge was reaching a sufficient number of companies and persuading them to participate, as some SMEs are deterred by what they perceive as excessive administrative burden associated with EU funding. Consequently, the cluster had to act not only as a funding operator, but also as a promoter, advisor and guide throughout the entire process.

A further difficulty involved balancing the European objectives – such as digital and green transition – with the local expectations of enterprises, which are often primarily focused on tangible business results.

Possibility of applying the good practice elsewhere

Thanks to the combination of financial support and advisory services in the areas of export and internationalisation, the cascade-funding model implemented by Interizon can serve as an inspiration for other clusters. It demonstrates that such instruments can support not only technological innovation, but also the expansion of SMEs into international markets. The cascade-funding model – based on participation in international projects and the distribution of EU funds to companies – can be adapted across a range of economic sectors.

The key conditions for success include adequate institutional preparedness, sufficient staffing and administrative capacity, and aligning the thematic scope of calls with the needs of cluster members. Cascade grants are particularly recommended as a tool for clusters seeking to develop pro-innovation services and strengthen their position within national and European cooperation networks.

Commentary

The DESIRE project provided us with an excellent opportunity to promote cascade grants, which enable companies to access financial resources for innovative projects with minimal bureaucracy. Thanks to the simplified application process, entrepreneurs gain the opportunity to develop new products and services, directly contributing to improved competitiveness and enhanced capacity to respond to dynamic market changes. Several Interizon cluster participants have benefited from this form of funding under the DESIRE initiative.

One of the key outcomes of the project was the creation of a cooperation platform – https://desire-development-of-e-health.b2match.io – which brings together a wide range of stakeholders: over 400 users from the healthcare sector, clusters, businesses, insurance institutions and local authorities. This platform provides real opportunities for knowledge exchange, experience-sharing and collaborative development of innovative e-health projects.

Through the implementation of the project, Interizon has become not only a space for sharing experience and innovation, but also a financial operator supporting the development of e-health technologies. The simplified application process and additional advisory services offer meaningful support for companies. The project has contributed to the internationalisation of the Pomeranian ICT Cluster, enabling its members to access new markets and partners.

Jarosław Parzuchowski, President of the Management Board, Interizon Foundation

8.2.13. Lubuski Metal Cluster: cross-border cooperation in the scientific and technical domain

Good practice areas (primary and additional)

Influence on shaping external conditions

Collaboration with the external environment

Innovation activity

Development of collaboration within the cluster

Objective and context for introducing the good practice

This origin, combined with the cross-border location of the Lubuskie region, has strongly shaped – and continues to shape – the cluster's strong focus on internationalisation activities and on building a robust export potential among its member companies.

As part of the international projects it has implemented, the cluster coordinator has, for many years, been developing expertise and supporting the international operations of member firms, with particular emphasis on enhancing the competencies of the coordinator's staff, cluster members and German partners. Notable completed projects include:

- INT-LERNEN – supporting interregional training competencies in the metal and electrical industries in the cross-border region of Eastern Brandenburg and Western Poland;
- Migration or Cooperation – a study of the metal sector in the Lubuskie–Brandenburg region and the development of human resources and cross-border cooperation in partnership with BIC under the Small Projects Fund of the PRO EUROPA VIADRINA Euroregion;
- Green Jobs in the Metal Industry – a transnational exchange of knowledge and experience on new qualification and skills requirements for the development of a sustainable metal industry in Brandenburg (in partnership with IMU Institut Berlin GmbH);
- Internationalisation and Commercialisation Methods for Business Networks – implemented with the financial support of the European Commission under the Lifelong Learning Programme.

An important aspect of the cluster's activities is the independent cross-border projects carried out by its members. A notable example is the scientific and technical collaboration between the Jacob of Paradies Academy in Gorzów Wielkopolski, the University of Zielona Góra and

Brandenburg University of Technology Cottbus–Senftenberg. This collaboration includes study visits as well as joint educational and R&D initiatives. A significant impulse for deepening cooperation in the border area was the implementation of the project Breaking Borders Through Key Enabling Technologies – Sustainable Development of a Cross-Border Competence Network for Knowledge and Technology Transfer in Lightweight Construction, co-financed under the INTERREG V A BB–PL programme from the European Regional Development Fund.

Description of the good practice

The Lubuski Metal Cluster has, for many years, consistently developed activities that integrate the region's industrial, scientific and institutional communities. A particular area of focus is the development of long-term cross-border links – especially with German partners – through participation in INTERREG programmes, joint projects with universities and research institutions, as well as matchmaking events, workshops and webinars facilitating business relationships.

A strong field of activity is also knowledge and technology transfer. The cluster initiates cooperation between science and industry by organising thematic sessions devoted to new materials and technologies, workshops on lightweight construction, and events focused on the digitalisation of production processes and Industry 4.0. This enables member companies to accelerate innovation uptake and adapt to rapid technological change.

Equally important are educational and training initiatives, which prepare the workforce for the energy and digital transition. The cluster is developing a competence network that includes vocational training and specialist qualifications essential to the modern metal and electromechanical industries.

The cluster's activities also encompass promotion and representation of the sector at regional, national and international levels. It co-organises conferences and debates on energy transition, digitalisation and local economic development, while strengthening the visibility of the metal sector in Poland and abroad. In doing so, it stands as a good practice example of combining industry integration with active involvement in regional and international development processes.

In the coming years, continued cross-border cooperation is planned, alongside the expansion of partnership networks to support the development of regions on both sides of the border – particularly in the areas of hydrogen technologies, composites, aviation and the circular economy. Cottbus is expected to play an increasingly important role as a scientific and technological centre in Brandenburg – alongside Berlin – with significant potential for joint R&D work on innovations in the aforementioned fields. It is worth noting that, thanks to the cluster's previous activities, BTU Cottbus–Senftenberg and the University of Zielona Góra jointly submitted in 2024 an R&D project application under the ZIM-International/INNOGLOBO (NCBR) programmes, concerning an innovative temporary road system, and continue scientific collaboration, including in the fields of composites and the circular economy.

Effects of implementing the good practice

For the coordinator, the activities of the Lubuski Metal Cluster have strengthened its position as a recognised partner both in the region and abroad. Regular participation in cross-border projects and the initiation of cooperation with universities and research institutions have helped build the cluster's reputation as a platform connecting business, academia and public administration. These activities provide easier access to international networks and support instruments, thereby enhancing the organisation's development opportunities.

From the perspective of cluster members, the benefits include easier access to knowledge and new technologies, opportunities to participate in R&D projects, and involvement in industry events delivered through international cooperation. Through joint initiatives, members are able to showcase their products and capabilities abroad and take advantage of training programmes and workshops that support workforce upskilling.

Possibility of applying the good practice elsewhere

The experience of the Lubuski Metal Cluster demonstrates that consistent development of international cooperation – particularly in border regions – can yield tangible benefits for both the coordinator and its members. This model is not limited to isolated events; instead, it is built on long-term relationships with foreign partners, on connecting business, science and public administration, and on the effective use of programmes such as INTERREG and sector-specific initiatives. As a result, the cluster becomes a platform that not only supports export and internationalisation, but also facilitates knowledge transfer and competence development in areas such as digitalisation, the green transition and advanced materials technologies.

Clusters in other regions wishing to develop a similar model should consider several key elements. First, an internationalisation strategy is required – one that links local activities with building a presence in more distant markets, for example through partnerships with clusters in the EU and beyond Europe. Second, cooperation with universities and research institutions as partners in international projects is strongly recommended, as their participation enhances credibility and opens access to R&D funding. Third, effective international cooperation should include a variety of formats – workshops, conferences, digital matchmaking platforms, webinars and joint R&D projects.

It is also advisable for clusters planning international expansion to strengthen the coordinator's competencies in managing international projects (including language skills, knowledge of funding procedures and experience in multicultural environments) and to invest in professional promotion of the cluster's brand abroad (joint export offers, participation in international trade fairs and active use of matchmaking platforms). Ensuring adequate financial and human resources is equally important to avoid limiting activities to occasional events and instead maintain continuous, well-structured cooperation.

For the coordinator, a key challenge remains ensuring the financial and organisational stability of the cluster. Delivering a wide range of initiatives requires significant time and resources, as well as maintaining a consistently high level of member engagement. It can also be challenging to reconcile the differing expectations of enterprises, universities and public institutions participating in the cluster's structures.

Cluster members face challenges related to the need to adapt to rapid technological change and the energy–digital transition. Participation in cross-border projects may require additional investments in staff, time and infrastructure, and smaller enterprises may have limited capacity to fully exploit the potential of international cooperation. In summary, the model developed by the Lubuski Metal Cluster can be adapted by clusters in both border regions and regions located further from national borders, provided it is based on a long-term strategy, broad partnerships and the coherent integration of internationalisation with innovation development and competence building. This practice strengthens cluster competitiveness and opens access to new markets and development opportunities at both European and global scales.

Commentary

Borderland communities are unique: for them, cross-border cooperation is not only important – it is a necessity. Territorial cooperation forms the foundation for building an integrated and competitive border region, and it serves as a gateway to collaboration with more distant territories. Cross-border projects foster development in education, the economy and cooperation between public administrations. Importantly, joint initiatives must take into account the potential and ambitions of both sides and be based on genuine partnership. The implementation of international R&D projects supports knowledge transfer, enhances the innovativeness of local economies and significantly strengthens the competitiveness of the entire border region. The border area can – and should – play the role of an active bridge in Polish–German cooperation.

Filip Dziedzic, Board Member, Association of Polish Mechanical Engineers and Technicians (SIMP), Gorzów Wielkopolski Branch

8.3. International good practices

8.3.1. France Clusters: Cluster Invest – platform for project and investment engineering

Good practice areas (primary and additional)

Innovation activity

Market activity

Development of collaboration within the cluster

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The Cluster Invest programme[91] was created as part of the experimental project Cluster's PME Territoires Invest, implemented by France Clusters[92] in cooperation with Banque des Territoires and the Agence Nationale de la Cohésion des Territoires (ANCT). It is a response to the difficulties faced by SMEs in securing the funding needed to implement innovation. Research carried out in December 2021 by France Clusters in partnership with Caisse des Dépôts identified more than 700 innovative industrial projects within French clusters that were ready for launch but faced barriers to obtaining the financing required for production scale-up.

France Clusters thus demonstrated the existence of a funding gap between the research and development phase and the industrialisation phase. The findings confirmed that too many promising projects reach an impasse due to the lack of appropriate financial instruments to support the transition from prototype to full industrial deployment. To facilitate access to development capital for innovative industrial projects, a programme was created to fill this "missing link" in the funding chain – bridging the gap between development capital and venture capital, which often does not support firms in the industrialisation stage.

Its main objective is to accelerate the growth of innovative SMEs and start-ups that are well positioned for rapid expansion but have exhausted their equity during the R&D phase and therefore no longer have access to grants. The programme provides these firms with capital

[91] More information is available at: https://www.franceclusters.fr/nos-projets/cluster-invest [accessed: 09.09.2025].

[92] France Clusters is one of the two functioning cluster associations in France. More information is available at: https://www.franceclusters.fr [accessed: 09.09.2025].

and expertise to support industrialisation. With a community of 300 clusters representing 55,000 companies, France Clusters positions itself as a key actor in the national reindustrialisation effort.

Description of the good practice

Cluster Invest is an initiative designed to support the financing and development of innovative SMEs and start-ups in the industrialisation phase, with a particular focus on industrial projects with strong growth potential. The programme was developed in response to the funding challenges encountered by companies transitioning from research and development to full industrial production – one of the most critical stages for innovative firms.

It is implemented in cooperation with the Secrétariat Général pour l'Investissement (SGPI) and other institutions such as Bpifrance, within the France 2030 programme, which aims to stimulate the establishment of new industrial facilities and optimise strategic investment. The initiative also supports regional industrial development policies, for example through cooperation with the Agence Auvergne Rhône Alpes Entreprises.

The programme integrates three key functions to maximise project potential and minimise investor risk:

- Support and preparation for capital raising: including training for cluster managers and partner networks on building investment offers, assessing investment readiness and negotiating with investors;
- Mobilisation of capital investors: active engagement of public and private funds in financing high-potential industrial projects;
- Qualified matchmaking through a carefully curated deal flow[93]: selection of projects that meet criteria of industrial readiness and market potential, thereby reducing investment risk.

The initiative is open to all interested clusters. The programme is based on the following pillars, which support clusters and their members in the financing process:

- Training and advisory services for clusters and firms: upskilling managers in the preparation of industrial projects, financing and internationalisation;
- Club Cluster Invest: a knowledge-sharing platform for cluster managers and fundraising specialists enabling the exchange of best practices and technical–financial expertise on pilot projects (currently involving 12 clusters, open to others);
- Cluster Invest Fund of Funds: establishing partnerships between France Clusters and fund managers dedicated to innovative industrial SMEs. The programme envisages a

[93] The term "deal flow" refers to the pipeline of potential investment opportunities – a set of carefully selected projects or companies that may be of interest to equity investors.

€100 million fund financed by enterprises, private institutional investors active in innovation and ESG94, and public institutions such as Bpifrance and the European Investment Bank (EIB). An example of a new private fund dedicated to industrial innovation is Next Health Capital in the health sector, managed by Turenne Capital and supported by clusters/networks seeking to assist high-growth industrial SMEs;

- Support for SMEs and start-ups: targeted at high-growth companies that have completed the R&D phase and require between €2 million and €10 million to scale production and commercialise their solutions. The support also includes services related to internationalisation, shareholder succession and business restructuring.

Effects of implementing the good practice

The implementation of the activities forming this good practice has translated into the following results:

- Optimisation of France's strategic investments in the 2030 perspective;
- Enrichment and structuring of territorial ecosystems for industrial innovation;
- Acceleration of industrial innovation deployment through support for innovative SMEs and start-ups in the expansion phase, taking regional potential into account;
- Financing of innovative, high-growth companies at the industrialisation stage – future medium-sized enterprises (fr. Entreprise de Taille Intermédiaire)[95] – as well as mobilisation of investment funds.

The programme's activities deliver a wide range of benefits for different stakeholders:

- For SMEs and start-ups: accelerated industrialisation of innovations, access to financing, networking opportunities, support for internationalisation and development of managerial competences;
- For clusters: strengthened role within innovation ecosystems, development of new skills and opportunities for collaboration with investors;
- For regions and the economy: job creation, development of new industrial sectors, increased attractiveness and competitiveness, and enhanced territorial innovation ecosystems;

[94] Ang. Environmental, Social and Governance – koncepcja oceny działalności przedsiębiorstw w trzech kluczowych obszarach: środowiskowym, społecznym oraz ładu korporacyjnego.

[95] Jest to kategoria firm określana w przepisach francuskich, która obejmuje przedsiębiorstwa zatrudniające od 250 do 4999 pracowników oraz osiągające roczny obrót nieprzekraczający 1,5 miliarda euro lub mające sumę bilansową poniżej 2 miliardów euro. ETI są postrzegane jako kluczowy element gospodarki Francji, ponieważ łączą elastyczność MŚP z potencjałem dużych przedsiębiorstw, przyczyniając się do innowacji, eksportu i tworzenia miejsc pracy.

- For the state and investors: optimisation of strategic investments in the 2030 perspective, increased efficiency of financing high-growth projects, and support for future medium-sized enterprises.

A practical example of implementation is the pilot initiative "Cluster Invest – Pack Innov' Indus" launched by the competitiveness cluster CIMES (Pôle de Compétitivité CIMES)[96] in the Auvergne–Rhône-Alpes region. The initiative aimed to:

- Support reindustrialisation and the reshoring of industrial production by focusing on innovative SMEs;
- Identify and support innovative SMEs to minimise project risks and create value in the place where R&D activities are conducted;
- Create a continuous pipeline of mature projects ready for investment and deployment, identified by clusters and business networks, based on the following prerequisites: completed R&D activities, a defined industrialisation strategy, confirmed interest from early customers and planned first sales, as well as anticipation of the skill requirements necessary for further development – particularly at managerial level.

The implementation of the activities constituting this good practice has led to the following outcomes:

- Optimisation of France's strategic investments in the 2030 perspective;
- Enrichment and structuring of territorial industrial innovation ecosystems;
- Acceleration of industrial innovation deployment through support for innovative SMEs and start-ups in the expansion phase, taking into account regional potential;
- Financing of high-growth innovative firms in the industrialisation phase – future medium-sized enterprises (Entreprises de Taille Intermédiaire)[97] – as well as the mobilisation of investment funds.

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[96] The acronym CIMES stands for Conception et Industrialisation de Microtechniques et Systèmes ("Conceptualisation and Industrialisation of Micro-technologies and Systems"). The cluster operates in the Auvergne–Rhône-Alpes region of France and focuses on the development of technologies in the fields of micro-technologies, embedded systems, smart systems and advanced manufacturing. It supports innovation across sectors such as industry, healthcare, transport and energy.

[97] This is a category of companies defined under French law, covering enterprises employing between 250 and 4,999 staff and generating an annual turnover not exceeding EUR 1.5 billion or with a balance sheet total below EUR 2 billion. ETIs are regarded as a key component of the French economy, as they combine the agility of SMEs with the capacity of large enterprises, contributing significantly to innovation, exports and job creation.

Possibility of applying the good practice elsewhere

The Cluster Invest programme offers Polish clusters an inspiring model for supporting start-ups and SMEs in the industrialisation phase through dedicated funds, training activities and collaboration platforms. It can therefore be adapted to enhance firms' competitiveness and strengthen their role in economic and strategic development. Establishing dedicated investment funds – in cooperation with public institutions such as the National Centre for Research and Development (NCBR) or the Polish Armaments Group, together with private investors or, for example, cluster members, local VC funds or business support institutions – modelled on the Fonds de fonds Cluster Invest, could help Polish clusters finance start-ups and SMEs scaling up their production. CleanTech clusters, for instance, could support the development of hydrogen technologies, helping to bridge the funding gap faced by firms moving from prototypes to full-scale production.

Polish clusters may draw on this initiative to build, independently or jointly with other clusters, mechanisms for co-investment in R&D projects, technology pilots or shared infrastructure. Diversifying funding sources, co-investing in R&D and engaging members as co-creators would increase companies' commitment and strengthen clusters' resilience to financial uncertainty – for example, in the context of declining EU funding or unpredictability of public financing.

Training programmes for cluster managers could also be adapted by Polish clusters that already run educational initiatives, such as those related to the circular economy. Such training could focus on preparing managers to identify investment-ready projects, negotiate with investors and develop financing strategies for SMEs. This would enhance clusters' capacity to support their members in accessing capital and implementing ambitious development plans.

The creation of collaboration platforms similar to the Club Cluster Invest enables the exchange of experience between managers, investors and public institutions – for example, through cross-sectoral forums – supporting the development of circularity standards or drone technologies, while also strengthening a sense of belonging and long-term engagement.

Polish clusters can also draw inspiration from the Cluster Invest approach to reducing the risks associated with industrial projects, particularly investment risk for start-ups and SMEs. Larger clusters, which bring together numerous local SMEs and start-ups, could adapt this model to support these entities in securing financing – for example, for the production of components for the defence sector. By adopting elements such as dedicated investment funds, management training and structured collaboration, clusters can strengthen their strategic role while simultaneously contributing to the economic development of their regions.

8.3.2. Smart City Cluster: public–private partnership for sustainable and innovative cities

Good practice areas (primary and additional)

Collaboration with the external environment

Market activity

Cluster digitalisation

Innovation activity

Development of collaboration within the cluster

Impact on the natural environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The good practice emerged in response to the growing demand from cities for the digitalisation of public services and the transition towards becoming smart cities[98]. Both the cluster and local authorities recognised the need for more effective resource management and a stronger commitment to urban transformation. Given Spain's significant urban and geographical diversity, there was a need for a model that would enable different stakeholders – local governments, businesses, universities, and citizens – to jointly develop and test smart-city solutions. Smart City Cluster integrates these expectations by facilitating access to funding and enabling the rapid deployment of innovation in a variety of local contexts.

Description of the good practice

The Spanish Smart City Cluster represents an effective model of collaboration between business, academia, local authorities and citizens, aimed at jointly addressing urban challenges. Its activities go beyond deploying specific technologies and also include education, certification, SME support and the development of international partnerships. By coordinating the work of

[98] Smart cities are urban areas that invest in human capital, integrate the functioning of critical infrastructure, address issues such as poverty and social exclusion, and enhance residents' quality of life. By collecting, analysing and making effective use of data, city authorities are able to make informed decisions and deliver services that meet citizens' expectations. More information is available at: https://www.gov.pl/web/cyfryzacja/dane-dla-inteligentnych-miast [accessed: 09.09.2025].

more than 200 members, the cluster has become a catalyst for implementing smart solutions in cities – from water-saving systems, smart-city platforms for street-lighting management, intelligent irrigation, urban mobility and CCTV, to local digital campuses improving residents' digital skills, ICT tools supporting online sales for local businesses, and digital platforms for municipal data management, among many others.

The cluster also delivers workshops and courses for municipalities (e.g. smart waste management or sustainable mobility), enhancing the skills of municipal staff and the local workforce. For its members, it provides access to technical training and AENOR certification (Asociación Española de Normalización y Certificación), covering key topics for the present and future of the sector, including the circular economy, innovation, sustainability, social responsibility and digital transformation.

This case demonstrates how clusters, through joint action and openness to innovation, can drive the effective transformation of cities into more sustainable, resilient and liveable urban spaces. It also confirms that such partnerships constitute a strategic investment that benefits all stakeholders involved.

The cluster provides expertise on innovation and supports cooperation in identifying solutions to urban challenges, as well as in sourcing funding opportunities. At the same time, it offers all stakeholders a platform to strengthen their capabilities in areas crucial for sustainable and innovative urban development.

Smart City Cluster also identifies collaboration opportunities by taking part in prospective consortia and by seeking strategic partners for new projects, while simultaneously mapping complementarities among its members. One example is the Aquadomus project, implemented jointly with the University of Córdoba and industrial partners, which enables the monitoring of domestic water consumption and the detection of leaks. The cluster sets quality standards for implementing smart-city solutions and provides a platform for knowledge exchange among diverse actors.

Projects of this kind – aligned with EU and Spanish strategies on green transition and digital innovation – reinforce the role of Smart City Cluster as a key reference point for developing technological solutions that support more sustainable and resilient cities.

In 2023, Smart City Cluster signed an agreement with RECI (Red Española de Ciudades Inteligentes – the Spanish Network of Smart Cities) to jointly promote smart-city solutions across the country. Both organisations committed to acting as intermediaries to facilitate public–private collaboration and ensure that cities benefit from the latest smart-city practices. Together, they develop innovative ideas, projects and solutions that demonstrably improve residents' quality of life in pioneering municipalities. The agreement includes coordination mechanisms to align efforts on promoting smart-city concepts, strategic urban-development planning, identifying and supporting innovative projects, and exchanging scientific and technical knowledge, research, reports and analyses. It also provides for participation in expert groups and coordination bodies to facilitate knowledge transfer and experience sharing. In the era of digital transformation, agile approaches to processes are essential, and supporting the smart-city sector – particularly in breakthrough technologies – is critical to achieving these ambitions.

Effects of implementing the good practice

The cluster establishes formal partnerships with municipal authorities, creating a strong synergy effect. Collaboration based on public–private partnership delivers tangible benefits to all parties involved. Cities are able to implement modern, needs-driven solutions more swiftly and efficiently, thereby improving the quality and effectiveness of public services (for example through the introduction of systems for traffic, water, energy, waste, CCTV and lighting management). The integration of systems such as street lighting, irrigation and monitoring generates cost savings for local authorities, improves energy efficiency and enhances the overall competitiveness of the region. At the same time, cooperation with the cluster enables municipalities to successfully secure external funding (both national and EU) for digital development.

Through its commitment to knowledge-sharing and joint development, the cluster contributes to strengthening innovation among SMEs (supported by cooperation with universities and participation in funded R&D projects) and facilitates access to high-quality training that enhances members' competitiveness and builds their digital capabilities. Cluster companies also gain access to new markets and opportunities to deploy and test technologies in real urban environments, thereby developing a reference portfolio that can be scaled to other regions. Meanwhile, the cluster itself, through active involvement in European projects and thematic forums, increases its international visibility.

The partnership also strengthens the local labour market. Technological deployments require the recruitment of IT specialists and the upskilling of new personnel, generating jobs and stimulating local economic activity.

As a result of the activities undertaken within this good practice, residents benefit from improved quality of life, enhanced safety and access to new services (such as digital tools for local entrepreneurs or educational campuses that build digital skills).

Possibility of applying the good practice elsewhere

The Smart City Cluster good practice demonstrates that close cross-sector collaboration and a focus on practical, scalable solutions are key to success. The smart city domain is not the only area where this approach can be adopted by clusters. Joint pilot projects – such as those concerning intelligent transport, water or energy management – can be developed in a similar manner.

It is equally important to emphasise that clusters can support local governments at every level, including the smallest municipalities.

Providing active support to members in securing EU funding and building international partnerships is essential for strengthening competence and capacity for such cooperation.

Polish clusters can draw inspiration from this model by recognising local authorities as valuable partners and as a source of development opportunities for the cluster itself. Developing expertise – e.g. through international networks in a given specialisation supported by programmes such as Horizon Europe – will enhance clusters' capabilities and long-term potential.

8.3.3. WaterCampus Leeuwarden: circular water management and regional development

Good practice areas (primary and additional)

Exports and pro-export activities

Impact on the natural environment

Market activity

Innovation activity

Development of collaboration within the cluster

Collaboration with the external environment

Influence on shaping external conditions

Objective and context for introducing the good practice

The WaterCampus Leeuwarden initiative originated in the province of Friesland in the Netherlands – a region which has historically faced significant water-related challenges, contributing to the development of a strong local specialisation in water technology (water-tech).

WaterCampus Leeuwarden is a cluster and innovation hub in the north of the Netherlands focusing on water technologies – ranging from water treatment and wastewater purification to water resource management and reuse. Its mission is to accelerate the development and deployment of cutting-edge solutions that respond to global water challenges while supporting the transition towards a circular water economy.

The activities undertaken aimed to create an integrated ecosystem for innovation in water technologies, responding to global challenges such as water scarcity, poor water quality, climate change and the need for sustainable resource management. This required practice-oriented scientific research and close collaboration with industry to speed up the development and commercialisation of water-tech solutions. From its inception, the cluster also placed particular emphasis on strengthening innovation and boosting the export capacity of firms, ensuring that local technological solutions could reach international markets. This was especially important given the relatively small size of the Dutch water-tech market, which means that ambitious companies are, by necessity, export-oriented.

Description of the good practice

WaterCampus Leeuwarden represents a unique ecosystem that integrates all stages of the innovation chain in water technology – from fundamental research, through development and piloting, to commercialisation and international market entry. The core of the cluster consists of four complementary organisations:

- Wetsus – the European centre of excellence for sustainable water technology. Responsible for carrying out scientific research (mainly applied, pre-commercial research). Wetsus operates long-term PhD programmes built around clearly defined research themes. These themes are proposed and co-funded by consortia of companies interested in solving specific technological issues, working in partnership with research groups from multiple universities. This model resembles a “round table” between science and business: companies present technological challenges they cannot solve independently, while researchers (PhD candidates supervised by professors) carry out the research, remaining in close contact with industrial partners. Regular thematic meetings involving both business and academia enable continuous knowledge exchange and ensure market-driven research orientation. Because companies are directly involved in the Wetsus research programme, all projects maintain a strong focus on practical application. Wetsus acts as a catalyst for breakthrough innovations. Research outcomes have led to pioneering solutions in areas such as advanced water purification, resource recovery from wastewater (e.g. phosphorus, bioplastics), and water–energy processes, including energy storage. These results contribute to global objectives such as clean water, clean energy and circular resource use. The financing model combines private and public funding – company membership fees, ministerial subsidies, university contributions, regional support and EU grants – ensuring programme stability while maintaining a strong economic relevance. An efficient intellectual property management mechanism ensures that companies obtain rights to commercialisation, including international implementation. By 2023, Wetsus had achieved 100 patent applications, most of which were developed jointly with companies and subsequently brought to market.
- CEW – Centre of Expertise Water Technology. A centre for applied research that complements Wetsus by focusing on shorter development and pilot projects conducted jointly by companies, universities and students of water-engineering programmes. CEW manages the Water Application Center (WAC), a demonstration facility equipped with specialised laboratories, installations and pilot spaces where new technologies can be tested and scaled under near-real conditions. It serves as a bridge between scientific research and industrial implementation, accelerating commercialisation by removing

technical barriers that often hinder product internationalisation and technology scale-up.

- Water Alliance – the key organisation supporting internationalisation and export. Water Alliance brings together over 200 companies (mostly SMEs) in the Dutch water-tech sector. It provides a wide range of services supporting commercialisation and international growth:
    - market intelligence (including regulatory insights for target countries),
    - networking and B2B matchmaking in the Netherlands and abroad,
    - marketing support and brand visibility for internationalisation,
    - organisation of trade fair participation and trade missions,
    - assistance in forming consortia and securing funding (e.g. EU grants for demonstrators),
    - voucher schemes and micro-grants for SME innovation.
- Water Alliance hosts thematic platforms (expert groups) focusing on specific issues, such as circular water systems, legionella control or resource recovery. It also coordinates start-up acceleration activities. The presence of a WaterCampus representation in Brussels facilitates contact with EU institutions and early access to information on European funding. In effect, Water Alliance functions as an export accelerator, helping companies move from an initial technological concept to successful international market entry.
- CIV Water – Centre for Innovative Craftsmanship. Responsible for vocational and technical education in the water domain at secondary and post-secondary levels. CIV Water collaborates with vocational schools and training institutions to ensure a steady supply of skilled technicians for the sector. It also contributes to early-stage education: Friesland has introduced specialised water-related educational modules in primary and secondary schools to cultivate future engineering talent and raise awareness of water technologies. The cluster therefore supports a full educational pipeline – from primary school through vocational and higher education (engineering and doctoral studies) – which is essential for long-term sectoral innovation. CIV Water also promotes lifelong learning, offering continuous professional training for employees in the water sector in response to emerging challenges such as digitalisation and circular water systems.

This good practice demonstrates a systemic, long-term approach to the entire innovation chain, underpinned by a strong export component. Firms, universities and regional authorities co-invest in infrastructure and projects that generate competitive advantages for the region, while Water Alliance actively enables international market access, making export a tangible and scalable outcome of cluster activity.

Effects of implementing the good practice

WaterCampus Leeuwarden, through its integration of science, business and education, has become a global reference point for innovation in the water sector. Its activities have resulted not only in dozens of patented solutions and industrial deployments, but also in a significant increase in the export of water-technology solutions, demonstrating a high level of commercialisation effectiveness. It is estimated that over 80% of research projects conducted within the cluster progress to further business development. Thanks to this initiative, Friesland has become one of the international leaders in water-tech, which has translated into local economic growth – the creation of highly skilled jobs and an increase in technology exports. Cluster companies regularly participate in international trade fairs and business missions, securing contracts across multiple continents. Another important outcome has been the reversal of the brain drain: attractive career opportunities within WaterCampus have encouraged many talented graduates to remain in the region rather than leaving for other innovation hubs. The cluster has also improved residents' quality of life through enhanced water and environmental security.

It is also important to note that water-focused clusters play a crucial role in climate adaptation. Growing threats such as droughts, water shortages and extreme rainfall require modern technologies, and WaterCampus Leeuwarden accelerates their development and deployment. Owing to its position as a global innovation hub, it attracts experts, entrepreneurs and institutions from across Europe and beyond. The result is a rapidly expanding cluster whose experience in integrating the entire innovation chain – from scientific concept to international commercialisation – can serve as inspiration for other regions.

Possibility of applying the good practice elsewhere przez inne klastry

The WaterCampus Leeuwarden model can serve as an inspiration for clusters seeking to strengthen their innovation capacity and effectively support companies in entering international markets. It can be successfully adapted in various sectors – such as renewable energy, agriculture or biotechnology – provided it is aligned with local conditions and challenges. Polish clusters could use this model to create or expand mechanisms supporting export, for instance by integrating the offer of member firms under a shared brand, participating in international fairs and missions, or establishing contact points abroad, such as in Brussels. This would increase the visibility of Polish technologies and improve their chances of competing for global contracts.

Key elements of the model – cooperation within the triple helix (science–business–government), long-term investment in infrastructure and strong internationalisation activities – are universal and applicable in regions with similar needs. A particularly important role is played by an active business organisation, such as Water Alliance, which not only supports entrepreneurship but also generates export opportunities.

Mechanisms for science-industry collaboration – such as thematic consortia, co-funded doctoral programmes or “round-table” cooperation formats – as well as comprehensive acceleration pathways from concept to export, supported by public funding (e.g. Horizon Europe), can also be successfully transferred to other clusters.

The principles underlying WaterCampus Leeuwarden – long-term partnerships based on trust, a focus on global challenges, and the integration of education with industry and research – are sufficiently universal to form the foundation for the development strategies of other innovation ecosystems. Clusters may consider creating similar structures: a centre for fundamental research, a facility for applied development and piloting, and a business platform focused on securing EU funding. Potential benefits include accelerated innovation, increased competitiveness and sustainable development, although success requires building trust among partners and patience in waiting for measurable results.

It is also worth emphasising that the challenges faced by WaterCampus Leeuwarden – such as water scarcity, climate change, and risks to drinking water quality and agriculture – are equally relevant for Poland. Polish clusters should therefore consider how to use their research, technological and business resources to improve water management and implement innovative water-tech solutions. Developing cooperation ecosystems based on the triple-helix model could facilitate the transfer of knowledge from laboratories to industrial practice, strengthening the competitiveness of Polish SMEs on domestic and international markets. Such initiatives would not only prepare the economy and society for climate challenges but would also help build new competitive advantages in the field of green technologies.

9. Conclusions

9.1. Specific and atypical phenomena across cluster groups

The chapter outlines characteristic, specific, or atypical phenomena identified in the latest edition of the benchmarking study. The aim of this section is to highlight the most dynamic changes, as well as those that distinguish the current edition from previous ones, particularly in areas such as membership, employment, finances, innovation, and digitalisation. The analysis aims to capture the evolution of Polish clusters and to identify factors that demonstrate their organisational maturity and increasing economic significance.

Comparing results across successive benchmarking editions can be limited by factors such as differences in the composition of the cluster sample. The current edition of the study was carried out in the first half of 2025, while the analytical period covered developments observed in 2022–2023. In the previous edition (2022), the benchmarking system was based on 90 indicators, whereas in the earlier edition (2020), it included 114 indicators. The present study again relies on 90 partial indicators, similar to those used previously. However, the number of clusters analysed has changed **–** specifically, an increase of one **–** along with their composition, as 32 clusters participated in both editions, while 10 did not participate previously. The changes observed at the level of partial indicators enable the identification of new and interesting phenomena in the functioning of Polish clusters, broadening the understanding of their potential.

The conclusions from the analysis of cluster trends are based on selected values of several partial indicators, which were cited in the 2022 report.

- A consistent rise in the number of cluster members is evident throughout the period 2009–2023, as shown in the table below.

  Table 10. Change in the number of members, including enterprises, in the clusters studied (edition of the study)

Indicator	2010	2012	2014	2018	2020	2022	2024
Number of clusters surveyed	47	35	40	40	41	41	42
Number of members	1 866	1 535	1 917	3 374	3 813	4 208	4 942
Number of enterprises	1 469	1 137	1 550	2 718	3 133	3 534	4 113

  Source: authors' own elaboration based on the results of the Benchmarking of Clusters in Poland study (2010, 2012, 2014, 2018, 2020, 2022 and 2024 editions)[99].

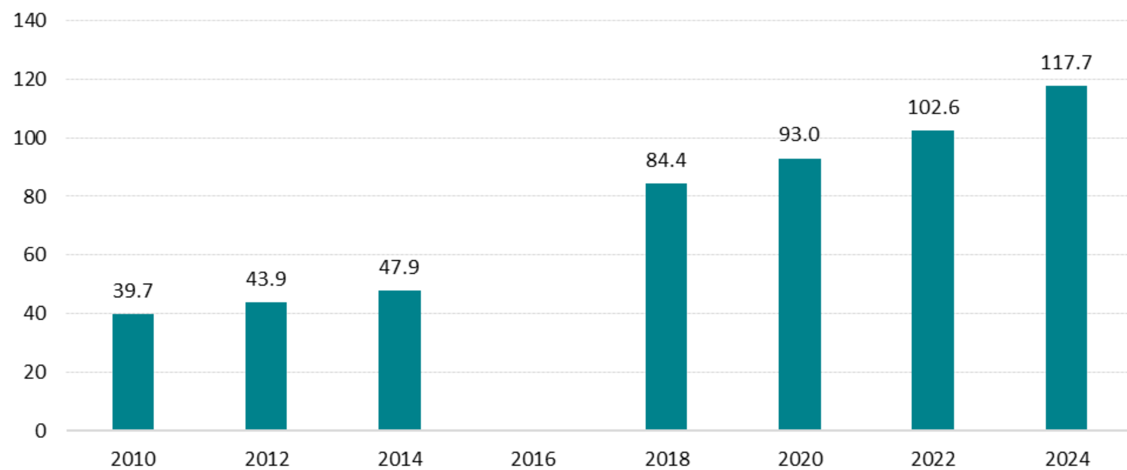
  The growth in the number of members within the surveyed clusters from 2010 to 2024 mainly results from the increasing number of enterprises involved in them. This

[99] There was no edition of the study conducted in 2016.

underlines the growing significance of clusters as a form of business collaboration and their capacity to attract new firms that see real value in joint projects, promotion, and knowledge transfer.

- A key phenomenon, therefore, is the numerical growth of members across the clusters included in the study. At the end of 2017, the average number of members in the surveyed clusters was 84.4, whereas by the end of 2023 it had increased 117.7[100]. This indicates that during this period, the clusters experienced an average annual growth of about 6.7% in membership (CAGR indicator[101]).

Figure 46. Average number of members per cluster participating in successive benchmarking editions



Source: authors' own elaboration based on the results of the Benchmarking of Clusters in Poland study (2010, 2012, 2014, 2018, 2020, 2022 and 2024 editions).

- The activity scope of most clusters remains mainly regional. In 22 clusters, the proportion of members located in the same voivodeship as the coordinator exceeded 70%. However, a noticeable decrease in geographical concentration is observed compared to the previous edition of the study (the average share fell from 70.7% to 66.2%, and the median from 74.0% to 72.8%). This suggests emerging trends towards expansion beyond the home region, although it is too early to determine whether these trends are widespread. In this context, a desirable development path for clusters – especially those without the National Key Cluster (KKK) status – should involve further quantitative growth (e.g. expansion into voivodeships with very low cluster activity, such

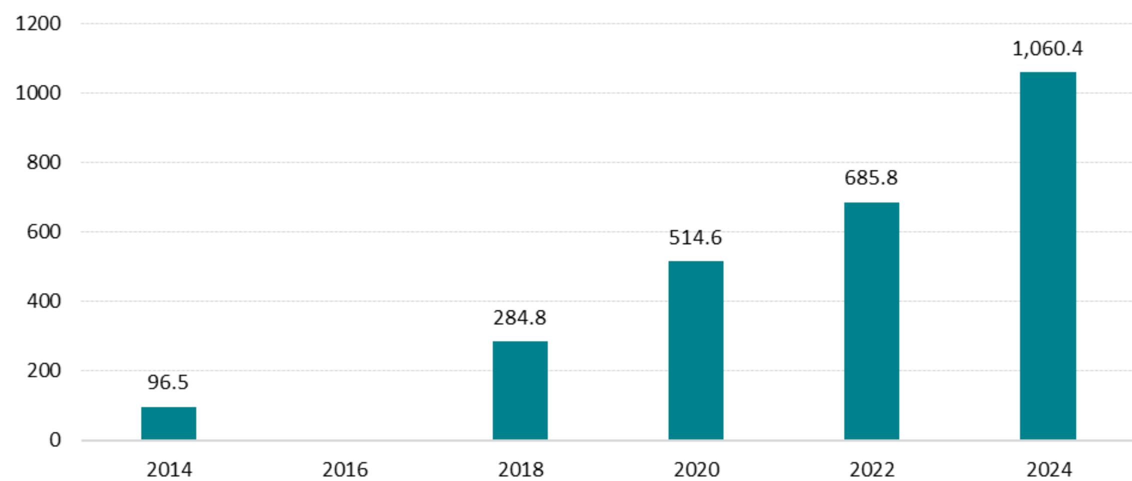
[100] Current edition of the benchmarking study.

[101] The CAGR indicator (Compound Annual Growth Rate) represents the average annual growth rate of a given value over a specified period, showing the constant rate at which that value would have grown if it had increased evenly each year.

as Warmian–Masurian, Świętokrzyskie and Opole, or into neighbouring voivodeships lacking a sectoral equivalent of a given cluster).

- In many areas and sub-areas of the study, there are significant disparities between median and average values on the one hand and benchmark results on the other (e.g. in infrastructure and financial resources, the median was 0.14 and 0.11 respectively, while the benchmark was 1.00). This suggests that at least half of the clusters achieve very low results, with only a few structures reaching very high scores.
- Over recent years, there has been a notable rise in employment within entities belonging to the surveyed clusters. In the 2014 edition, the total was 96.5 thousand employees, increasing to 284.8 thousand in the 2018 edition. Estimates from the 2020 edition indicate that total employment among cluster members reached 514.6 thousand. In the previous edition of the benchmarking study, this figure was approximately 685.8 thousand. In the current edition, the number rose to 1,060.4 thousand employees (calculated for 41 clusters, as – similarly to the two previous editions – one cluster did not provide total employment data).

Figure 47. Employment in entities belonging to clusters in successive benchmarking editions (thousand persons)



Source: authors' own elaboration based on the results of the Benchmarking of Clusters in Poland study (2010, 2012, 2014, 2018, 2020, 2022 and 2024 editions).

- Two factors influence this situation. Firstly, the number of cluster members has more than doubled – from 1,917 entities in the 2014 edition to 4,942 in the current edition. However, this alone does not fully explain the rise in employment. When looking at average employment per member, it was 50.3 employees in 2014, compared to 214.6 now. This suggests that over the past six years, clusters have increasingly attracted larger entities, especially enterprises, which can significantly impact their critical mass, ability to shape framework conditions, and overall development potential.

- In the latest edition of the benchmarking study, a slight decline was observed in the number of staff assigned to cluster management within coordinator institutions (total employment decreased from 251 FTEs at the end of 2021 to 219.5 FTEs at the end of 2023). This indicates a deterioration in the staffing situation of clusters and a reduced capacity to initiate various development activities. Differences in estimates may arise from the changing composition of clusters participating in the 2022 edition compared to the current edition (32 clusters participated previously, with 10 new ones). No clusters were found to significantly inflate this indicator (in four clusters, the number exceeded 10 staff members, reaching 16, 15, 15, and 13 respectively). Conversely, in six clusters, the number of employees did not exceed one.
- In the period 2012–2013, the total budget of the surveyed clusters was PLN 139.4 million. Between 2016 and 2017, this figure dropped to more than four times lower – PLN 35.25 million, including PLN 23.5 million in external funding. During 2018–2019, the total value of cluster budgets rose considerably to PLN 222.1 million (considering changes in sample size), with over PLN 17.3 million from own funds and more than PLN 200 million from external sources, mainly grants for activities aligned with cluster coordination. The period 2020–2021 experienced a sharp decline in external funding (grants), primarily due to the phasing out of calls under operational programmes and the conclusion of the financial perspective. Consequently, total cluster budgets fell significantly to around PLN 96.0 million. In the latest edition of the study, the total budget for clusters in 2022–2023 was PLN 151.5 million – a growth of over 50% compared to the previous period. From 2022 to 2023 alone, a nearly 40% increase was observed, which is a positive sign of building more stable financial foundations for cluster operations.
- An interesting phenomenon is the observed decline in the number of patent applications among the surveyed clusters – nearly halved compared with the previous edition (from 368 to 167) – while the number of granted protection rights increased (from 279 to 343). This may partly reflect the cumulative effect of earlier activities and the natural time lag in patent procedures, where decisions on granting protection typically take several years to be made. At the same time, a drop in new applications does not necessarily imply reduced innovation activity. Statistics from institutions such as the European Patent Office (EPO)[102] show that, in recent years, the share of applications from traditional sectors has declined, while ICT, AI, and electrical

[102] European Patent Office. (2023). Key patenting trends. https://www.epo.org/en/about-us/statistics/patent-index-2023/key-patenting-trends [accessed: 09.09.2025].

engineering have become increasingly prominent. In these fields, some companies forgo patent protection in favour of faster ways of disseminating knowledge, such as publications or open licences, driven by rapid technological change and short innovation cycles. For this reason, the decrease in applications within clusters may be interpreted more as an adaptation to global trends and shifts in intellectual property protection strategies than as a clear signal of weakening innovation potential..

- Cluster members view digitalisation as a strategically important area for development (average rating: 4.4/5), yet 40.9% do not currently see tangible results from initiatives undertaken by cluster coordinators or through joint cluster activities. This reveals a gap between members' expectations and the reach or visibility of digital initiatives, which may be due to limited access to specific projects and inadequate communication of the results of ongoing efforts.

9.2. Strengths and weaknesses of clusters

The assessment of clusters' strengths and weaknesses was based on the median values of the scores obtained by clusters in individual sub-areas. Elements with a median score exceeding 0.30 for the surveyed group of clusters were identified as strengths, while those with a median not exceeding 0.20 were classified as weaknesses. An analysis of the table shows that the number of strengths surpasses the number of weaknesses.

Table 11. Strengths and weaknesses of the clusters studied (median values in brackets)

Strengths of clusters	Weaknesses of clusters
Digitalisation of the cluster (0.78)	Development of cooperation in the cluster (0.15)
Managerial processes (0.65)	Infrastructural resources (0.14)
Influence on shaping external conditions (0.42)	Financial resources (0.11)
Impact on the natural environment (0.38)	Development of innovation in the cluster (0.11)
Collaboration in the cluster (0.35)	
Innovation activity (0.34)	
Development of competences in the cluster (0.30)	

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Aspects related to digitalisation, management processes, and the ability to influence the external environment – as well as internal communication and innovation activities – received particularly high scores. This may indicate a growing awareness among clusters of the need for modernisation and adaptation to emerging trends. The weaknesses, by contrast, stem from resource constraints – both infrastructural and financial – along with insufficient development of collaboration and innovation, which form the foundation of cluster functioning. The results suggest that further strengthening of clusters should focus on removing resource barriers and deepening cooperation among members, which could enhance their innovation capacity and competitiveness.

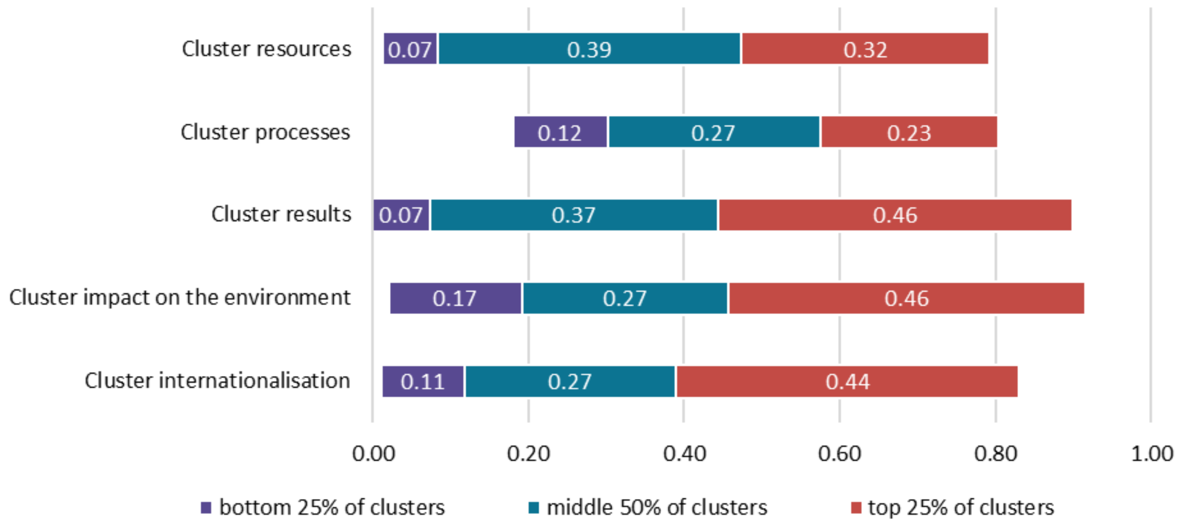
A comparison of the results from the two benchmarking editions (the current and 2022 editions) reveals that the profile of strengths and weaknesses of clusters in Poland has partly shifted. The same fundamental weaknesses persisted across both editions: financial resources (median decrease from 0.13 to 0.11), infrastructure resources (unchanged at 0.14), and a low level of innovation development (decrease from 0.13 to 0.11). This indicates that resource barriers and difficulties in systematically fostering innovation remain longstanding challenges. The differences mainly concern the areas of strength. In the 2022 edition, the highest-rated areas were digitalisation (0.71), management processes (0.68), and external impact (0.44), while in the current edition these values changed to 0.78, 0.65, and 0.42 respectively. However, the position of some elements has shifted: market activity, marketing activity, and internationalisation potential (all with a median of approximately 0.33 in the 2022 edition) no longer feature among the strengths, having been replaced by competence development (0.30) and innovation activity (0.34). This indicates a transition from a market- and promotion-focused approach towards internal organisational growth and innovation, although resource constraints and difficulties in developing joint innovations still remain unaddressed. Overall, the findings suggest a gradual process of cluster maturation – strengthening internal cooperation and digitalisation – yet there is still insufficient translation of these strengths into market and financial results.

An analysis of strengths and weaknesses across sectoral groups reveals that the distribution of results is uneven and heavily reliant on sectoral features. The lowest outcomes were observed in clusters from the education, consultancy, food, and tourism sectors, where limited financial and infrastructure resources lead to fewer innovations and lower levels of internationalisation. ICT clusters, by contrast, are characterised by strong digitalisation and management processes but still encounter difficulties in converting technological potential into tangible innovation deployments. In biotechnology and medical clusters, substantial R&D implementation capacity is evident, yet there is a shortage of capable leaders who can establish national benchmarks. Automotive, aviation, and transport clusters are notable for high levels of product innovation and internationalisation. Metal industry clusters, along with those in the chemical industry and circular economy, most effectively balance resources, processes, and external impact – the former through strong institutional embeddedness and social initiatives, the latter due to high budgets, numerous projects, and technology audits. Consequently, for some sectors, the "strengths" listed in the table arise from developed cooperation and scale of operation, whereas for others – particularly smaller clusters – weaknesses mainly derive from resource limitations and the lack of mechanisms to support innovation.

Further conclusions stem from the analysis of the distribution of synthetic indicator values across clusters (lower 25%, middle 50%, and upper 25%). The analysis revealed that the greatest variation between clusters occurred among the top performers (a range from 0.23 to 0.46). This indicates that weaker clusters should avoid comparing their position to the benchmark values of the highest-performing clusters and should instead refer to average values, medians (as shown in the statistical annex), or boundary ranges for clusters with typical performance levels.

Compared to the previous edition, disparities have increased in areas such as cluster resources (with the range for the middle 50% rising from 0.32 to 0.41) and cluster results (with the range increasing from 0.27 to 0.37 for the middle 50%). Conversely, a reduction was noted in the external impact area (from 0.37 to 0.27 for the middle 50%).

Figure 48. Range of synthetic indicators at the level of benchmarking areas for cluster groups



Source: own elaboration based on the cluster coordinators' survey (N = 42).

The chart also reveals that in areas such as cluster results, cluster resources, and internationalisation, some clusters showed virtually no activity or achievements – a situation similar to that in the previous edition of the study.

10. Recommendations

The primary sources used to develop the recommendations include:

- The results of the benchmarking study, including an analysis of the strengths and weaknesses of the clusters. The weaknesses inspired the development of recommendations aimed at enhancing performance in specific areas.
- Qualitative insights were developed based on interviews and conversations with representatives of the analysed clusters. During the project, it was common for cluster representatives to provide valuable additional information about the condition of their own cluster or other clusters in Poland, along with suggested solutions. The data collected from interviews with cluster coordinators was verified by the research team and supplemented with findings from desk research analysis.
- A comprehensive review of best practices from both domestic and international clusters, conducted using all available sources, which served as inspiration for implementing proven and effective solutions in other cluster structures.
- The results of the cluster member survey, particularly in sections addressing the weaknesses of cluster activities.

Some of the recommendations in this report introduce entirely new proposals, driven by current trends and development directions seen in cluster policies and economic strategies worldwide. Others address long-standing issues and objectives that, despite the passage of time, remain relevant for both cluster coordinators and the public institutions responsible for shaping cluster policy in Poland. In such cases, the recommendations have been revised and tailored to the current context, incorporating the latest insights from the benchmarking study.

The recommendations are aimed at a broad range of stakeholders – including public institutions (the European Commission, ministries, executive agencies, regional and local governments) and private sector organisations (clusters, business support organisations, enterprises). Their goal is to support the ongoing development of the Polish cluster ecosystem and to better align it with the challenges from the green and digital transition, the European Union's competitiveness agenda, and national development priorities.

At the same time, the recommendations offer practical guidance for the cluster community on potential directions for professionalising operations, enhancing the skills of cluster coordinators, and broadening the range of services provided – both for SMEs and for local government units and other stakeholders in the innovation ecosystem.

10.1. Cluster policy and financing

Regular review and update of cluster policy in light of new conditions (including EU funding)

Minister responsible for economy and finance

Recommendation

Since the publication of the policy document outlining the directions of cluster policy in Poland in 2020, the socio-economic environment has changed considerably (COVID-19 pandemic, war in Ukraine, energy crisis). It is therefore essential to update the assumptions of the cluster policy, considering new geopolitical and energy realities, as well as the priorities of the green and digital transition in line with the European Green Deal.

Experts suggest the policy should be reviewed regularly (for example, every two years, ideally using the cluster benchmarking exercise conducted by PARP as the main verification tool) and aligned with current EU strategies (including the Net-Zero Industry Act, AI Act, and the International Digital Strategy for the European Union), as well as national strategic documents (such as the National Development Concept 2050, the National Recovery Plan, the Productivity Strategy 2030, and operational programmes supporting enterprises).

The review should ensure coherence of funding sources for clusters within the 2021–2027 perspective and beyond, including national and regional funds as well as EU programmes. It should also integrate clusters and related ecosystem actors into the opinions and recommendations prepared for the ongoing 2028–2034 programming period.

It is advisable to establish a permanent stakeholder group comprising ministries, regional authorities, clusters, business support organisations, and scientific institutions. This group should act as an advisory and consultative forum, collaboratively shaping cluster policy. It should also supervise the implementation of the policy and initiate adjustments in response to emerging challenges (e.g. new AI regulations, supply-chain disruptions, energy crises) and opportunities (e.g. European Green Deal programmes, Horizon Europe).

Involving clusters in the implementation of public tasks

Responsible entity

Involving Clusters in the Implementation of Public Tasks

Recommendation

Regional governments often encounter challenges in effectively integrating clusters into public policy implementation. Therefore, it is advisable to take a series of actions that support regional authorities in engaging clusters as partners in regional development. These actions include:

- **Legal analysis** – a review of EU, national, and regional regulations, as well as strategic and programme documents of EU funds, to identify opportunities for cooperation with clusters in the implementation of public tasks.
- **Guidance for regional authorities** – preparation or update of a practical handbook on implementing public policy instruments with the involvement of clusters (including instruments financed under EU funds).
- **Good practices** – dissemination of effective and efficient examples of clusters contributing to public tasks (e.g. clusters supporting EU missions in areas such as energy transition, climate neutrality of cities, or circular economy development).
- **Communication and information** – creation of a single, reliable information platform containing available instruments, initiatives, and needs of regional authorities related to cooperation with clusters. The platform, maintained in collaboration with cluster organisations (e.g. the **Polish Clusters Association**), would enhance information flow and facilitate matchmaking between clusters and public administration.

These measures will enhance the participation of clusters in executing regional development strategies and public missions, and assist regional authorities in reaching policy goals (e.g. climate, innovation) by better leveraging the potential that clusters offer.

Engaging clusters in sector development strategies and foresight processes

Responsible entity

Minister responsible for economy and finance, Ministry of Development Funds and Regional Policy, PARP, cluster coordinators, sectoral bodies

Recommendation

Clusters possess a distinctive pool of sectoral and technological knowledge that is often underused in developing economic strategies and foresight analyses. Currently, their involvement in consultations on sectoral or regional strategies is limited. Increasing their participation in the formulation of strategic documents (e.g. sector strategies, updates of regional smart specialisations) and foresight processes (e.g. developing sector-specific technology roadmaps) is highly recommended.

Such engagement provides mutual benefits: public administration gains insights from experts and market data, while clusters have the opportunity to influence policy directions aligned with their industry needs. Consequently, representatives of clusters should be invited to working groups and consultations at both national and regional levels. Furthermore, workshops, expert panels, and foresight exercises involving clusters should be employed to better identify emerging trends, such as the application of artificial intelligence in specific sectors or new models of a zero-emission economy.

Examples of good practice include involving clusters in defining new smart specialisations, such as selecting “Automotive” as a smart specialisation in Podkarpackie at the initiative of an industry cluster. Consequently, sector development strategies and programmes will better reflect market realities and the challenges faced by enterprises, including digitalisation, Industry 5.0, Manufacturing-X, and decarbonisation.

Standardising reporting and monitoring frameworks for clusters

Responsible entity

Minister responsible for economy and finance, PARP, Polish Clusters Association

Recommendation

For many years, cluster coordinators have reported significant administrative burdens arising from diverse reporting and monitoring requirements (e.g. National Key Clusters competitions, monitoring of NKC status, national cluster benchmarking, EUCLES certification).

The lack of unified standards leads to the duplication of similar data submissions across multiple systems formats[103]. It is recommended to harmonise indicators and reporting requirements across various cluster-related programmes. Efforts should focus on developing a shared reporting tool for collecting a core set of indicators (e.g. number of members, revenues, projects, innovations), with standardised definitions and reporting periods. In particular, national competition requirements should be aligned more closely with European standards (EUCLES), so that data collected for cluster assessments can be used once and applied across multiple processes. Standardising reporting procedures will reduce administrative burdens for cluster coordinators and enhance data comparability, thereby improving the monitoring of cluster policy outcomes and the identification of support needs.

European benchmarking and international reference points for Polish clusters

Responsible entity

PARP

Recommendation

Previous editions of the Polish cluster benchmarking exercise show that National Key Clusters score significantly higher than smaller clusters. To ensure that leading clusters continue to receive meaningful development incentives, it is recommended to introduce **a European perspective** into the assessment process – by comparing Polish clusters with top-performing clusters across the EU.

This can be achieved through collaboration with EUCLES[104] to gather aggregated benchmarking data on leading European clusters (e.g. those holding gold or silver labels). Such comparisons could be coordinated by PARP in partnership with the organisation responsible for the certification and labelling process, with significant support and approval from the European Commission.

An alternative approach would involve utilising data available on the ECCP platform, which hosts the European Cluster Map, to compare the performance of Polish clusters with those from other countries registered on the platform. Currently, due to the absence of a real-time update system for the ECCP Map, this option is not feasible. Nonetheless, such an initiative could encourage broader professionalisation efforts across clusters, including systematic data

[103] PARP was able, within the benchmarking study, to partially incorporate the requirements of other institutions and to align a number of indicators with them.

[104] Given the non-public and commercial nature of the organisation, the possibility and scope of data sharing, as well as the conditions of cooperation, would need to be subject to prior agreement.

collection and verification, the adoption of modern management models, and the development of evidence-based public policies at regional, national, and EU levels.

For Poland, adopting an international benchmarking approach would provide context for evaluating the performance of National Key Clusters against European leaders, identify **development gaps**, and showcase potential European frontrunners emerging from Poland. Internationalising the benchmarking process would boost its prestige and increase cluster interest in participation, while offering national authorities valuable insights into how Polish clusters compare with advanced innovation hubs in the EU. In the long term, this could support the development of more effective policy instruments aligned with the standards of top performers (e.g. in management, internationalisation, or digitalisation). The European Commission could also benefit from such insights at EU level while supporting the development of cluster policies across Member States.

Integration of long-term national development directions (e.g. KRK 2050) into cluster strategy

Responsible entity

Cluster coordinators

Recommendation

It is advisable that cluster development planning considers long-term national strategic documents such as the Concept of National Development 2050 (KRK 2050, endorsed by the government in July 2025, along with its annex on development trends towards 2050) and trend analyses towards 2050, to ensure alignment between cluster activities, anticipated megatrends, and the country's strategic priorities.

Polish high-level strategic documents emphasise several socio-economic and technological megatrends that will influence Poland in the coming decades. These include, among others: the ongoing digitalisation of all sectors of the economy, the increasing importance of biotechnology and life sciences, population ageing, heightened cybersecurity requirements, growing pressure for sustainable development amid climate change and environmental degradation, as well as potential geopolitical shifts (e.g. risks to supply chain stability). Clusters aiming to remain strategically prepared and resilient should incorporate these trends and national policy assumptions into their strategies.

Practical implications for clusters, regardless of sector, may include the following:

- **Focus on health, quality of life, and personalisation.** In response to demographic ageing and increasing health awareness (highlighted in KRK 2050), sectors such as healthcare, food, recreation, or ICT should consider projects related to healthy ageing (e.g. assistive technologies for seniors, nutrition tailored for older adults), as well as personalised products and services (e.g. personalised diets based on microbiome analysis, customised medical devices, or made-to-order industrial solutions). This supports a human-centred approach that aims to improve citizens' quality of life.

- **Acceleration of digitalisation in R&D and production.** Digital transformation is everywhere. Clusters in industry, agriculture, and services all need to digitalise their processes. They should invest in internal digital infrastructure, such as shared databases and collaboration platforms, and encourage their members to adopt digital tools like data analytics, automation, IoT, and AI. KRK 2050 and related trend analyses highlight areas such as omics analytics, artificial intelligence, and cybersecurity, which may become priorities for clusters. For example, agricultural clusters might use big data platforms for crop monitoring; logistics clusters could develop AI-driven route optimisation systems; and medical clusters might create shared data repositories for research into civilisation diseases. Early-stage clusters can make small improvements like digitalising member databases or using basic IoT tools, while more advanced clusters should implement complex digital demonstration projects of national importance.
- **Strengthening supply chain and raw material resilience.** The pandemic, geopolitical tensions, and climate events have shown the fragility of global supply chains. KRK 2050 considers scenarios where such chains might be disrupted. As a network of local actors, clusters can take early actions to boost member resilience. Examples include shortening or localising supply chains, identifying local suppliers, or organising joint procurement at regional level. Traceability (using IoT or blockchain technologies) may become standard; the cluster can facilitate its adoption. Clusters should also promote business continuity planning among members. A dedicated working group on supply chain risk management could support knowledge sharing and preparedness.
- **Developing sustainable sources of raw materials and new production methods.** Environmental and technological trends highlight the need for transformation in agriculture and food production – although similar changes are relevant across various sectors. Agro-food and biotechnology clusters can help develop alternative protein sources (plant-based, microbial, and cell-based foods) in response to health trends and sustainability pressures. Precision agriculture (drones, soil sensors, autonomous machinery) is also an emerging trend; agro-tech clusters can support pilot projects. In industrial sectors, comparable developments relate to 3D printing, advanced materials, and automation. Clusters should actively monitor technological trends and introduce innovations before they become mandatory.
- **Circularity and environmental efficiency.** National strategies towards 2050 emphasise shifting to a circular economy and improving resource efficiency. Examples include tracking and lowering water and energy use per unit of output, implementing water

retention and recycling systems in production, or upcycling by-products (e.g. fruit pomace for supplements or cosmetics, wood waste for biocomposites). Regenerative agriculture and smart water management – highlighted in the 2050 trends document – underline the need for clusters to encourage members to adopt greener practices. Coordinators may support this through ESG training, good practice checklists, or internal eco-innovation competitions.

Incorporating long-term strategic assumptions, such as KRK 2050, into cluster strategies enhances their long-term coherence with public policies and boosts their credibility among national and regional authorities. This can improve access to support instruments that align with national development goals. Importantly, clusters will ready their members for upcoming demographic, climate, and digital challenges, allowing them to adapt sooner and gain a competitive advantage over non-clustered entities.

Aligning cluster activities with priority European Union strategies

Responsible entity

Cluster coordinators

Recommendation

EU-level policies and strategies establish the framework within which clusters should position themselves – both in terms of development priorities and access to financial support. Clusters operating in isolation from the main strategic directions of the European Union risk missing opportunities for funding and for building a competitive advantage. In this context, key EU strategic documents should serve as guiding references for cluster development across different sectors. For example:

- **Upcoming EU legislative proposals**, such as the *European Research Area Act* (ERA Act) and the *European Innovation Act*, should be regarded as important frameworks that clusters can proactively incorporate into their development strategies.
  Consultations on the ERA Act anticipate, among other things, the harmonisation of R&D investments, improved coordination of national and EU-level policies, and the facilitation of knowledge flows and researcher mobility across Member States.
  The European Innovation Act aims to simplify regulatory frameworks, enhance access to finance and research infrastructure, and strengthen support mechanisms for testing new technologies, innovation activities, and scaling ventures at the European level.
  For clusters, this means predicting and integrating these shifts into their action plans – for instance, by strengthening their capacity to participate in European funding mechanisms, aligning internal processes with upcoming regulatory standards, and developing cross-border partnerships that may benefit from a more integrated

European innovation landscape. This approach will help clusters respond more effectively to evolving conditions, increase their attractiveness to investors, and position them within European research and innovation structures.

- **For clusters operating in food, bioeconomy, and health-related sectors**, it is crucial to adhere to the principles of the "*From Farm to Fork*" Strategy, which supports sustainable and safe food systems, organic farming, food waste reduction, and innovation in agri-food production. Simultaneously, the EU Bioeconomy Strategy highlights the effective utilisation of biological resources and the circular economy. Clusters active in these fields should steer their projects towards topics aligned with these policies – for instance, alternative protein sources (plant-based, microbial, fermentation-based), biotechnologies for healthy food products, or technologies that minimise waste and emissions across the agri-food value chains.
- **In high-tech sectors (ICT, electronics, photonics, industrial technologies)**, clusters should consider key European initiatives related to Key Enabling Technologies (KETs), as well as digitalisation and the green transition (European Digital Strategy, European Green Deal). Clusters in areas such as Industry 4.0, Smart City, or renewable energy should align their activities with the goals of digital transformation and climate neutrality, which will enable them to access dedicated support programmes.
- **Monitoring EU framework programmes**, such as Horizon Europe, is also essential. Within Horizon Europe, thematic clusters (also known as "*Clusters*") represent EU policy priorities – for example: *Cluster 6* – food, bioeconomy, natural resources, agriculture; *Cluster 5* – climate and energy; and *Cluster 4* – digitalisation and industry. Participation in these programmes – whether as a partner or a coordinator – not only provides funding but also helps develop skills among cluster members and promotes internationalisation.

Strategic management and transforming strategy into action

Responsible entity

Cluster coordinators

Recommendation

According to the benchmarking results, not all clusters have a development strategy. Moreover, existing strategies are often outdated, and their development processes were not inclusive (i.e., they did not actively involve cluster members). In addition, merely possessing a strategy is insufficient; what matters is translating it into concrete operational plans for the cluster. It is recommended that clusters – particularly those with limited human resources – focus on a small number of clearly defined thematic priorities that align both with EU and national policies and with the competencies of their members.

For example, a cluster working at the crossroads of biotechnology and food could choose 2–3 priority areas such as:

- **Healthy and safe functional foods and alternative protein sources** – e.g. research and development on health-promoting foods, using fermentation to create new food products, and developing plant-based proteins as meat substitutes (aligned with the objectives of the "From Farm to Fork" strategy and EU climate policy).
- **Solutions for health and an ageing society** – e.g. personalised nutraceuticals based on patient profiles, technologies supporting care for older adults, digital tools for telehealth and dietetics (aligned with EU priorities in life sciences and the silver economy).
- **Circular economy and resource efficiency** – e.g. technologies that reduce water and energy consumption in production processes, systems for monitoring and reducing waste (IoT for supply chain tracking and product traceability), upcycling by-products into high-value materials – aligned with the aims of the European Green Deal and trends identified in the national Koncepcja Rozwoju Kraju 2050.

Every cluster – regardless of sector – can identify its own priority niches in a similar manner. It is crucial that the cluster then consistently undertakes thematic projects in these areas, forming consortia that include members (companies, universities, research institutions) as well as external partners (including international ones). A good practice is to run pilot projects in real environments (e.g. for a medical cluster – pilots in hospitals or clinics; for an education cluster – pilots in schools; for an industrial cluster – in a member factory or at a local client's site). These pilots enable rapid testing and refinement of solutions, and the resulting case studies greatly support subsequent dissemination, promotion, and commercialisation on a larger scale.

Effective management of projects with limited resources

Responsible entity

Cluster coordinators

Recommendation

Most clusters in Poland operate with very limited human resources, often only 2–3 staff members, which raises concerns about whether several ambitious initiatives can be managed simultaneously. It is advisable to adopt a "smart management" model for cluster projects:

- **Prepare ready-to-use document templates for typical initiatives** (e.g. a short project concept template including a preliminary timeline, budget outline and list of potential partners). This enables cluster staff to quickly transform new ideas into project drafts ready for discussion with partners or submission to funding calls.
- **Maintain a calendar of funding calls and opportunities** (both national and EU-level), to enable advance planning for which ideas and consortia should prepare for specific

programmes. For example, being aware of an annual Horizon Europe call in a particular thematic area allows the cluster to mobilise partners several months in advance.

- **Assign the formal coordination of large projects to partners with greater administrative capacity.** If a consortium includes a university or a large enterprise, that organisation can assume the role of project leader (financial management, reporting, administration), while the cluster concentrates on its strengths – initiating the project, integrating partners and providing expert leadership on piloting and user engagement. For international projects, it may be advantageous to appoint the coordinator role to an experienced foreign partner – reducing administrative workload while the cluster still gains expertise and strategic value.
- **Seek external expertise for highly specialised topics beyond the capabilities of the core staff within the cluster.** For example, if the project involves innovative food requiring "novel food" procedures or medical certification under the MDR/IVDR, the cluster can utilise expertise from its members, establish framework agreements with specialised consultants, or collaborate with other clusters. Similarly, for international activities, networks such as EIT Food or the Enterprise Europe Network can assist in partner searches and offer insights on regulatory and market requirements.
- **Join European networks.** To strengthen its position and access up-to-date knowledge, the cluster should consider membership in selected European platforms or associations aligned with its sector. For example, the ECCP platform offers a range of resources (including open-access tools) and disseminates information on partnerships and key events. Through such networks, coordinators and members can access European trends and easily connect with potential partners. It should be noted, however, that the minimum requirement for effective engagement in these activities is having an English-language cluster website (as a basic showcase) and staff capable of working in English.
- **Promote member competencies externally.** Develop concise "competence sheets" for each member (e.g. a one-page profile with key technologies, readiness for pilots, target markets). Such a cluster portfolio can be used in meetings with international partners or at networking events, increasing opportunities to match partners to projects.
- **Measure progress.** Establish simple key performance indicators (KPIs) over a 12–18 month period to evaluate the effectiveness of the new approach. Examples include: number of initiated project consortia (including international ones), number of engaged companies, changes in employment, turnover, and export volume/value among members, number of completed pilots, amount of external funding secured (grants, subsidies), number of first deployments at customer sites achieved through cluster projects, and reduced time from idea to pilot. A clear set of KPIS allows for ongoing adjustments and demonstrates tangible value to members and stakeholders.

By aligning activities with EU priorities and effectively utilising available instruments, the cluster becomes more innovative and competitive. Members benefit through access to new projects (including those with external funding), opportunities to develop products using cutting-edge European practices, and increased participation in international consortia. The cluster, in turn, strengthens its reputation as a modern organisation aligned with megatrends (digitalisation, green economy, healthy society), boosting its standing in Poland – for instance, in the eyes of government institutions or in future competitions for obtaining or renewing KKK status. In short, translating EU-level goals into tangible local actions positions the cluster as a catalyst for their realisation, to the benefit of its members and the broader ecosystem.

10.2. Cluster development

Further quantitative and qualitative development of clusters

Responsible entity

Cluster coordinators, Minister responsible for economy and finance (in the scope of criteria for National Key Clusters – Krajowe Klastry Kluczowe)

Recommendation

Trend analyses show the increasing significance of large, mature groups – the total number of member companies and employment within groups continues to grow. Many Polish groups may consider expanding their activities through:

- **Geographical expansion** – attracting members from beyond the home region to become supra-regional. This is especially relevant for voivodeships with limited cluster presence (e.g. Opolskie, Warmińsko-Mazurskie) or regions lacking clusters of a similar profile. Supra-regional activity enhances the cluster's potential but may require greater flexibility in KKK criteria.
- **Sectoral diversification** – broadening the value chain covered by the cluster. An example could be the Canadian "supercluster" model, which integrates different industry sectors around wider challenges. A cluster may gradually include entities from related sectors if it allows for more comprehensive service offerings (e.g. a furniture cluster expanding to include smart-home / IoT producers to meet the growing smart-living trend). Some related conclusions are discussed in Chapter 7 on inter-cluster collaboration.
- **Collaborating with other clusters** – where there is thematic alignment, clusters may consider forming a consortium or formal association to gain scale effects and enhance sector representation (e.g. merging smaller biotechnology clusters).

The Ministry should also revise the geographical concentration criterion used in KKK assessments. Removing or modifying this requirement is advisable to prevent discouraging the formation of national-level cluster structures. As a result, Polish clusters will be better positioned to compete with Europe's largest cluster organisations and contribute to more balanced development across the country.

Expanding and strengthening cluster management teams

Responsible entity

Cluster coordinators, PARP

Recommendation

The strong assets of many clusters – such as well-developed infrastructure, active participation in R&D projects, high technological specialisation, and growing membership – provide a solid foundation for collaboration and competitiveness at both national and international levels. However, the key factor that transforms this potential into real results is the capacity and competence of the cluster management team. In practice, this means:

- **Ensuring adequate staffing aligned with the cluster's activity level.** If staffing levels have decreased in recent years, efforts should be made to restore or increase the number of positions to support effective management of the expanding range of initiatives and projects. This is especially important for rapidly growing clusters and larger structures (including KKK clusters), where the task portfolio is broadest. Smaller and newer clusters should also establish a minimal yet competent operational team early on to avoid future bottlenecks.
- **Investing in the development of coordinator competencies.** This includes training in modern cluster project management as well as specialised areas relevant to current challenges (e.g. digitalisation, green transition, internationalisation). Well-prepared staff will be better equipped to initiate innovative activities and respond to members' needs. For mature clusters (e.g. those holding KKK status), strengthening team competences can generate a multiplier effect – resulting in more advanced services for members and stronger external representation.

Enhancing human resources will improve the coordination of internal activities and boost the cluster's capacity to develop innovative services and projects. Better management will also more effectively address weaknesses identified in analyses (e.g. limited activity in certain areas or low monitoring capacity). In the long term, building a strong team will increase the resilience and competitiveness of the entire cluster structure. PARP can play a significant role in supporting the professionalisation and development of cluster management teams, both through systemic measures and dedicated programmes. The Agency already offers training and capacity-building activities for managers, covering strategic management, fundraising, international partnerships, and the implementation of pro-innovation services, which clusters can access via tools such as the Development Services Database (*Baza Usług Rozwojowych*) or the PARP Academy (*Akademia PARP*). New cluster animators and local governments planning to establish clusters can also benefit from the Guide for Cluster Initiative Animators in Poland.

An additional development mechanism could involve providing mentoring and advisory programmes where experienced experts (e.g. from KKK clusters) support other teams in overall development and in addressing specific challenges.

Development of the cluster service offering and the creation of a service portfolio

Responsible entity

Cluster coordinators, universities and research institutes, business support organisations

Recommendation

A strong cluster is defined not only by its number of members but primarily by the value it offers. Coordinators should actively develop the cluster's services and professionalise its delivery. Research shows that cluster members expect a wide range of services: promotion and marketing support, internationalisation help, specialised training, and facilitation of networking inside and outside the cluster. Many members also state they are willing to pay extra fees for services that genuinely help their growth.

Therefore, it is advisable to develop a service portfolio customised to members' needs and the cluster's business model. The coordinator can offer services directly (if the team possesses the right skills) or serve as a intermediary connecting members with external providers (e.g. experts, R&D units). Key areas for extending the offer include:

- **Pro-innovation services** – advisory and project support in green transformation, digital transformation, and the implementation of Industry 4.0/5.0 technologies (more than half of surveyed cluster firms have not yet used such services but show interest);
- **Internationalisation services** – assistance in forming collaborations with overseas partners, organising missions and trade fair visits, and starting international projects (over 85% of firms express demand for these activities);
- **Training services** – including general courses (e.g. project management) and highly specialised technical programmes, provided in collaboration with universities or training providers.

Coordinators should also enhance partnerships with universities and business support organisations – for example, by collaboratively establishing competence centres or acceleration programmes that broaden the cluster's offerings beyond its internal resources. A good practice is developing joint products or services by groups of members (e.g. solution packages provided to external clients under the cluster's brand).

Enhancing the service offering and boosting its professionalism will make cluster membership more attractive and enable the cluster to diversify revenue sources such as service fees, success fees, and commissions. This, in turn, will reinforce the cluster's financial independence and its capacity to offer meaningful support to member firms.

Participatory development of cluster strategies

Responsible entity

Cluster coordinators, cluster members

Recommendation

An effective cluster development strategy requires member engagement from the planning stage. Yet almost half of Polish cluster members report that they did not participate in preparing their cluster's strategic documents. It is advisable to adopt a more participatory approach to developing cluster strategies and operational plans. Coordinators should ensure various forms of consultation and co-creation: sharing draft strategies internally with options for online comments; organising regular strategic workshops (e.g. annually) with member companies; establishing thematic working groups responsible for proposing specific initiatives. It is also crucial to involve members in operational planning, such as through joint development of annual action plans, where individual firms or institutions commit their contributions to selected activities.

Such a co-creation model boosts members' identification with the chosen strategy and their willingness to implement it. Furthermore, members contribute practical market insights, allowing for more accurate targeting of cluster goals. It is also recommended to involve members in monitoring the progress of implementation, for instance by preparing an annual report summarising achievements and key performance indicators and submitting it for member consultation.

Involving the broadest range of cluster stakeholders in the planning process guarantees that strategic documents are practical, widely endorsed by the cluster community, and flexible to evolving external conditions.

10.3. Cluster finances

Proactive pursuit and securing of new funding sources (internal and external)

Responsible entity

Cluster coordinators, business support organisations

Recommendation

Ensuring stable financing is crucial for sustaining a high level of cluster activity. Coordinators should focus on two actions: diversifying internal revenue streams and maximising the use of external funding opportunities.

In the area of internal financing, clusters should further expand their range of paid services offered to members and external entities (see the recommendation on developing the cluster service offer) – each service represents a potential source of revenue. It is also worth considering business activities carried out directly by the cluster (e.g. provision of advisory services, delivery of fee-based open training) or the commercialisation of intellectual property developed collaboratively with members. Some members may be willing to accept higher membership fees if this is accompanied by a clear, valuable service offering.

In parallel, clusters should proactively seek external funding. Priority should be given to available EU funds for 2021–2027 at both national level (e.g. FENG programmes, Horizon Europe research and innovation consortia involving clusters, Digital Europe funding for EDIHs, Erasmus+ partnerships for education and skills development) and regional level (RDPs/RPOs – support for innovation, digitalisation, collaboration, and in some regions dedicated funding instruments for clusters).

Coordinators should also expand the membership base to include entities capable of providing financing or financial services – such as investment funds, banks, or leasing companies. These partners may offer preferential financial conditions to cluster members (e.g. development loans, leasing of machinery for firms implementing innovations).

Additionally, clusters should monitor emerging support instruments such as blended finance mechanisms combining grants with loans, international cooperation programmes (e.g. Interreg), or EU mission-oriented funds (e.g. climate-neutrality missions relevant for energy clusters). Proactive monitoring and applications for these instruments will enhance the financial resilience of clusters, making them less dependent on a single funding source and more resilient to economic fluctuations.

Coordinators should consider establishing a dedicated funding information unit or team within the cluster structure, responsible for systematically identifying funding opportunities and supporting members in applying for grants and financial instruments. This approach will not only secure the cluster's own operational resources but also position the cluster as a channel through which funding flows to its members – greatly increasing its value for current and potential participants.

10.4. Collaboration and knowledge exchange

Creating a platform for the exchange of best practices in clusters

Responsible entity

Cluster coordinators, PARP, Polish Clusters Association

Recommendation

Clusters are eager to share their solutions and experiences, but a permanent mechanism for dissemination is currently absent. Recent editions of the benchmarking exercise have collected numerous examples of best practices, yet only a small portion can be published in reports. Therefore, it is recommended to create a dedicated online platform serving as an open repository of cluster best practices or to integrate this functionality into the planned Cluster Map 2.0, which is set to launch in 2026.

Coordinators could continuously upload descriptions of successful initiatives from their clusters – ranging from R&D projects and effective business collaboration models to actions benefiting local communities (e.g. support during crises). The platform should enable users to search by sector, thematic area (e.g. digitalisation, internationalisation, green transition), and type of activity.

PARP, in collaboration with other stakeholders, could verify submissions and highlight the most valuable examples, such as those gathered during benchmarking (possibly within the upcoming Cluster Map). Such a repository would support knowledge sharing: less experienced clusters would gain rapid access to proven solutions, which is especially crucial during times of swift environmental change (e.g. responses to COVID-19 or the energy crisis). The overall outcome would be an improvement in the professionalism of the Polish cluster ecosystem.

Another option could be organising a competition for the best cluster practices, with voting conducted separately by clusters and external stakeholders.

Enhancing internal communication and activity monitoring (minimising information discrepancies)

Responsible entity

Cluster coordinators, cluster members

Recommendation

It is advised to enhance internal information sharing and the system for monitoring initiatives within the cluster, ensuring that the coordinator has a complete view of members' activities and accomplishments. This will minimise discrepancies between data reported by coordinators and information provided by members, and will facilitate more effective strategic management.

In many clusters – especially large and geographically spread ones – information asymmetry is clear: members' activities and achievements are not always shared with the coordinator's office. This can lead to situations where, during surveys or benchmarking (e.g. by PARP), the coordinator reports a lack of data or activity in a particular area, while members highlight specific accomplishments. The discrepancy often stems from poor internal communication or a lack of tools for systematically gathering data. Sometimes, it is also due to informal collaboration between members that the coordinator is unaware of. This issue is particularly relevant for mature clusters with many members and projects. Early-stage clusters can see it as a warning – establishing clear communication mechanisms from the outset pays dividends later.

Suggested actions are as follows:

- **Establishing regular internal reporting.** A straightforward system of quarterly or semi-annual reports submitted by members (e.g. via an online form) can be introduced, covering key information on current projects, achievements, needs, and barriers. Coordinators should collate and analyse these data to keep an up-to-date overview. A brief, standardised questionnaire will minimise member burden and improve data completeness.
- **Developing a standardised internal reporting tool.** A template for internal reporting – such as an online form or a module within a CRM – should be created and shared with members. It should include key fields related to projects, achievements, barriers, and collaboration. This will aid in collecting comparable data, lessen member workload, and allow coordinators to gather and analyse information efficiently.
- **Active monitoring and documentation of collaboration.** Cluster staff (as resources permit – see earlier recommendations) should actively observe and record initiatives undertaken within the cluster. This includes participating in selected meetings or projects, maintaining a register of joint projects carried out by members, and documenting outcomes (e.g. developed technologies, organised events, contracts

secured through cluster involvement). Such a register can be kept in a simple format (spreadsheet, CRM). The main requirement is regular updates and ease of access for decision-making.

- **Improving communication channels.** It is advisable to assess whether the current channels (mailings, newsletters, intranet platforms, discussion groups) are effective and widely used. If not, they should be upgraded or replaced. Increasingly, clusters use online collaboration platforms where members can share information independently. Coordinators should actively moderate these tools, encourage participation, and remind members of the benefits of information sharing (e.g. increased visibility of successes, easier partner matching within the cluster).
- **Self-assessment of management processes.** Regular self-evaluation using available tools (e.g. PARP's Cluster Management Standards) can help identify strengths and weaknesses in current coordination and communication practices. The results will highlight areas needing improvement – for example, if internal communication or monitoring scores poorly. KKK clusters often require higher management standards; regular KKK assessments or EUCLES certification assist in maintaining and enhancing these standards. Smaller clusters can utilise these tools to benchmark against best practices and speed up their professionalisation.
- **Utilisation of the upcoming Cluster Map (scheduled for 2026).** Less experienced clusters can use it as a starting point for systematic data collection, management analysis, and comparison with European leaders. Incorporating the map as an official resource and communication channel will enhance the professionalisation of cluster management. As Ketels notes, cluster mapping is essential for strategic decision-making and meaningful comparison across regions.

Enhanced internal communication and information flow will minimise the risk of missing important member achievements – whether in reporting, applying for grants, or seeking KKK accreditation. Coordinators with access to detailed information will be better positioned to spot opportunities and needs – such as recognising when multiple members share a similar idea and connecting them within a project, or identifying gaps in the service portfolio.
For members, improved communication boosts their sense of involvement and visibility within the cluster. Ultimately, consistent and reliable internal data will make participation in funding programmes, benchmarking, and competitions more effective and credible.

Enhancing cooperation between clusters at the national level

Responsible entity

Cluster coordinators, Polish Clusters Association

Recommendation

Poland hosts numerous clusters across various sectors – from ICT and bioeconomy to chemicals, automotive, and health. This diversity remains underutilised. It is advisable to promote wider collaboration between clusters to develop complementary offerings that harness capabilities from different industries.

For example, ICT clusters can assist members of traditional clusters (such as construction, food, and manufacturing) in digital transformation and Industry 4.0 implementation, while clusters focused on sustainability or energy can offer services related to energy efficiency, renewable energy, and waste management to firms in other sectors. Such cross-sectoral collaboration benefits both parties: service-providing clusters attract new clients and references, while recipient firms gain proven solutions that boost their competitiveness.

To encourage this cooperation, it may be helpful to introduce preferential conditions (e.g. discounts) for services exchanged between members of different clusters, motivating firms to utilise offerings from "neighbouring" clusters. Additionally, a dedicated cluster announcement platform could be established, enabling clusters to publish their service or product offerings aimed at other clusters along with contact details.

Over time, this may result in the formation of inter-cluster collaborations that undertake joint projects (e.g. R&D and deployment initiatives) and enhance the position of Polish clusters when bidding for large-scale ventures such as Euroclusters or international partnerships.

It is important to highlight that grassroots initiatives for inter-cluster cooperation are already forming in Poland, demonstrating the willingness of coordinators and members to develop cross-sectoral networks. Examples outlined in Section 7.4 of the report include joint thematic projects and efforts to establish sectoral linkages across regions. However, these experiences suggest that expanding and institutionalising such cooperation requires systemic support – through financial instruments, dedicated platforms, or competitions. Only then can local and regional initiatives grow into robust inter-cluster structures capable of competing and collaborating at the European level.

Developing innovative cooperation models (digital innovation hubs, living labs, thematic networks)

Responsible entity

Cluster coordinators, PARP, Minister responsible for economy and finance, local government units

Recommendation

Given the rapid digitalisation and increasing demand for collaboration among different types of organisations, clusters should proactively develop new cooperation models that extend beyond traditional frameworks.

Digital Innovation Hubs (DIHs) – established, among others, under the EU Digital Europe Programme – serve as centres offering companies access to infrastructure, expertise, and funding for digital transformation. Many Polish clusters already participate in European Digital Innovation Hub (EDIH) consortia or can develop regional hubs together with universities and research institutes[105, 106]. Clusters are encouraged to utilise the opportunities offered by EDIHs (e.g. vouchers for digital services for SMEs) and to develop hub-based partnerships, enabling cluster members to access specialised support in AI, IoT, automation, and related fields.

Living labs – user-centred testing environments – are another promising model where end-users, businesses, and researchers co-create innovations in real-world settings. Clusters can set up sector-specific living labs (e.g. in healthcare, energy, smart cities), involving members in piloting solutions directly with end-users. An example is the Lublin Medicine Cluster, which develops its services as a living lab for the medical sector in collaboration with Nordic Proof network[107]. Creating cluster-based living labs should be supported through grant programmes and by connecting them to mission-oriented initiatives (e.g. Mission on Climate-Neutral Cities).

Additionally, clusters should participate in international thematic networks (such as EIT Knowledge and Innovation Communities) to tackle specific technological or societal challenges. Joining these networks encourages sharing experiences, gaining access to European projects, and building strategic partnerships.

[105] An example of such an initiative is available at: https://www.lubuskiklaster.pl/polskie-konsorcja-w-europejskiej-sieci-hubow-innowacji-cyfrowych [accessed: 08.09.2025].
[106] European Commission. (n.d.). European Digital Innovation Hubs (EDIHs). https://digital-strategy.ec.europa.eu/en/policies/edihs [accessed: 09.09.2025].
[107] For further details, see the General Report. Benchmarking 2020: https://www.parp.gov.pl/publikacje/publication/benchmarking-klastrow-w-polsce-edycja-2020 or the website: https://medycyna.lublin.eu/2022/05/19/klaster-lubelska-medycyna-poszerza-swoja-oferte-jako-living-lab/ [accessed: 08.09.2025].

Overall, implementing innovative cooperation models will position clusters as key nodes within innovation ecosystems – flexible and open to diverse actors (start-ups, NGOs, public administration) and capable of responding swiftly to emerging opportunities and challenges.

10.5. R&D and innovation activity, start-ups

Enhancing intra-cluster innovation collaboration

Responsible entity

Cluster coordinators, cluster members, business support organisations (including financial institutions and higher education and science institutions)

Recommendation

It is recommended to enhance collaboration among cluster members – especially in the areas of joint R&D and innovation projects – through improved integration, communication, and expansion of the pro-innovation services offered within the cluster.

Many clusters have a broad and diverse membership base (enterprises, universities, business support organisations, etc.) and access to various funding sources (e.g. EU funds, venture capital). They possess significant potential to enhance innovation cooperation, which is often underutilised. Regardless of the sector, clusters should strengthen science–business partnerships and more proactively engage all stakeholders in joint initiatives. In mature, well-established clusters, there is a need to introduce new momentum into innovation projects, while for clusters at an early stage, the priority may be to establish the foundations of cooperation and trust among members.

Proposed courses of action (to be tailored to the specific profile of each cluster):

- **Regular communication and member integration.** Introduce cyclical online meetings (e.g. monthly or quarterly) during which individual members present their capabilities, current needs, and project ideas. Additionally, organise 1–2 in-person meetings per year (e.g. workshops or mini-conferences) to promote direct knowledge exchange, relationship-building, and the initiation of further joint initiatives. Such integrative activities are especially valuable in large clusters where members may not know each other personally. In smaller clusters, regular communication from the outset fosters a collaborative culture.
- **Identifying common R&D themes and initiating projects.** The coordinator, supported by the cluster council or scientific committee (where applicable), should conduct a mapping of members' R&D potential (e.g. university laboratories, company R&D departments, research infrastructure). Based on this, areas with the greatest synergy can be identified, and pilot R&D projects launched to address shared sectoral challenges. For example, if the cluster brings together entities from the food and health

sectors, potential projects could include new diagnostic methods, functional foods, or medical technologies. In production-oriented clusters, this may involve the joint development of Industry 4.0 technologies or environmentally friendly production solutions. Even small pilots help integrate partners and may lead to larger projects (e.g. national or European grants).

- **Expanding the range of pro-innovation services.** As an innovation ecosystem, the cluster should support its members in developing and implementing new solutions. It is advisable to broaden the advisory and training offerings to include areas such as technology audits, commercialisation of research results, obtaining patents, and protecting intellectual property. If the cluster includes a business support organisation or a technology transfer unit, their expertise should be fully utilised to provide these services. These activities are relevant across all sectors – innovation may relate to an industrial product, an IT process, or a new business model in services.
- **Joint promotion and brand building.** The combined strength of cluster members can be more visible on the market than individual entities acting alone. It is recommended to intensify promotional activities covering both the cluster brand as a whole and the offerings of individual members. In practice, this means using multi-channel communication tools – from sectoral portals and social media to participation in trade fairs and conferences (discussed in more detail in the section on internationalisation). Good practice includes developing joint promotional materials (e.g. a catalogue of members' products and competences) and organising shared exhibition stands at industry events, thereby reducing costs for individual firms and increasing the visibility of the entire community. This recommendation is particularly relevant for well-established clusters that can promote themselves using the KKK status or other distinctions – but younger clusters can also build their reputation from the ground up through consistent promotion. An important tool for promotion and brand building will also be the previously described Cluster Map.
- **Inter-cluster cooperation.** Establishing strategic partnerships with other clusters – both domestic and foreign – can speed up the transfer of good practices and enable the realisation of larger projects than would be possible individually. It is advised to identify clusters with a similar profile or complementary competences and to build relationships with them (e.g. through joint projects, cooperation agreements, exchange of experience). For example, a medical cluster may benefit from the experience of another mature medical cluster or establish cooperation with an ICT cluster on e-health projects; an automotive cluster may collaborate with a materials cluster on new components, and so on. For young clusters, partnerships with more experienced structures can be a pathway to faster development (learning from the best); for mature clusters, they can

be a means to expand and scale up activities (e.g. inter-cluster consortia in international programmes).

Implementing the above actions should lead to better utilisation of the potential of a large and diverse cluster membership base. The number and quality of joint projects, especially innovation projects, will increase, resulting in more visible successes measured by the number of implemented solutions, patents, or industry awards. Closer cooperation and stronger member integration will enhance the cohesion of the cluster as a whole – members will be more loyal and engaged when they see direct benefits, such as new business contacts, know-how, and market access, stemming from participation. Consequently, the cluster will become more attractive to potential new members and partners.

Acceleration programme featuring an investment (venture) component and a venture studio model

Responsible entity

Cluster coordinators, business support organisations, higher education and science institutions

Recommendation

It is recommended that clusters launch an acceleration programme for start-ups and innovative projects, supported by an investment fund (seed/venture) linked to the cluster, and consider implementing an entrepreneurial studio model (venture studio)[108] to actively develop selected innovations within the cluster.

Young, innovative companies such as start-ups, spin-offs, and spin-outs are widely recognised as catalysts of technological progress and vital elements of the innovation ecosystem. An increasing number of these initiatives are emerging within cluster settings; for example, in the past two years, many clusters have reported the creation of start-ups related to their activities or the launch of incubation projects. However, there is often no formalised platform that connects start-ups with experienced firms, enables testing of prototypes in real-world conditions, and offers seed capital and business support essential for rapid growth.

The European Union has recognised this need – since 2025, a new EU Strategy for Start-ups and Scale-ups (Startup and Scaleup Strategy, European Commission, May 2025) has been in place, emphasising, among other aspects, the role of clusters as environments for testing and scaling innovations. The strategy stresses improved access to finance, regulatory support, talent development, and innovation-friendly public procurement, with a clear indication that clusters can act as catalysts for these processes at regional and national levels. Therefore, it is crucial

[108] Moiana, D., Ghezzi, A., & Rangone, A. (2025). Venture Studios: Beyond Entrepreneurial Support Organisations? A case study analysis and framework. Politecnico di Milano.

that cluster coordinators closely monitor the offers of PARP and other entities within the PFR Group, such as PFR Ventures and the PFR Foundation, which provide financial and substantive support for start-up-oriented activities.

Against this backdrop, clusters – particularly those already possessing a certain financial foundation or access to investors – are encouraged to develop their own acceleration programmes. Their aim would be to accelerate the development of the most promising innovations emerging within the cluster's environment. Key elements of such a programme include:

- **Structure of the accelerator.** The programme could last, for example, 3–6 months for a single cohort of start-ups or projects. Calls for applications would be organised once or twice a year, with clearly defined thematic tracks corresponding to the cluster's profile. For instance, a cluster in the agri-food-bio-medical sector could define tracks such as: functional food and supplements; medical devices and equipment for healthcare; digital health and solutions for older people – each track attracting projects from a specific niche. Industrial clusters could run tracks such as: Industry 4.0 and automation; materials technologies; green innovations, etc. Such a structure enables matching mentors and investors to the specific needs of projects.
- **Offer for participants.** Start-ups and project teams admitted to the accelerator may receive a comprehensive support package, including:
    - Technological and business mentoring – experts (preferably practitioners, including representatives from experienced cluster member companies) advise teams on product development and business model design.
    - Regulatory and legal support – in regulated sectors, adopting the right approach to compliance is essential from the beginning (e.g. MDR certification in medtech, authorisations from the Chief Sanitary Inspectorate and EU for novel food, safety standards in energy). The accelerator should offer consultations with lawyers or regulatory specialists in relevant fields..
    - Workshops on product design and business development – hands-on sessions covering lean start-up approaches, design thinking, IP protection, preparing a pitch deck, etc., complementing the teams' skills..
    - Access to infrastructure and living labs is a vital asset of the cluster. Participants should be able to test their solutions in real-world conditions using members' resources. For example, a medical device prototype can be tested in a partner hospital; a new app for farmers – on the fields of a cluster member; an industrial machine prototype – on a pilot basis in a member's factory. Such pilots (living labs) offer invaluable feedback and serve as initial references.

  - Seed funding – the cluster's investment fund (if existing or established in collaboration with private investors) could offer small investments in exchange for equity or as seed grants. Typically, this would involve amounts from several tens to several hundred thousand PLN per project, enabling teams to progress from idea to prototype or initial sales. The financing terms should be transparent – for example, part of the funds disbursed upfront and the rest upon achieving specific milestones, such as a working prototype, positive test results, or acquiring a key pilot customer.

- **Venture studio component.** In addition to a traditional accelerator (where support mainly involves mentoring and funding, while teams independently develop the business), the cluster may consider adopting a venture studio model. For selected, especially promising projects, the cluster actively enhances the team for a certain period by seconding its own staff or funding additional specialists. For example, if a start-up is established by researchers lacking business experience, the cluster could assign a project manager or a commercialisation expert to support the team during the phase of refining the business model and generating customers. When regulatory expertise is absent, the cluster could provide a dedicated consultant to guide the certification process until approval is secured. The venture studio model improves the chances that projects will successfully navigate the "valleys of death" (critical phases where many start-ups fail due to resource or knowledge shortages), as the cluster becomes a co-creator of the project. This approach requires time and financial investment, so it can be applied selectively, with greater intensity and scale reserved for projects with high potential returns or strategic importance for the ecosystem.
- **Collaboration with external investors and institutions.** Even if the cluster has its own fund, it is beneficial to actively invite other investors (such as business angels and VC funds) and public innovation-financing organisations (for example, seed funds, NCBR) to participate in cluster activities and acceleration programmes. Their involvement as members or strategic partners not only expands access to finance but also provides mentoring capabilities and experience in scaling innovations. Additionally, the presence of corporations or large companies (including those outside the cluster) as corporate partners offers the customer perspective and potential contracts for start-ups, as well as possible corporate venture capital (CVC) investments.

Launching an acceleration programme will establish the cluster as a local hub for start-up and new technology development. Expected outcomes include: an increased number of new companies emerging within the cluster (retaining their presence in the region and creating jobs), faster innovation deployment (measured, for example, by a shorter time from prototype to first sale), stronger links between start-ups and large enterprises (e.g. the number of pilots or implementations of start-up technologies at industrial partners), and an influx of capital (projects securing subsequent funding rounds, including from outside the region, thereby enriching the local ecosystem).

For cluster members – a especially large firms – the programme offers an opportunity for technology scouting and quicker access to innovative solutions, thereby enhancing their competitiveness. For universities, it provides a pathway to commercialise research, such as student spin-offs and research projects converted into businesses. The cluster itself bolsters its role as a platform connecting science, SMEs, and established industry, while the region gains a reputation as a hub friendly to innovation.

Importantly, this model is scalable: in advanced clusters (e.g. KKK), it can develop into a fully-fledged programme with its own fund and multiple thematic tracks, whereas clusters still developing their ecosystem can start on a smaller scale – such as launching a pre-accelerator (a shorter mentoring programme without equity investment but focused on refining ideas) or forming partnerships with existing regional accelerators, contributing their specialised sectoral expertise.

10.6. Digitalisation, AI and the green transition

Promotion of implementations in artificial intelligence, digitalisation (Industry 4.0/5.0), green transition, and key enabling technologies (KET)

Responsible entity

Cluster coordinators, cluster members

Recommendation

The digital and green transitions are vital development priorities for the European Union – clusters should serve as their local ambassadors and integrators. Among Polish clusters, some already possess extensive experience in **enterprise digitalisation** (e.g. ICT clusters implementing Industry 4.0), in the **green transition** (e.g. chemical and energy clusters), or in **developing key enabling technologies** such as photonics or nanomaterials. It is advisable for these clusters to take a leading role in promoting and transferring such technologies. Coordinators should organise training courses and workshops to enhance knowledge and skills in these areas, both within their own memberships and for other clusters, as part of inter-cluster cooperation. Special emphasis should be given to popularising artificial intelligence – highlighting its potential in process optimisation, offer personalisation, and the creation of new business models. In the age of **generative AI models**, clusters can assist SMEs in understanding and practically adopting AI (e.g. through pilot AI projects within member companies, AI hackathons involving start-ups and researchers). Simultaneously, clusters should support their members in ethically implementing AI in accordance with relevant regulations (such as the EU

AI Act, which sets requirements for AI systems) – for instance, by providing audits of algorithm compliance or training in ethical artificial intelligence.

In the realm of **Industry 5.0**, clusters should promote ideas that combine automation with the humanisation of work and sustainable development. For example, they can assist companies in designing workplaces for human–cobot collaboration (collaborative robots) or in implementing solutions that enhance employee well-being and the energy efficiency of processes (aligned with the human- and environment-centred approach of Industry 5.0). Clusters should also enable enterprises to access infrastructure for testing new technologies (such as Industry 4.0 demonstration centres, pilot lines for low-emission technologies). Additionally, coordinators must develop support for innovation financing – informing members about grants and tax incentives (for instance, the robotisation tax relief, funds for the low-carbon economy) and helping to establish R&D project consortia (e.g. under Horizon Europe or LIFE). These activities will help accelerate the adoption of modern technologies (AI, IoT, big data, robotics, clean technologies) within enterprises, boosting their competitiveness and aligning with the objectives of the European Green Deal. Importantly, they also align with the Net-Zero Industry Act (NZIA)[109], which envisages building a strong manufacturing base for clean technologies in the EU – clusters can act as incubators and cooperation networks for companies developing, for example, photovoltaics, energy storage, hydrogen or other technologies from the NZIA list.

It is important to highlight that several clusters in Poland are already functioning as European Digital Innovation Hubs (EDIH)[110] and provide companies – particularly SMEs – with free advisory, testing, and pilot services in the fields of digitalisation, AI, green transition, and Industry 4.0/5.0 deployment. For instance, the Wro4digital hub in Wrocław allows companies from Lower Silesia to access these services at no cost, supporting their modernisation efforts. Encouraging other clusters to collaborate with EDIHs – such as through forming partnerships, inviting them to joint projects, or utilising their training and advisory resources – can considerably reduce the digital and green transition period for those lacking similar infrastructure. Incorporating this approach into the recommendation reinforces the role of clusters as local technology integrators and ambassadors of transformation, especially since EDIH services are publicly funded and available to enterprises free of charge to the cluster or its members.

[109] Further details can also be found at: https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en [accessed: 09.09.2025].

[110] The EDIH map (including a country filter) is available at: https://european-digital-innovation-hubs.ec.europa.eu/edih-catalogue?f%5B0%5D=country%3APoland [accessed: 09.09.2025].

10.7. Cluster internationalisation

Actions to support internationalisation of the clusters

Responsible entity

Cluster coordinators, Polish Clusters Association (as representative in the European Clusters Alliance)

Recommendation

Although progress has been made, the internationalisation of Polish clusters remains moderate. Many clusters are not fully utilising available tools that could enhance their visibility and credibility abroad. The focus should be on integrating clusters into European networks and collaborative initiatives.

Firstly, each cluster should register on the European Cluster Collaboration Platform (ECCP) – this is a simple and free step that offers access to a database of partners and international events, while also boosting the confidence of foreign stakeholders (currently, some Polish clusters are still not listed in this database).

Secondly, clusters should aim for quality certification within the EUCLES system. As a starting point, they can use the free self-assessment tool available on PARP's website, which aligns with the Cluster Management Standards and allows them to evaluate their readiness to obtain the Bronze Label. Afterwards, clusters – especially those with an established position (KKK and supra-regional growth clusters) – should apply for international certifications (Silver and Gold Labels). Currently, only 9 out of 42 clusters surveyed hold an EUCLES quality certificate (as of September 2025). Increasing this number will enhance the international reputation of Polish clusters. Securing funding for this purpose is essential – for example, by using the funds under measure 2.17 FENG dedicated to cluster certification or by encouraging regional governments to co-finance such processes.

Thirdly, the most advanced clusters should consider joining global cooperation networks such as TCI Network (the oldest international cluster organisation) or thematic networks under the European Cluster Partnerships for Excellence and Euroclusters initiatives. Participation in international associations and projects (COSME, Single Market Programme – Euroclusters, Horizon Europe) will enable clusters to gain experience, partners, and resources for developing internationalisation. The Polish Clusters Association, as a member of the European Clusters Alliance, should support domestic clusters in establishing contacts, inform them about calls for proposals, and initiate joint applications to EU programmes.

Regarding internationalisation, a comprehensive approach to expanding globally is advised. The key components of such a strategy, tailored to each cluster's specific profile, include:

- **Participation in international industry events.** Regular presence at trade fairs, conferences, and symposia abroad is essential for building networks and promoting the cluster offer outside Poland. It is advisable that each cluster plans annual participation in selected trade events aligned with its sector (e.g. medical and biotech fairs for life science clusters; industrial fairs such as Hannover Messe for engineering clusters; global tech congresses for ICT clusters, etc.). Organising joint stands for groups of cluster members is a beneficial strategy – it reduces unit costs for companies (through economies of scale in renting space and logistics) and enhances recognition of the cluster brand as a strong representation (which captures visitors' attention). Clusters can also initiate business missions around such events, combining trade fair participation with additional B2B meetings or study visits.
- **Establishing and maintaining active relations with foreign cluster partners is crucial.** International cluster cooperation should not be limited to one-off contacts– it is worthwhile to build long-term partnerships with foreign clusters and sectoral networks. EU platforms and initiatives are helpful here, such as the European Cluster Collaboration Platform (ECCP), participation in Euroclusters projects or Horizon Europe programmes (where multi-country consortia are often required). Cluster coordinators should actively seek partner organisations abroad with similar profiles or complementary competences and conclude cooperation agreements with them. This may result in, among other things, joint R&D projects (international research consortia), know-how exchange (study visits, job shadowing), and facilitated entry of cluster members into foreign markets through recommendations by local partners. These activities are particularly vital for clusters aiming for key-cluster status – internationalisation is one of the criteria for maturity assessment. However, smaller clusters can also find "twin" organisations abroad for experience sharing, helping them avoid mistakes and accelerate development.
- **Supporting members in preparing for international expansion is key.** A cluster's role should include acting as an "internationalisation incubator" for its firms. Practically, this involves organising training courses and workshops for members on, for example, certification procedures and regulations in various foreign markets (such as different legal requirements for medical products in the EU versus the FDA in the US; quality standards in the automotive industry in Germany; food packaging standards across countries, etc.), providing advisory services on market entry strategies (business models, competition analysis, cross-cultural marketing strategies), and helping to find partners and distributors abroad. Clusters can utilise networks like the Enterprise Europe Network (EEN) or economic cooperation units at embassies. For clusters with limited

experience in internationalisation, initial activities might focus on nearby markets (neighbouring countries, the EU), while more advanced clusters should plan expansion into global markets.

- **Building international recognition for clusters.** It is worthwhile to invest in promoting clusters in foreign markets. This involves preparing information materials in foreign languages (at least in English), such as an English-language cluster website with current offerings, catalogues, and presentations; publishing articles or press notes in foreign industry media and specialist magazines (e.g. describing the cluster's achievements or new technologies); and ensuring cluster experts participate in global events (such as having cluster representatives as speakers at conferences, webinars, or panel discussions). It may also be advantageous to submit the cluster and its members' projects for international awards and rankings – success in these competitions can automatically boost publicity. These brand-building activities are especially crucial for clusters aiming to become international innovation hubs (e.g. KKK), but even local clusters can gradually gain recognition in specific niches (for example, a narrow technological speciality can build a global reputation despite the cluster's small size).
- **Joint pro-export initiatives and product consortia.** Clusters can facilitate joint market entry for firms by creating bundled offers or export consortia. If members offer complementary products or services, the cluster can help integrate them into comprehensive solutions for foreign customers. For example, in the food sector, several producers of functional foods can jointly offer a wide range of health products under the cluster brand; in the industrial sector, manufacturers of machinery, sensors, and software from one cluster can collectively propose a turnkey solution for a client's factory. Joint export projects (e.g. a group of firms participating in a single foreign tender or a study visit combined with promotion of a regional offer) can also make expansion more effective – individual SMEs may struggle to win a large contract alone, whereas a group has better chances. The cluster coordinator should identify such synergistic opportunities and encourage the creation of consortia. Clusters in early development stages may initially test this approach on domestic or nearby foreign markets to gain experience, while mature clusters should actively seek global niches where their collective offer will be competitive.
- **Advocacy for dedicated internationalisation support.** The Polish Clusters Association can take the initiative to promote dedicated internationalisation support through national and EU programmes – for example at PARP and the Ministry of Funds and Regional Policy. This especially concerns barriers identified by Dr Mariusz Citkowski, who emphasises the role of clusters as platforms connecting enterprises with expertise, prestige, and foreign markets. In practice, the Association could lobby for funding voucher schemes, micro-grant cluster projects, and co-financing of cluster and member

participation in missions, trade fairs, and export programmes. Such activities could significantly boost the effectiveness and reach of internationalisation efforts, particularly in clusters that currently lack resources or experience in this area.

Sustaining systemic support for internationalisation of clusters

Responsible entity

Minister responsible for economy and finance, Ministry of Funds and Regional Policy, PARP, EU funds managing authorities (including regional governments)

Recommendation

Following the conclusion by PARP of sub-measure 2.3.3 POIR Internationalisation of KKK, the reduction of funding for cluster internationalisation under measure 2.17 FENG Development of cluster offer for companies, and the work on the new financial perspective, it is worth considering a return to systemic support for the internationalisation of Polish enterprises (including large companies), which to date has mainly been implemented through National Key Clusters (and potentially also through Supra-regional Growth Clusters).

Drawing on the results of a study conducted in 2025[111], Dr Mariusz Citkowski concludes that the current lack or limitation of support in this area negatively impacts the competitiveness of Polish entities compared to their foreign competitors.

In addition to the national level, it is advisable to make such support available simultaneously under regional cluster policies, covering not only KKK at regional level but also growth clusters. In both cases, implementing systemic internationalisation support will enhance the competitiveness of Polish enterprises in international markets.

It is also essential to emphasise the involvement of KKK in implementing public policy at both national and regional levels, including in the area of international promotion of enterprises and their foreign expansion. Furthermore, it is advisable to develop support for international R&D cooperation. To achieve this, the institutional capacity of Polish entities (such as ministries, PARP, and NCBR) should be enhanced to systematically assist clusters in applying for EU funds and utilising them effectively, including programmes such as Horizon Europe and EUREKA.REKA.

[111] Citkowski, M. (2025). Analysis of Cluster Support Models in Selected Countries (Five EU Member States and One Non-EU Country) and Potential Changes to Cluster Support at the National and Regional Levels in Poland, in Line with EU Cluster Policy Guidelines. Analysis commissioned by the Polish Clusters Employers' Association.

10.8. Skills and workforce development

Assisting enterprises in enhancing employee skills and attracting fresh talent

Responsible entity

Cluster coordinators, institutions from the science and higher education sector

Recommendation

Rapid technological and market shifts (digitalisation, automation, green economy) are creating a skills gap – companies require new competencies and specialists to manage the transformation. Clusters, in collaboration with universities and educational institutions, should play a key role in developing the skills of Poland's workforce.

First, identifying these competence gaps is essential. Clusters should systematically assess the skills needs of their member companies through methods like surveys, workshops with entrepreneurs, and analysis of sector trends. This information should serve as the basis for setting training priorities. Next, it is advisable to organise sectoral job and career fairs in collaboration with universities, targeting students and graduates from fields aligned with the cluster's profile (e.g. IT/Industry 4.0, green technologies, chemical engineering, automotive, construction, etc.). Such events will enhance companies' opportunities to attract young talent with up-to-date skills (e.g. AI programming, data analytics, eco-design).[112]

Certain examples support the thesis that these activities can be conducted in a low-cost manner. For instance, Bydgoski Klaster Przemysłowy organises the "Your Future" Job and Career Fair on the campus of Bydgoszcz University of Science and Technology, demonstrating that a cluster can utilise existing university infrastructure to host recruitment events locally. In this context, it can thus be added that this approach (low-cost career fairs organised jointly by the cluster and a university) is a practical option for clusters with limited budgets. The coordinator would handle recruiting companies, logistics, and stand organisation, while the university would promote the event among students. Meanwhile, companies could present their profiles, needs, and skills in short pitches – significantly reducing costs while facilitating effective interaction between students and enterprises.

It is also advisable to establish cluster–university collaborations to develop specialised training programmes and postgraduate courses tailored to the specific needs of cluster firms. For instance, a construction cluster working with an educational institution could introduce a training programme on green building certificates. This strategy also presents an opportunity to activate clusters in lower-rated sectors (e.g. education, consulting), which could partner with other clusters to offer effective methodologies and tools (e.g. online platforms).

[112] https://klaster.bydgoszcz.pl/targi-pracy-i-kariery-your-future-2024 [accessed: 09.09.2025].

Clusters can initiate staff exchange programmes between companies and universities or between companies themselves. Short-term placements of industrial employees at universities (and vice versa – researchers in companies) will enable knowledge transfer: enterprises will benefit from university know-how and research infrastructure, while researchers will gain a better understanding of practical business challenges.

Furthermore, clusters could collaborate with universities and research institutes through industrial PhD programs, in which the doctoral candidate is simultaneously employed by a cluster member company and conducts research tailored to that company's needs. Such approaches enhance both the research capacity of businesses and the skill development of staff – while resulting in tangible technological advancements (e.g. process optimisation, novel materials, digital solutions).

It is also vital to broaden the range of internships and placements within cluster enterprises so that students and graduates can gain experience in real business environments and have the chance to directly apply their theoretical knowledge. Acting as a bridge between companies and universities, clusters can organise and coordinate such programmes, support their funding, and promote them among their members.

Furthermore, cluster representatives should participate in the Sectoral Skills Councils operating at PARP (see Chapter 7 on inter-cluster cooperation) to influence the development of national training and qualification standards within their industries. Engagement in these Councils will allow the industry (including clusters) to have a voice in shaping the education system, ensuring that curricula better reflect the real needs of the labour market (for example, by placing greater emphasis on digital skills, data science, or green technologies in programmes).

Overall, cluster activities related to skills will help reduce labour market mismatch – companies will gain access to qualified employees, and workers will have ongoing opportunities for development and reskilling, which are vital in the transition towards a digital and green economy.

Enhancing knowledge sharing among clusters

Responsible entity

Polish Clusters Association, cluster coordinators

Recommendation

Knowledge sharing among clusters is one of the most effective ways to accelerate organisational learning and build competitive advantages throughout the entire cluster ecosystem in Poland. Developing platforms and networks for sharing experiences facilitates the dissemination of best practices, the transfer of organisational, technological, and marketing solutions, and mutual support during digital and green transitions. Benefits for participating clusters include, among others, increased management efficiency, lower costs for finding partners and technologies, shorter innovation implementation times, and improved skills of cluster staff.

Knowledge sharing can take many forms – from regular industry meetings and thematic workshops, to joint databases and knowledge repositories (such as digital collaboration platforms), to mentoring programmes and short-term staff exchanges between clusters. Particularly valuable are initiatives that connect clusters from different sectors, such as cooperation between circular economy clusters and industrial clusters on material reuse and eco-design, or ICT clusters implementing digital solutions in traditional industries – food, construction or healthcare. There is also significant learning potential between clusters with different levels of organisational maturity: clusters holding National Key Cluster status can serve as mentors for newer structures, sharing management methods, monitoring tools, and experience in securing international funding.

It is advisable to adopt a systematic approach to knowledge sharing, which includes launching an inter-cluster knowledge exchange programme coordinated by the Polish Clusters Association. This programme should encompass workshops, case study repositories, and competitions for joint initiatives in knowledge and technology transfer.er.

11. Annexes

11.1. Glossary of key terms

Additive manufacturing. The process of materialising a digital (virtual) 3D model of an object by adding material layer by layer using a 3D printer[113].

Arithmetic mean. The sum of the values of a variable for all units in the studied population divided by the number of those units[114].

Artificial intelligence (AI). A field of knowledge that includes fuzzy logic, evolutionary computation, neural networks, artificial life and robotics. In the context of Industry 4.0, it is usually understood as a set of technologies that enable machine learning and allow machines to solve complex problems. Artificial intelligence has enormous potential to reorganise how value chains function, because it helps obtain accurate forecasts of customer demand, makes it possible to optimise research and development, and reduces production costs while increasing the technological sophistication of products. Value chain leaders use AI to monitor production processes in real time, shorten lead times, accelerate the introduction of innovations to the market and increase process efficiency. In particular, artificial intelligence makes it possible to better steer customer purchases and provide them with enhanced experiences[115].

Artificial Intelligence of Things (AIoT). The application of artificial intelligence to strengthen the Internet of Things and make it faster, smarter, more environmentally friendly and safe[116]r.

Autonomous robots. Technical devices which, in order to perform a given task, move collision-free within a defined environment and, without direct operator intervention and under the supervision of a control system, carry out a sequence of actions imposed from outside or planned by themselves[117].

Benchmark. The highest value of an indicator achieved by a cluster in a given area or sub-area[118].

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[113] Stadnicki, J. (2016). Additive manufacturing: Development perspectives and impact on the spatial organisation of the economy. Gospodarka i Finanse, 7, 63–71.

[114] Sobczyk, M. (2001). Statistics. Warsaw: PWN.

[115] Kauf, S., & Laskowska-Rutkowska (2020). Digitalisation in improving supply chain management. In Laskowska-Rutkowska (Ed.), Digitalisation in management. Warsaw: CeDeWu.

[116] Zhang, J., & Tao, D. (2020). Empowering things with intelligence: A survey of the progress, challenges, and opportunities in artificial intelligence of things. IEEE Internet of Things Journal, 8(10), 7789–7817. https://doi.org/10.1109/JIOT.2020.3039359 [accessed: 09.09.2025].

[117] Chmielniak, A. (n.d.). Extended outline of the syllabus for the course "Autonomous Mobile Robots". http://airmgr.elka.pw.edu.pl/pdf/arm_streszczenie.pdf [accessed: 09.09.2025].

[118] Polish Agency for Enterprise Development (PARP). (2024). Terms of Reference for the study "Cluster Benchmarking in Poland – 2024 edition". Warsaw: PARP.

Benchmarking. A method, well known and used for many years in organisational practice, that consists in imitating others. It is a method which, by means of observation and existing examples, makes it possible to identify best-in-class solutions and implement them in one's own operations. This method – which can be described as positive imitation – is a way of learning and adaptation that is largely free of the risk of errors[119].

Best practices. A concept originating in organisational management and directly linked to benchmarking. Best practices are not new solutions; they are activities that have already been tested in practice and successfully implemented in other organisations. Their implementation is aimed at improving organisational performance, increasing productivity and efficiency[120].

Big data analytics. Analytics of large, variable and diverse data sets (the so-called 3V – Volume, Velocity, Variety), generated automatically and at high frequency, which are processed using specialised methods. Big data analytics involves the use of advanced methods and models of data analysis mainly to identify interdependencies and predict future phenomena. Despite its enormous potential and benefits, the use of big data analytics is evolutionary in nature and is currently at an early stage of application in management[121].

Blockchain. A data structure in the form of a chain of blocks that are linked together to form a set of records known as a main ledger, with cryptography being a key component of the entire process. In value chains, including clusters, blockchain technology can be used in integrated monitoring and control systems that track the implementation of various stages of the chain, e.g. validating product deliveries, verifying payments or enhancing their security. This technology does not have a declared storage mechanism – instead, it has a set of protocols regulating how the data chain is extended[122].

CATI (Computer Assisted Telephone Interview). A telephone interview carried out with the support of computer software that assists the research process, in particular the recording and archiving of collected data[123].

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[119] Matusiak, K. B. (Ed.). (2008). Innovation and technology transfer. Glossary of terms. Warsaw: Polish Agency for Enterprise Development.

[120] Matusiak, K. B. (Ed.). (2008). Innovation and technology transfer. Glossary of terms. Warsaw: PARP.

[121] Kache, F., & Seuring, S. (2017). Challenges and opportunities of digital information at the intersection of big data analytics and supply chain management. International Journal of Operations & Production Management, 37(1), 10–36.

[122] Bartkiewicz, W., Czerwonka, P., & Pamuła, A. (2020). Contemporary tools of organisational digitalisation. Łódź: University of Łódź Press.

[123] Ibidem.

CAWI (Computer Assisted Web Interview). An interview conducted via the Internet, consisting in the respondent independently filling in a questionnaire hosted on an online survey platform[124].

Cloud computing. A way of accessing, via a computer network, shared and easily configurable computing resources (networks, servers, data storage, applications and services), which can be dynamically allocated and released on demand, with minimal involvement of technical support services. The main characteristics of cloud computing are: self-service configuration tailored to individual user needs, availability from various network-connected devices regardless of location, flexibility in changing required resources, and measurability of the service with pay-as-you-go billing[125].

Cluster coordinator. An institutional entity (hence also the term cluster organisation) that organises and facilitates the development of interactions, linkages and cooperation within the cluster, and provides specialised services for companies and other entities operating in the given agglomeration. In the early stages of cooperation, these functions are often performed not by an institution but by an individual referred to as an animator[126].

Cluster initiative. Organised activities aimed at intensifying the growth and competitiveness of clusters in a region, involving cluster firms, government and/or the research community[127].

Cluster members. Entities operating within a cluster, including enterprises and support institutions belonging to the R&D sector (universities, research institutes, educational institutions) and forming the business support infrastructure (incubators, science and technology parks, technology transfer centres, special economic zones, certification bodies, training and consulting firms, financial institutions and other specialised business support institutions), as well as public administration[128].

Cluster strategy. A long-term plan for cluster development, containing a set of goals that can be achieved through collective actions of cluster members. A cluster strategy should be developed based on a jointly shared vision of cluster development, worked out within the cluster through consensus[129].

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[124] Ibidem.
[125] Mell, P., & Grance, T. (2011). The NIST definition of cloud computing. Recommendations of the National Institute of Standards and Technology. U.S. Department of Commerce, NIST Special Publication 800-145.
[126] Polish Agency for Enterprise Development (PARP). (2012). Directions and assumptions of cluster policy in Poland until 2020: Recommendations of the Cluster Policy Working Group. Warsaw: PARP.
[127] Sölvell, Ö., Lindqvist, G., & Ketels, C. (2003). The cluster initiative greenbook. Stockholm: Ivory Tower AB.
[128] Polish Agency for Enterprise Development (PARP). (2012). Directions and assumptions of cluster policy in Poland until 2020: Recommendations of the Cluster Policy Working Group. Warsaw: PARP.
[129] Polish Agency for Enterprise Development (PARP). (2024). Terms of Reference for the study "Cluster Benchmarking in Poland – 2024 edition". Warsaw: PARP.

Cluster. "Geographical concentrations of interconnected companies, specialised suppliers, service providers, firms operating in related industries and associated institutions […] in particular fields, competing with one another but also cooperating."[130]

Cybersecurity. Ensuring safe conditions for the use of digital technologies. In the context of Industry 4.0 technologies, the risks associated with cybersecurity increase significantly. The issue of cyber protection should be considered in two aspects: security of digital infrastructure and security of data. Many existing plants and production lines are insufficiently adapted to operate in a digital environment, therefore, along with the implementation of new technological solutions enabling data flows and the integration of different systems, it will be necessary to ensure the secure use of these solutions[131].

Data coding. The process of converting data obtained directly during the study into values compatible with the computer software used to perform the statistical analysis[132].

Desk research. A research technique based on analysing already available data (secondary data) in order to obtain useful information and conclusions. Examples of secondary data include documents, reports, websites (materials published online), statistical data, trade press and others. Before use, sources of secondary data should be analysed in terms of their reliability[133].

Digital platforms. Various technological solutions that overcome territorial barriers and enable cooperation between two or more entities, often in ways that are not available through traditional forms of collaboration[134].

Digital twin. The simulation of real processes in a digital model used in decision-making processes. Comparing the state of object images over time enhances the quality of predictive analysis[135].

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[130] Porter, M. E. (2001). Porter on competition. Warsaw: Polish Economic Publishers.

[131] Kowalski, A. M., & Mackiewicz, M. (2019). Challenges and instruments of innovation policy in Poland in the context of Industry 4.0. In A. M. Kowalski & M. A. Weresa (Eds.), Poland: Competitiveness Report 2019. International competitiveness in the context of development of Industry 4.0. Warsaw: Warsaw School of Economics.

[132] Sobczyk, M. (2001). Statistics. Warsaw: PWN.

[133] Matusiak, K. B. (Ed.). (2011). Innovation and technology transfer: Glossary of terms. Warsaw: PARP.

[134] Musiatowicz-Podbiał, G. (2021). Digital platforms as cooperation tools – new opportunities and threats. In Z. Drążek & T. Komorowski (Eds.), Informatics and management. Problems and challenges of the digital economy (pp. 9–25).

[135] Drąg, P., Kamińska, A. M., & Nowak, M. U. (2019). Measuring the benefits of geoinnovations using an object model as an example. In Z. Malara & J. Tutaj (Eds.), Innovations and the well-being of society, the economy and enterprises. An attempt at measurement. Wrocław: Wrocław University of Science and Technology Press.

Digitalisation. The use of information and communication technologies (ICT – Information and Communication Technologies) to create value[136].

DIH – Digital Innovation Hub. Institutions that support the digital transformation of enterprises in order to increase their market competitiveness through the use of innovative solutions in the broad area of digital technologies. They are selected in a national-level competition organised by the minister competent for economic affairs[137].

EDIH – European Digital Innovation Hub. Centres that bring together knowledge and competences in the field of digital transformation of economic activities. Their role is to help increase the competitiveness of companies by supporting them in the digital transformation process. They are selected at European level[138].

ESG. An approach that takes into account environmental, social and corporate governance criteria (Environmental, Social and Governance) in assessing the non-financial performance of organisations in order to motivate them to integrate the concept of sustainable development into strategic management[139].

Expert. An expert is a person who, thanks to long-term experience and specialised knowledge, is able to effectively solve problems and assess situations in their field. Ericsson and Smith (1991) point out that a key characteristic of an expert is the ability to apply knowledge in practice[140].

Expert method. A research method from the group of qualitative methods, which consists in formulating conclusions based on group judgements, aiming to select the option consistent with the opinion of the majority or all experts – individuals with knowledge and experience in the studied area[141].

Indicator. A proper indicator that provides data for cluster benchmarking and enables positioning of detailed aspects of cluster functioning relative to benchmarking partners[142].

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[136] Ibidem.
[137] Polish Agency for Enterprise Development (PARP). (2024). Terms of Reference for the study "Cluster Benchmarking in Poland – 2024 edition". Warsaw: PARP.
[138] Ibidem.
[139] Ibidem.
[140] Ericsson, K. A., & Smith, J. (Eds.). (1991). Toward a general theory of expertise: Prospects and limits. Cambridge: Cambridge University Press.
[141] Kędzior, Z. (Ed.). (2005). Market research: Methods and applications. Warsaw: Polskie Wydawnictwo Ekonomiczne.
[142] Mejsak, R., & Siedlecki, M. (2015). New methodology of cluster benchmarking together with a survey of cluster members' opinions. Warsaw: PARP.

Industrial Internet of Things (IIoT). The use of Internet of Things technologies in industry, in particular for measurement, monitoring and management of distributed assets, as well as the processing of collected data to obtain knowledge, manage processes, systems and value chains, and optimise their operation. According to research, four typical stages of IoT implementation are: (1) connecting objects to the network, (2) introducing monitoring of objects, (3) using collected data to optimise processes, and (4) transferring the acquired information into the product portfolio and developing new offers and services[143].

Industry 4.0. A concept representing the adoption by industrial enterprises of techniques and processes enabled by digitalisation, cloud computing, the Internet of Things and big data analytics in order to gain competitive advantage on domestic and global markets[144].

Information system. A part of an organisation's information system (of an enterprise or institution) that is separated in time, space, technical, technological and logical terms, whose task is to acquire, process and provide decision-makers with the data and information necessary for managerial decision-making processes, carried out using computer technology[145].

Internet of Things (IoT). A concept according to which objects and devices can collect, process and exchange data with each other via communication networks, in particular the Internet. By measuring the effectiveness of individual operations and automating business processes, it leads to improved quality, greater predictability and reduced operating costs. It is therefore a complex technology ecosystem comprising modules and devices, communication means, purpose-built platforms, mass storage, servers, analytical software, IT services and security solutions[146].

Median. Divides an ordered population into two equal parts so that 50% of units have values lower and 50% higher than the median[147].

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[143] Bartkiewicz, W., Czerwonka, P., & Pamuła, A. (2020). Contemporary tools of organisational digitalisation. Łódź: University of Łódź Press.
[144] Kowalski, A. M., & Weresa, M. A. (Eds.). (2019). Poland: Competitiveness Report 2019. International competitiveness in the context of development of Industry 4.0. Warsaw: Warsaw School of Economics – Publishing.
[145] Fjałkowski, Z. (n.d.). Information and informatics in logistics systems. http://fjalkowski.neostrada.pl/Teksty/ZF_Informacja_i_informatyka_w_systemach_logistycznych.pdf [accessed: 09.09.2025].
[146] Liwarska-Fulczyk, K. (2020). Internet of Things – organisational implications. e-mentor, 3(85), 23–31.
[147] Sobczyk, M. (2001). Statistics. Warsaw: PWN.

National Key Cluster (KKK). A cluster of major importance for the country's economy and with high international competitiveness. National Key Clusters are identified at national level, based, among other things, on criteria regarding: critical mass, development and innovation potential, past and planned cooperation, as well as the experience and capacity of the coordinator[148].

National Smart Specialisations. Sectors whose development will: create innovative socio-economic solutions, increase the value added of the economy and enhance its competitiveness on the international stage[149].

Normalisation. The process of transforming the values of measurable variables (which may have different units or orders of magnitude) so that they are placed on a common scale, allowing them to be compared without the influence of unit differences. Most often this involves removing measurement units (e.g. transforming values into relative form) and rescaling data (e.g. to the 0–1 range)[150].

Ordinal scale. A type of measurement scale used in research that makes it possible to quantify the strength of the studied phenomenon and examine "less–more" relationships[151].

Polish Classification of Activities (PKD). A conventionally adopted, hierarchically structured breakdown of types of socio-economic activity, used in statistics, records and documentation, as well as in official registers and information systems of public administration[152].

Quartiles. Values of a studied variable that divide it into defined parts in terms of the number of units. The first quartile divides the ordered population into two parts in such a way that 25% of units have values lower than the first quartile and 75% higher. The third quartile divides the ordered population so that 75% of units have values lower and 25% higher than the third quartile[153].

Resilience. The ability of enterprises to maintain business continuity, adapt and continue to grow in the face of sudden disruptions of an economic, social or geopolitical nature. It covers both the capacity to survive crisis situations (e.g. the COVID-19 pandemic, the war in Ukraine, abrupt regulatory changes) and flexibility in responding to new environmental conditions, as well as the ability to implement innovative solutions enabling the transformation of the

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[148] Ministry of Development (n.d.). National Key Clusters. http://www.gov.pl/web/rozwoj/krajowe-klastry-kluczowe [accessed: 09.09.2025].

[149] National Smart Specialisations (n.d.). What are the National Smart Specialisations? https://krajoweinteligentnespecjalizacje.pl [accessed: 09.09.2025].

[150] Walesiak, M. (2014). Review of variable normalisation formulas and their properties in multivariate statistical analysis. Przegląd Statystyczny, 61(4), 363–372.

[151] Kędzior, Z. (Ed.). (2005). Market research: Methods and applications. Warsaw: PWN.

[152] Council of Ministers Regulation of 24 December 2007 on the Polish Classification of Activities (PKD). Journal of Laws, No. 251, item 1885.

[153] Sobczyk, M. (2001). Statistics. Warsaw: PWN.

operating model. Enterprise resilience is linked to having adequate resources (human, infrastructural, financial), diversification of revenue sources and markets, an efficient management system and broad cooperation within the triple helix (business – science – administration). The literature emphasises that resilience does not simply mean returning to the pre-crisis state, but also the ability to learn, restructure and use difficult situations as an impulse for development and strengthening competitive position[154].

Smart specialisation (smart specialisation strategy). An innovative policy concept that emphasises setting priorities according to a vertical logic (favouring certain technologies, fields, groups of firms) and defines methods for identifying such desirable areas of policy intervention in the field of innovation[155].

Stimulant (benefit variable). A variable whose high value is desirable from the perspective of the overall characteristics of the studied phenomenon[156].

Sub-synthetic benchmark. The value of the highest arithmetic mean of indicators assigned to a given benchmarking sub-area[157].

Support institutions (business support organisations). An organisationally diverse group of non-commercial institutions active in supporting entrepreneurship and self-employment, technology transfer and commercialisation, and improving the competitiveness of SMEs[158].

Synthetic benchmark. The value of the highest arithmetic mean of sub-synthetic indicators that make up individual benchmarking areas[159].

Unitisation. Normalisation of variables to obtain a standardised range of variability (constantly equal to 1), defined – in the classical sense – by the difference between their maximum and minimum values[160].

[154] Martin, R., & Sunley, P. (2015). On the notion of regional economic resilience: Conceptualization and explanation. Journal of Economic Geography, 15(1), 1–42. https://doi.org/10.1093/jeg/lbu015 [accessed: 09.09.2025].
[155] Foray, D., & Goenaga, X. (2013). The goals of smart specialisation (JRC Scientific and Policy Report, S3 Policy Brief Series No. 01/2013). European Commission, Joint Research Centre.
[156] Ibidem.
[157] Ibidem.
[158] Matusiak, K. B. (Ed.). (2011). Innovation and technology transfer: Glossary of terms. Warsaw: Polish Agency for Enterprise Development.
[159] Ibidem.
[160] Polish Agency for Enterprise Development (PARP). (2024). Terms of Reference for the study "Cluster Benchmarking in Poland – 2024 edition". Warsaw: PARP.

Value chain. A sequence of activities undertaken by an enterprise to create value for customers. In the value chain, two types of activities can be distinguished: primary and support activities. Primary activities relate directly to the production process and include inbound logistics, operations, outbound logistics, marketing and sales, and after-sales service. Support activities underpin the primary functions of the value chain and are essential for enterprise effectiveness. They include procurement, technology development, human resource management and infrastructure[161].

Venture studio. An organisation that creates start-ups from scratch, providing the founding team, strategic direction and seed capital, and playing an active operational role in developing the new venture[162].

[161] Porter, M. E. (1985). The competitive advantage: Creating and sustaining superior performance. New York: Free Press.
[162] Moiana, D., Ghezzi, A., & Rangone, A. (2025). Venture Studios: Beyond Entrepreneurial Support Organisations? A case study analysis and framework. Politecnico di Milano.

11.2. Accessibility analysis of cluster websites

11.2.1. Introduction

As part of the current edition of the benchmarking study, an **additional analytical component** was carried out, proposed by the Contractor in the Offer, concerning the **digital accessibility of cluster websites**. The scope of this analysis included a preliminary assessment of the level of digital accessibility of cluster web pages in accordance with applicable standards such as **WCAG (Web Content Accessibility Guidelines)**, as well as an evaluation of the potential impact of this factor on the image and functioning of clusters.

Digital accessibility plays an increasingly important role in building a positive image of an organisation that is open and user-friendly for all users, including persons with disabilities. Clusters with more accessible websites can reach new partners, members, and investors more effectively, and better respond to the growing legal requirements in this area in Poland and across Europe – including those resulting from the transposition of **Directive (EU) 2019/882, the European Accessibility Act (EAA)**[163], into national law. In the current edition of the study, the indicator concerning the accessibility of websites was introduced on a **pilot basis**. It had a quantitative-qualitative character and did not affect the aggregated benchmarking results.

11.2.2. Measurement methodology

In developing the methodology for measuring the level of digital accessibility of cluster websites, the study drew on the experience and findings from the report "Final report on the study of user needs of websites/mobile applications of public sector entities in the field of digital accessibility of these websites/applications"[164], prepared as part of the project "Digital Accessibility Network – support for the systemic implementation of digital accessibility in public entities" (European Funds for Social Development Programme 2021–2027). This report provided valuable methodological and practical insights, including the testing of measurement tools, the selection of assessment criteria consistent with **WCAG guidelines**, and the development of approaches for presenting results.

The knowledge accumulated during the implementation of that project made it possible to develop a simplified methodology for assessing the accessibility of cluster websites, tailored to their organisational and communication characteristics. When constructing the assessment criteria for cluster websites, the analysis drew upon findings regarding the most frequently occurring accessibility errors identified on public sector websites – errors that caused the

[163] Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services. (2019). Official Journal of the European Union, L 151, 70-98. https://eur-lex.europa.eu/eli/dir/2019/882/oj [accessed: 09.09.2025].

[164] Innoreg Sp. z o.o. (2024). Accessibility of websites and mobile applications of public institutions for people with low vision. Final report. European Funds for Social Development 2021–2027 Programme.

greatest difficulties and barriers for persons with disabilities participating in the tests conducted under the aforementioned project.

The audit was based on 10 criteria reflecting the most common accessibility issues. Each criterion could be scored on a scale of **0 (not met)** or **1 (met)**. Due to the wide range of potential errors and the adopted scoring scale, a score of 1 could also be assigned when a website contained minor issues that did not significantly affect accessibility. The audit was conducted manually, supported by automated tools (including WAVE, axe, Colour Contrast Analyser, and the NVDA screen reader, depending on the criterion being assessed).

Assessment Criteria

1. **Alternative text for images (WCAG 1.1.1)**
   Verification of whether all graphic elements (<img>, icon-based buttons, charts) have appropriate *alt* attributes. Text alternatives make visual content accessible to screen-reader users. Missing descriptions indicate that graphic content is inaccessible.
2. **Heading structure (WCAG 1.3.1)**
   Verification of whether headings (<h1>–<h6>) are used logically and hierarchically. A proper heading structure enables users of assistive technologies to better understand and navigate the page. Skipping levels or using headings for styling purposes only impedes orientation.
3. **Text colour contrast (WCAG 1.4.3)**
   Verification of whether the contrast between text and background meets the required thresholds (minimum 4.5:1 for standard text, 3:1 for large text). Insufficient contrast can make reading difficult, especially for users with low vision.
4. **Form labels and accessibility (WCAG 3.3.2)**
   Verification of whether form fields have proper labels (<label> or aria-label) and whether users receive feedback in case of errors or invalid data. Missing labels make forms unusable for blind users.
5. **Descriptiveness of links (WCAG 2.4.4)**
   Verification of whether link text clearly communicates the purpose of the link. Links such as “click here” are not meaningful when read out of context (e.g. in a screen-reader-generated list of links). Descriptive link text improves navigation.
6. **Language declaration for the page and its fragments (WCAG 3.1.1 and 3.1.2)**
   Verification of whether the <html> tag correctly defines the document language (e.g. lang="pl") and whether fragments in other languages include the appropriate *lang* attribute. This is essential for proper screen-reader behaviour.

7. **Keyboard accessibility (WCAG 2.1.1)**
   Verification of whether all functionalities (links, buttons, forms) are accessible using the keyboard alone (Tab, Enter). If elements are not operable without a mouse, this represents a significant barrier for many users.
8. **Page title (WCAG 2.4.2)**
   Verification that each page has a unique and meaningful title in the <title> element. The page title is essential for orientation in the browser, bookmarks, and search results.
9. **Use of colour as the sole visual indicator (WCAG 1.4.1)**
   Verification of whether colour is not the only means of conveying information (e.g. using red to indicate an error without supporting text or icons). Distinctions should be supplemented with icons, text, or emphasis.
10. **Alternatives for multimedia content (WCAG 1.2.1, 1.2.2)**
    For video and audio material, verification of whether captions, transcripts, or audio descriptions are provided. Without them, content is inaccessible to users with hearing or visual impairments.

Method of use

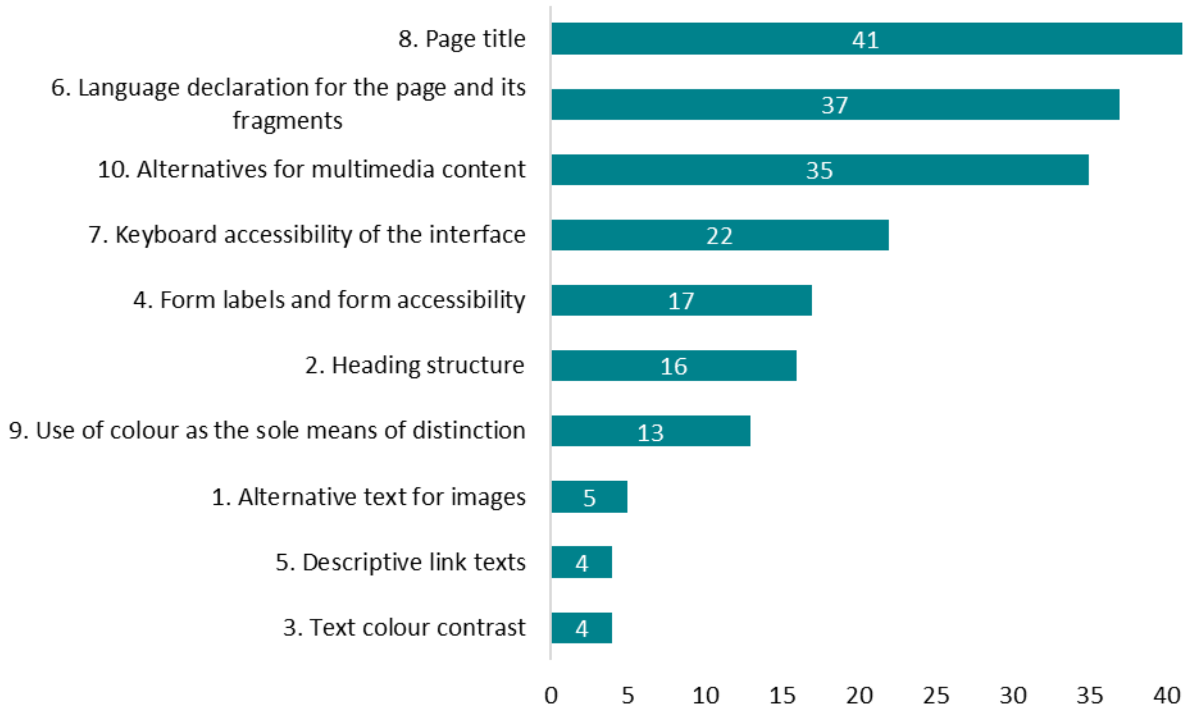
The total number of points (maximum 10) enables a quick assessment of a website's accessibility level. Interpretation:

- 9–10 points – the website meets basic accessibility standards,
- 6–8 points – the website has important gaps and requires corrections,
- ≤5 points – the website is inaccessible and requires substantial improvements.

11.2.3. Results of the accessibility study of cluster websites

When presenting the audit results, the first step was to include a summary showing the number of cluster websites that met each of the specified assessment criteria (the numbering of criteria follows the measurement methodology).

Figure 49. Number of cluster websites meeting given criteria



Source: Own elaboration based on audits of cluster websites (N = 42).

The results presented in the figure indicate that the level of compliance of cluster websites with digital accessibility principles is highly varied. The best-met criteria are those of a technical and formal nature, which are typically incorporated already during the website development stage – such as the page title (41 websites) and the declaration of the page language and language of fragments (37 websites). This means that most administrators ensured the presence of basic metadata that allow browsers and assistive technologies to correctly interpret the content.

Slightly fewer websites (35) meet the criterion related to alternatives for multimedia content, which can be interpreted as a positive sign – indicating that some clusters consciously attempt to adapt video and audio materials (e.g. through captions or transcripts). A noticeable decline, however, appears in the area of keyboard accessibility (22 websites) and form labels and form accessibility (17 websites). This means that nearly half of the websites still do not provide full keyboard operability or clear labels in contact and registration forms – representing a significant barrier for users relying on screen readers.

The situation is only slightly better in the case of heading structure (16 websites), which may hinder navigation and negatively affect search engine performance. Even less frequently met are the more demanding visual and semantic criteria, such as the prohibition of using color as the only means of conveying information (13 websites), alternative text for images (5 websites), descriptive link text (4 websites), or sufficient text color contrast (4 websites). As a result, users with visual impairments often cannot fully read or understand the content published by clusters.

In summary, the audit demonstrated that while most cluster websites in Poland meet basic technical requirements, there remains a substantial gap in perceptual and operational accessibility. Below is a presentation of the most common accessibility issues identified within each assessment criterion.

1. **Alternative text for images (WCAG 1.1.1)**

   The most frequently recurring issue under the first criterion – alternative text for images – is the complete absence or incorrect use of the alt attribute in graphic elements on cluster websites. In many cases, graphics, photos, or icons lack any alternative description, making it impossible for users relying on screen readers to understand what visual content or functions are being presented. A common problem is also the lack of a description of the image's purpose when it functions as a link – for example, a partner logo or article thumbnail serving as the only content of a hyperlink but offering no information on where it leads. There are also instances where informative graphics are incorrectly marked as decorative, causing them to be skipped by assistive technologies. In a few cases, errors include duplicating the graphic description in the alt attribute with the same text as a neighbouring link, resulting in redundancy and distortion of the message. Overall, the main challenge is inconsistency in applying the rules of alternative text – key to ensuring that visual content is accessible to all users, including those who are blind or have low vision.

2. **Heading structure (WCAG 1.3.1)**

   The most common error under the second criterion – heading structure – is the lack of logical and hierarchical organisation of heading tags on cluster websites. In many cases, the main heading (H1) is completely missing, even though it should clearly define the topic or title of the page. Frequently, the first visible heading is H2 or even H3, which confuses assistive technologies such as screen readers and makes navigation more difficult for users. There are also cases where subsequent heading levels (e.g. H4, H5) are used without maintaining proper hierarchy, disrupting the logical structure of the document. Sometimes visually emphasised text (e.g. bold text) is incorrectly marked as a heading despite not serving that function, or conversely – heading tags are left empty.

Such errors prevent screen-reader users from efficiently navigating between page sections and understanding the content structure. As a result, both accessibility and usability are significantly reduced. Proper hierarchical use of headings (H1–H6) is crucial not only for accessibility but also for readability and SEO, and cluster coordinators should ensure consistent implementation of this principle.

3. Colour contrast of text (WCAG 1.4.3)

The most common issue under the third criterion – colour contrast – is the use of insufficient contrast between text and background, making it difficult to read for people with low vision or those using low-quality screens. In many analysed cases, the contrast ratio between text and background does not meet the minimum WCAG 2.1 requirements of 4.5:1 for standard text and 3:1 for large text or UI components. In practice, this means that light-coloured text – such as grey, turquoise, or green – placed on a light background (usually white or beige) often reaches contrast ratios as low as 1.7:1 to 3.4:1, rendering it barely readable. These issues occur both in main content and in UI elements such as buttons, headings, or menus. Some problems also arise when text is placed on photos or gradients, where contrast varies across the background. As a result, users struggle to read the content and may need to zoom in to compensate. Cluster coordinators should pay close attention to meeting WCAG contrast requirements by testing colour combinations and choosing darker text or lighter backgrounds to improve both accessibility and readability.

4. Labels and form accessibility (WCAG 3.3.2)

The most common issues under the fourth criterion – form accessibility – include both technical and communication-related errors. Many form fields lack proper labels or descriptions, making them unreadable by screen readers. Missing attributes such as label, aria-label, or aria-labelledby prevent users with visual impairments from understanding what information is required. Another recurring problem is the unclear marking of required fields – for example, using an asterisk (*) without explaining its meaning – and the occasional absence of a clearly defined "Submit" button, which prevents keyboard-only users from completing the form.

Further challenges include vague or unclear error messages, such as “Enter a valid email address,” without instructions on how to correct the mistake, or error messages appearing in English on otherwise Polish-language pages. Validation errors are also common – for instance, forms allowing submission without checking for incorrect email formats. In many cases, errors are indicated solely by colour (e.g. a red border), which is inaccessible to users with colour-vision deficiencies. Additionally, some forms cannot be fully navigated or submitted using only the keyboard.

In summary, the major issues relate to inconsistent labeling, poor validation, and unclear error communication – all of which hinder accessibility for people with disabilities and also reduce usability for mobile users. Adding proper labels, improving error messages, and ensuring full keyboard operability would significantly enhance form accessibility.

5. **Link descriptiveness (WCAG 2.4.4)**

The most common problems under the fifth criterion – link accessibility – include unclear link descriptions, incorrect marking of hyperlinks, and insufficient visual distinction. Frequently, pages contain empty links (with no text), making their purpose inaccessible to screen-reader users. Links with vague labels such as "Read more" or "Download" fail to communicate their destination or content; therefore, more descriptive alternatives are recommended, e.g. "Read more about the GreenTech project" or "Download the full report (PDF, 2 MB)."

Many websites also lack information about file type, size, or language, which is important for mobile users or those with limited data. Additionally, new browser tabs or windows often open without warning, causing confusion for some users – particularly those with cognitive disabilities.

From a visual standpoint, many websites rely solely on colour to indicate links, without underline or increased contrast, which is inaccessible for users with colour-vision deficiencies. In several cases, images function as links but lack alternative text, leaving their purpose unclear when using assistive technologies.

6. **Declaration of page language and language of fragments (WCAG 3.1.1 and 3.1.2)**

The most frequent issue under the sixth criterion – language declaration – is inconsistency in marking page language and language fragments. Many Polish-language pages include English elements such as buttons ("Read more," "Submit," "Send"), form error messages, or field labels ("Name," "E-mail"). Without the lang="en" attribute, screen readers mispronounce these elements, making them difficult to understand for blind or low-vision users.

Similar inconsistencies are found in forms, where English-language error messages appear in otherwise Polish-language contexts. These discrepancies not only hinder comprehension but also diminish the professional appearance of cluster websites. They may also create cognitive barriers for users who do not speak English.

Correctly marking the page language and language fragments (e.g. quotations, brand names, or technical terms) in compliance with WCAG 2.1 – and fully localising the user interface – would significantly improve accessibility and user experience.

7. **Keyboard accessibility (WCAG 2.1.1)**

The most common issue under the seventh criterion – keyboard operability – is the lack of a visible focus indicator showing which element is currently active. In many cases, keyboard-only users (using the TAB key) are unable to determine which element they have reached, because no highlighting, border, or colour change is applied. In some cases, focus appears only on certain elements (e.g. form fields) while others – such as buttons, menu links, or dropdowns – remain inaccessible.

A recurring issue is that some website functions cannot be triggered without using a mouse – users may be unable to open menus, submit forms, or expand sections. This poses major barriers for people with motor impairments or those using assistive technologies.

The absence of visible focus significantly reduces both accessibility and usability, causing disorientation and interaction errors. To comply with WCAG 2.1, all interactive elements should include a clearly visible and consistent focus indicator, such as a contrasting outline, background highlight, or shadow, and full keyboard operability should be ensured.

8. **Page title (WCAG 2.4.2)**

Under the eighth criterion – page titles – only one cluster website exhibited non-compliance. The issue involved missing or insufficiently descriptive titles in the <title> element, which may hinder navigation and negatively impact SEO. Every subpage should include a unique, meaningful title clearly describing its content, supporting both accessibility and overall usability.

9. **Use of colour as the only means of distinction (WCAG 1.4.1)**

Under the ninth criterion – colour-dependent distinction – it was found that some cluster websites do not comply with accessibility requirements in this area. The most common issue is marking links using colour only, without additional cues such as underline, increased contrast, or bold text. This approach is difficult for users with colour-vision deficiencies and those with low contrast sensitivity, who may not be able to distinguish links from plain text.

In isolated cases, interactive elements (e.g. navigation menu items) changed colour only on mouse hover, making them impossible to identify for keyboard-only or screen-reader users. To ensure full WCAG 2.1 compliance, all links and interactive elements should be distinguishable not only by colour but also by form – for example through underlining, font styling, or icons.

10. Alternatives for multimedia content (WCAG 1.2.1, 1.2.2)

Under the tenth criterion – multimedia accessibility – most analysed cluster websites did not meet minimum requirements. The most common issue was the absence of captions or audio description for video materials, making them inaccessible to users with hearing or visual impairments. Some videos included automatically generated captions, but only in one language (e.g. Polish captions for English-language videos), limiting their usefulness.

Visual materials – including photos, infographics, and promotional graphics – were also frequently missing alternative text, preventing screen-reader users from understanding the content. To improve accessibility, all new audiovisual materials should be published with captions, transcripts, or audio descriptions, and all images should include alternative text in line with WCAG 2.1 success criteria 1.2.2 and 1.2.5.

11.2.4. Recommendations

The structure reflects implementation priority: first, the critical changes (safety, operability without a mouse, readability of content), followed by semantic and content-related corrections, and finally supplementary improvements and accessibility governance.

Priority 1 – Essential changes required for the basic functioning of the website

The elements described below must be implemented first, as their absence prevents or significantly hinders many people from using the website.

Keyboard operability – navigating the website without a mouse

Many people cannot or do not want to use a mouse – these include users with motor disabilities, blind users relying on screen readers, and people who simply prefer keyboard navigation for efficiency. Elements to verify/improve:

- All interactive elements (buttons, links, menus, forms, cookie banners, language switchers, image galleries) must be fully operable via keyboard.
- Users must be able to move between elements with Tab (forward) and Shift+Tab (backward), activate elements with Enter or Space, and navigate dropdown menus using arrow keys.
- When an element is active (i.e., has *focus*), this must be clearly visible – for example, with a coloured outline around the button or link. Removing the default focus outline without replacing it with a clearly visible alternative is not permitted.
- In pop-up windows (e.g. cookie consent banners), the user must not become “trapped” – they must be able to close the window using the Esc key and return to browsing the page.

As a result, every user – whether using a mouse, touchpad, or keyboard only – will be able to move freely across the entire website.

Adequate contrast and readable text

Text that is too light on a light background – or too dark on a dark one – is difficult to read, especially for older adults, people with low vision, or those with colour-vision deficiencies (e.g. colour blindness). Elements to verify/improve:

- The contrast ratio between text and background must meet WCAG minimum requirements:
  4.5:1 for regular text, 3:1 for large text (over 18 pt) and user interface elements (buttons, icons).
- This applies equally to interactive states: hovered links, focused elements, and visited links.
- Colour must not be the only means of conveying information. For example, if a link differs from surrounding text only by colour, some users may not notice it. Underlining, bolding, or adding an icon is required.

The result will be text readable for everyone – regardless of age or vision – and an overall more professional and user-friendly website.

Clear, understandable, and accessible forms

Contact forms, newsletter subscriptions, or user registrations are often incorrectly marked – users do not know what to enter, which fields are required, or how to correct errors. Elements to verify/improve:

- Every form field must have a clear label that is semantically associated with the input field – ensuring that screen readers announce it correctly.
- Required fields must be clearly indicated, and optional fields should be distinguished.
- If a field requires a specific format (e.g. date in DD-MM-YYYY format), this must be explicitly stated.
- Error messages must be specific (e.g. “The email address is invalid” instead of generic “Error”) and associated with the relevant field.
- Buttons such as “Submit” must have meaningful names and correct semantic markup.

As a result, users will know what to fill in, make fewer errors, and abandon forms less frequently.

Descriptive links and predictable navigation

Links such as "Read more," "Click here," or "More" do not communicate their destination. Screen-reader users often browse a list of all links on a page – if all of them say "Read more," they cannot distinguish between them. Elements to verify/improve:

- Each link should describe its destination on its own, e.g. "Read more about the Innovation Cluster project" instead of "Read more."
- Links leading to files (PDF, Word) must include type and size, e.g. "Download report (PDF, 1.2 MB)."
- If a link opens in a new browser tab or window, the user must be informed.
- Links within content must be clearly distinguishable – not only by colour, but also through underlining or other stylistic cues.

As a result, users will find information more easily and will not be surprised by unexpected website behaviour.

Quick access to the main content of the page

Users relying on keyboards or screen readers often need to navigate through dozens of items (logo, menu, banners) before reaching the core content. This is frustrating and time-consuming. Elements to verify/improve:

- At the top of the page, add a "Skip to main content" link that becomes visible after pressing Tab and moves the user directly to the primary content area.
- Organise the tabbing order so that keyboard navigation is logical and intuitive.
- Remove or hide from assistive technologies duplicate navigation elements (e.g. repeated menus).

As a result, users of assistive technologies will save time and reach desired information more quickly.

Priority 2 – semantic and content clean-up (high impact, quick to implement)

The actions described below improve the "skeleton" of the website and the way content is presented. They usually require only minor changes in code or editing, yet significantly enhance how the website is perceived by all users, including people using screen readers.

Correct heading structure and marking of page regions

Headings (section titles) should create a logical document structure – like a table of contents in a book. Unfortunately, they are often used chaotically or created only visually (large font size) without proper markup in the code. Likewise, pages frequently lack a clear division into regions

(e.g. navigation, main content, footer).
Elements to verify/improve:

- Each subpage should contain exactly one main H1 heading (e.g. the article title or the subpage name).
- Subsequent headings should follow a logical hierarchy: H2 for main sections, H3 for subsections within an H2, and so on. Skipping levels (e.g. from H2 directly to H4) is not allowed.
- “Fake” headings must be avoided – text that only looks like a heading (large, bold font) but is not marked as a heading in the code.
- The page should be divided into semantic regions (landmarks):
    - header – page header (logo, main menu)
    - nav – navigation
    - main – main content (only one per page)
    - footer – footer
    - where appropriate: aside (side content), section (logical sections), article (standalone articles).

As a result, screen readers can generate an automatic “map” of the content, allowing users to quickly jump between sections. Search engines better understand the structure of the page, which supports SEO.

Alternative text for images

Blind and partially sighted people use screen readers that “read” the page aloud. If an image has no alternative description (alt text), the reader either skips it or reads the file name (e.g. “IMG_5432.jpg”), which provides no meaningful information.
Elements to verify/improve:

- Every image that conveys information (e.g. a chart, event photo, infographic) must have a concise alternative text that reflects its meaning in the context of the page.
- If an image is also a link (e.g. a logo linking to the home page), the description should indicate the destination (e.g. “Home page”).
- Purely decorative images (ornaments, backgrounds) should be marked in a way that makes assistive technologies ignore them: an empty alt="" attribute or aria-hidden="true".

- Icon-only links (for example, a PDF icon without text) should be avoided. Every such icon must have an accessible name – visible text or an aria-label attribute.

As a result, users of screen readers receive full information about the content of the page. In addition, if images fail to load (e.g. due to a slow Internet connection), users can still understand what was intended to be shown.

Alternative text for images

Blind and partially sighted people use screen readers that "read" the page aloud. If an image has no alternative description (alt text), the reader either skips it or reads the file name (e.g. "IMG_5432.jpg"), which provides no meaningful information.
Elements to verify/improve:

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- If an image is also a link (e.g. a logo linking to the home page), the description should indicate the destination (e.g. "Home page").
- Purely decorative images (ornaments, backgrounds) should be marked in a way that makes assistive technologies ignore them: an empty alt="" attribute or aria-hidden="true".
- Icon-only links (for example, a PDF icon without text) should be avoided. Every such icon must have an accessible name – visible text or an aria-label attribute.

As a result, users of screen readers receive full information about the content of the page. In addition, if images fail to load (e.g. due to a slow Internet connection), users can still understand what was intended to be shown.

Correct language declaration for the page and foreign-language fragments

Screen readers and speech synthesisers need to know what language content is written in to pronounce it correctly. If the language is missing or incorrectly declared, the reader may attempt to read Polish text with English pronunciation (or vice versa), which becomes unintelligible.
Elements to verify/improve:

- In the page code, the language of the entire document should be set in the html tag (e.g. lang="pl" for the Polish version, lang="en" for the English one).
- If a fragment in another language appears within Polish text (e.g. the English name of a programme, a quote), it should be locally marked with the appropriate lang attribute.

- The language switcher should be organised properly – it should lead to the corresponding version of the same content and use hreflang attributes for search engines.

As a result, speech synthesisers pronounce the content correctly, significantly improving comprehension for blind users. Search engines also index multilingual versions of the website more effectively.

Accessibility of multimedia and changing content

Video materials without captions are inaccessible to deaf and hard-of-hearing people. Elements that move or change automatically (e.g. rotating banners, animations) can be distracting and, for some users (e.g. with photosensitive epilepsy, ADHD), even dangerous or make it impossible to concentrate.
Elements to verify/improve:

- Every video should have captions at least in the language of the material. If the video conveys key information visually (e.g. charts, demonstrations without narration), it is advisable to provide audio description or an extended textual description below the media.
- All elements that move or change automatically (sliders, carousels, counters, animations) must have a pause/stop control.
- The website should honour the user's "reduced motion" preference (prefers-reduced-motion) – if the user has enabled this setting at system level, animations should be disabled or significantly limited.

As a result, multimedia content becomes accessible to people with diverse sensory needs. Users gain control over motion on the page, reducing distraction and discomfort.

Correct behaviour of complex interface components

Modern websites include advanced components: cookie consent pop-ups, calendars, pagination systems, image carousels. If they are not implemented correctly, they can be difficult or impossible to use for people navigating via keyboard or screen readers.
Elements to verify/improve:

- Cookie banner:
  - It should behave as a proper modal dialog with the appropriate role (role="dialog").
  - It must trap focus – when it appears, keyboard users should not be able to move outside it until they have made a choice.

    - It should allow closing with the Esc key.
    - Buttons must have clear, descriptive labels (e.g. “Accept all”, “Cookie settings”, “Reject”).
- Calendars and pagination:
    - Descriptive labels (aria-label) should be added, e.g. “Select date” for a calendar, “Article pagination” for pagination controls.
    - The current element (e.g. the current page) should be marked with the aria-current attribute.
    - Appropriate semantics should be used – tables for calendars, lists for pagination.
    - All elements must be operable from the keyboard.
- Carousels/sliders:
    - They must be fully keyboard-operable (previous/next buttons, pause).
    - Controls should have clear labels (e.g. “Previous slide”, “Next slide”, “Pause”).
    - If content changes automatically, users of screen readers should be informed about changes where appropriate (e.g. with aria-live), so they know that something on the page has changed.

As a result, advanced interface elements will become usable for everyone – including people using assistive technologies – without sacrificing modern design or functionality.

Priority 3 – Documents, consistency, responsiveness (sustaining quality and compliance)

The actions described below ensure consistent accessibility across the entire website ecosystem – not only within the site itself but also in downloadable documents. Additionally, they streamline the interface, eliminate unnecessary elements, and improve usability across different devices.

Accessible downloadable documents (PDF, Word, Excel)

Many clusters provide important information in PDF, Word or Excel files – such as reports, forms or presentations. Unfortunately, these documents are often inaccessible: they lack structure, consist of scans instead of real text, or include images without descriptions. For a person using a screen reader, such a document is unusable.

Elements to verify/improve:

- PDF documents should be tagged (i.e., contain a logical structure), with a correct hierarchy of headings, alternative text for images, and a correct reading order.

- Word and Excel files should also contain a structured layout: headings, image descriptions, clear tables with column/row headers.
- Each document should have a meaningful title (not a file name like “document_final_v3.pdf”, but the actual title of the content).
- Scanned documents should be avoided – if unavoidable, OCR (text recognition) must be applied and the output quality verified.
- Document links should include information about the file type and size (e.g. “Download annual report (PDF, 2.3 MB)”).
- If the document is in a different language than the website, it should be indicated (e.g. “Annual Report (PDF, 2.3 MB, English)”).

As a result, users gain equal access to all materials, regardless of format. This is particularly important for official documents, reports and forms.

Responsiveness and ability to zoom content

Users with low vision often enlarge page content (sometimes up to 200–400% of the standard size) or use high-contrast modes. If a site is not prepared for such use, text may “escape” off-screen, elements may overlap, and some features may stop functioning. The same problem affects mobile device users.

Elements to verify/improve:

- The site must scale correctly at 200–400% zoom – text should wrap, and users should not need to scroll horizontally to read sentences.
- All functions must remain accessible after zooming – buttons, menus and forms cannot disappear or become cut off.
- The focus indicator (the outline around the active element) must remain visible and clear in high-contrast modes and when zoomed.
- The site must be responsive – it should look and function properly on smartphones, tablets and various screen sizes.

As a result, the site becomes more comfortable for people with low vision, older users, and anyone browsing on mobile devices. Comfort increases and the need for horizontal scrolling decreases.

Reducing unnecessary interface elements

Websites often contain unnecessary, empty or duplicated elements: dead links, leftover placeholder text (“Lorem ipsum”), multiple repeated menus, empty buttons. For keyboard and screen reader users this creates barriers – they must “tab through” dozens of unnecessary elements before reaching meaningful content.

Elements to verify/improve:

- Remove empty links – elements that look like links but lead nowhere.
- Remove dead template elements – unused blocks, non-functional buttons, placeholder test content.
- Eliminate duplicated blocks – if the same menu appears multiple times, hide duplicates from assistive technologies (aria-hidden="true").
- Reduce excess tab stops – reorder elements so that keyboard users do not have to navigate through unnecessary items.

As a result, navigation becomes shorter, faster and more predictable. Users of assistive technologies save time and avoid confusion caused by clutter.

Proper use of ARIA – support, not patching errors

ARIA (Accessible Rich Internet Applications) is a set of attributes that help assistive technologies interpret complex interface elements (e.g. dropdown menus, modal windows, tabs). Unfortunately, ARIA is often misused – as a “patch” for poorly written HTML – which worsens accessibility instead of improving it.

Elements to verify/improve:

- ARIA should be used only when native HTML semantics are insufficient. If a native element exists (e.g. <button> instead of <div role="button">), HTML must always be preferred.
- ARIA does not fix HTML errors – if the page structure is incorrect, adding ARIA will not help. HTML must be fixed first.
- ARIA attributes must reflect the actual component state:
  - aria-expanded (expanded/collapsed) must change when the menu is opened/closed.
  - aria-controls should point to the element being controlled.
  - aria-current should indicate the current item (e.g. the active page in the menu).
  - role="dialog" for modal windows must be combined with proper focus management.
- ARIA behaviour should be tested with screen readers – incorrectly used attributes may confuse or completely block access.

As a result, assistive technologies receive reliable, up-to-date information about the interface. Screen reader users can effectively operate complex components without guessing what is happening.

Priority 4 – Maintenance, testing and governance (ensures ongoing compliance)

The actions described below go beyond one-time fixes – they establish a system ensuring that accessibility is maintained over time. This involves procedures, standards, and clearly defined responsibilities so that each new change does not break what has already been improved.

Regular accessibility testing and reviews

Accessibility is not a one-off task – websites change regularly, adding new content, updates and features. Without systematic testing, accessibility can easily deteriorate: something that once worked may stop functioning after a new update. A lack of ongoing review causes problems to accumulate and become harder to fix.

Elements to verify/improve:

- Every significant change to the site (new feature, template update, added component) must be tested for accessibility before publication.
- Testing should include:
    - Keyboard testing – verifying that all elements can be accessed without a mouse and that focus is visible and logical.
    - Screen reader testing (e.g. free NVDA) – verifying that content is read correctly and is understandable.
    - Automated tools such as WAVE, axe DevTools or HTML CodeSniffer – for detecting typical issues (missing alt text, contrast problems, structural errors).
    - Contrast testing using Colour Contrast Analyser – verifying that colours meet minimum requirements.
- Maintain a list of exceptions and outstanding issues – problems that cannot be fixed immediately but are documented for future updates.
- Establish a review cycle – e.g. a full audit every 6 months or after each major release.

As a result, continuous quality control ensures that accessibility does not degrade over time. Problems are detected early, when they are easier and cheaper to fix. The team builds competence and awareness.

Editorial standards and a component library

When different people create content and interface elements without shared rules, inconsistency emerges – some articles include descriptive links, others do not; some forms are accessible, others not. Creating each new component from scratch increases costs and the risk of errors.

Elements to verify/improve:

Editorial standards – clear guidelines for content authors:

- Headings: how to use H1, H2, H3 (one H1 per page, logical hierarchy).
- Links: how to write descriptive link names (instead of “click here” → “Download the 2024 annual report”).
- Alternative descriptions (alt): how to describe images depending on context (informational, decorative, links).
- Downloadable files: how to mark file type and size (PDF, 1.5 MB).
- Forms: how to write field labels, instructions, and error messages (clear, consistent language).
- Semantics: how to use sections and landmarks (header, nav, main, footer).

Component library – ready-to-use interface elements:

- Build a reusable library of WCAG-compliant components: dropdown menus, modal windows, sliders, forms, buttons, cards, pagination, etc.
- Each component should be tested for accessibility (keyboard, screen reader, contrast) and documented (how to use it, available options).
- Use the same components across all cluster websites – instead of building a new menu from scratch each time, reuse an approved solution.

As a result, users know what to expect. Costs and development time decrease. The risk of errors is reduced because components have already been verified.

Accessibility policy and clear assignment of responsibilities

Without a defined policy and division of roles, accessibility becomes “everyone’s and no one’s responsibility” – no one feels accountable, there are no procedures, and users do not know whom to contact. Users also do not know whether the site is actively pursuing accessibility improvements.

Elements to verify/improve:

- Accessibility statement – a short public declaration including:

  - Purpose: commitment to ensuring digital accessibility,
  - Standard: the accessibility level targeted (e.g. WCAG 2.1 AA),
  - Last review date: when the site was last audited,
  - Contact: how to report accessibility barriers (email or form),
  - Optional: known issues and plans for improvement.
- Clear division of responsibilities:
  - Content owner/editor: responsible for accessible text, images and documents (alt text, headings, descriptive links).
  - Front-end developer: responsible for HTML/CSS/JS, semantics, keyboard support, ARIA, responsiveness.
  - UX/UI designer: responsible for contrast, readability, visible focus, and accessible design.
  - QA/tester: performs accessibility testing before release.
  - Accessibility coordinator: oversees the process, maintains reviews, updates the accessibility policy, manages reports.
- Review cycle:
  - Establish a regular schedule (e.g. full review every 6 months + checks after major releases).
  - Document results, prioritise fixes, track progress.

As a result, users see that the organisation takes accessibility seriously and know how to report issues. Accessibility becomes part of the organisational culture, not a one-time project.

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11.4. List of figures

11.5. List of tables

12. Statistical annexes

12.1. Values of partial indicators

12.1.1. Cluster resources

On the following pages, five tables are presented, illustrating the values of the partial indicators for the areas covered by the benchmarking. The tables show the raw / non-normalised values of the partial indicators using three measures: average, median and benchmark.

Table 12. List of partial indicators – cluster resources area

Sub-area / Indicator	All clusters
Human resources	
Total employment in all entities belonging to the cluster	Average: 25,863 persons Median: 17,393 persons Benchmark: 175,000 persons For four clusters, total employment was equal to or below 1,000 persons. At the other end of the distribution, clusters reported total employment levels of 90,000 and 175,000 persons. This indicator shows substantial differences in the critical mass of clusters, measured by total employment.
Number of persons employed in cluster enterprises	Average: 20,957 persons Median: 11,188 persons Benchmark: 175,000 persons Employment in enterprises accounted for approximately 79% of total employment in cluster entities. Four clusters had enterprise employment not exceeding 1,000 persons. This means that in some smaller clusters, employment in other types of institutions (universities, other higher education and science entities, and local government units) plays a significant role.
Number of research staff involved in cluster activities	Average: 93 persons Median: 9 persons Benchmark: 2,000 persons The highest value was recorded by a cluster holding Key National Cluster (KKK) status, characterised by strong involvement of universities. Three clusters reported no involvement of research staff, and a further 14 clusters reported fewer than five such staff.

Sub-area / Indicator	All clusters
Number of staff employed by the cluster coordinator	Average: 5.2 persons Median: 3.5 persons Benchmark: 16 persons Two clusters reported no coordinator staff involvement. Nine clusters were managed by one or two persons – similar to the previous edition. Only four clusters reported 10 or more coordinator staff, and none exceeded 16 persons.
Infrastructure resources	
Area of research infrastructure available to the cluster (owned or provided under agreements)	Average: 3,690 m² Median: 25 m² Benchmark: 100,000 m² Around half of the clusters (22) provide research infrastructure. For 15 clusters, the available area was below 1,000 m². The average is significantly inflated by two clusters declaring 20,000 m² and 100,000 m². The low median reflects the fact that 20 clusters declared no available research infrastructure.
Value of investment in research infrastructure available to the cluster (owned or provided under agreements) in the last two years	Average: 6,269.1 thousand PLN Median: 0.0 thousand PLN Benchmark: 60,000 thousand PLN Only 14 clusters declared both having research infrastructure and investing in its development. Investment levels varied substantially – from several tens of thousands PLN to several tens of millions PLN in four clusters.
Area of production infrastructure available to the cluster (owned or provided under agreements for cluster members)	Average: 49,524 m² Median: 0 m² Benchmark: 2,000,000 m² A median equal to 0 m² indicates that more than half of clusters do not provide production infrastructure. Among the 17 clusters that do, most are production-oriented clusters. Exceptions include one “quality of life” cluster and two ICT clusters that also provide such infrastructure.
Value of investment in production infrastructure available to the cluster (owned or provided under agreements) in the last two years	Average: 4,745.7 thousand PLN Median: 0.0 thousand PLN Benchmark: 90,000 thousand PLN Only 13 clusters declared investment in production infrastructure. For three clusters, investments exceeded 10 million PLN.

Sub-area / Indicator	All clusters
Number of functionalities available in the cluster's IT platform	Average: 2.5 Median: 3.0 Benchmark: 6.0 Most frequently indicated functionalities (from the list of five) were: communication (88%), knowledge repositories (57%) and collaboration management (47%). Less common were educational functions, such as e-learning (36%), and a group purchasing platform (17%). The benchmark exceeded the number of platform functionalities because some clusters indicated additional features, including R&D project facilitation, technology mapping, integration with regional Smart Specialisations, and project management tools.
Value of investment in the cluster's IT infrastructure in the last two years	Average: 1,080.8 thousand PLN Median: 250.0 PLN Benchmark: 30,000 thousand PLN Twenty-one clusters reported IT infrastructure investment. Values varied greatly – from several hundred PLN (e.g. small office equipment purchases) to nearly 30 million PLN.
Financial resources	
Cluster budget (at the coordinator's disposal) in the last two years	Average: 4,093.6 thousand PLN Median: 847.2 thousand PLN Benchmark: 54,864.0 thousand PLN Clusters show considerable variation in available budgets. For 18 clusters, the budget over the two years exceeded 1 million PLN, while for six clusters it was below 100 thousand PLN. Notably, the average budget increased from 1,711.9 thousand PLN in 2022 to 2,383.8 thousand PLN in 2023 (a growth of over 39%). This continues the upward trend observed in the previous edition.
Value of cluster's own funds in the last two years	Average: 12,391.2 thousand PLN Median: 423.2 thousand PLN Benchmark: 400,000 thousand PLN Only two clusters reported zero own funds. For another six clusters, own funds did not exceed 100 thousand PLN. Conversely, 13 clusters declared more than 1 million PLN in own funds.
Value of public funds obtained by the cluster in the last two years	Average: 5,588.6 thousand PLN Median: 335.6 thousand PLN Benchmark: 120,000 thousand PLN As with overall budgets, public funding varies widely. The large gap between average and median indicates that half of the clusters have public funding not exceeding 335.6 thousand PLN. The leader recorded 120 million PLN.

Sub-area / Indicator	All clusters
Financial instruments available to cluster members via the cluster	Average: 0.8 Median: 0.0 Benchmark: 4.0 Among the four types of financial instruments, the most frequently indicated were loan funds and venture capital (21% each), followed by seed capital (12%). Guarantee funds were indicated by 7%. Additional instruments mentioned included cascade grants (Euroclusters), vouchers (BioMan4R2), innovation vouchers and start-up support. However, none of these meets the statutory definition of financial instruments under the Polish Act on Trading in Financial Instruments (29 July 2005) or International Accounting Standards.

12.1.2. Cluster processes

Table 13. List of partial indicators – cluster processes area

Sub-area / Indicator	All clusters
Management processes	
Formulation and updating of the cluster strategy	69% of clusters have a written strategy that is regularly updated; another 12% have a written strategy but do not update it; 19% have no written strategy. In addition to general provisions, the strategy may also cover detailed operational areas. The most frequently included additional areas are cluster digitalisation (68%), green transition (56%) and social responsibility (ESG or equivalent, e.g. CSR, CSV) (32%) – percentages refer only to clusters with a strategy. As in the previous edition, 50.1% of surveyed members confirmed their participation in shaping the cluster strategy, meaning that nearly half of cluster members do not actively participate in strategy development.
Possession of operational documents (action plans)	45% of clusters have detailed documents; another 48% have high-level documents; only 3 clusters lack operational documents.
Number of specialised cluster bodies (e.g. management board, cluster council, audit committee, cluster office, programme and scientific council)	64% of clusters have three or more specialised bodies; another 26% have one or two such bodies; 10% of clusters do not have any formal bodies. The most frequently reported bodies include: president/management board, cluster council/programme council, general assembly of members, audit committee and secretariat/cluster office. In some clusters, bodies with substantive functions were also identified (e.g. scientific groups, working groups, thematic groups). At the same time, member involvement in the work of these bodies is relatively low – only 22% of surveyed members declared that they delegate employees to participate in at least one cluster body.
Regularity of surveys on member needs/satisfaction	52% of clusters conduct such surveys regularly (at least once per year); 41% conduct them ad hoc; 7% of clusters do not conduct such surveys at all.

Sub-area / Indicator	All clusters
Number of enterprises within the cluster that have implemented ISO standards	Mean: 43 Median: 30 Benchmark: 322 The highest number of ISO-certified enterprises was recorded in a very large cluster (322 cases).
Cluster communication	
Number of meetings organised by the cluster per year	Mean: 24 Median: 12 Benchmark: 171 Four clusters declared that they organised no meetings at all in 2022–2023. The average number of meetings increased from 20 in 2022 to 28 in 2023.
Number of communication tools used in the cluster	Mean: 5.8 Median: 6.0 Benchmark: 14.0 Among the list of five main tools, the most frequently used were: website (100%), social media (86%), newsletters/bulletins (83%). Additional tools included: internal communication platforms (48%) and forums/discussion groups (33%). Among social media platforms, the clear leaders were Meta (Facebook) (92%) and LinkedIn (86%). Further positions included Twitter (19%) and Instagram (17%). Some clusters additionally reported using online meetings, project management platforms or e-learning platforms.
Aktywność rynkowa	
Number of value chain stages jointly implemented within the cluster	Mean: 3.1 Median: 3.0 Benchmark: 7.0 Out of seven possible value chain stages, the most frequently indicated were: marketing and sales (76%), product and/or service development/planning (62%), production operations and/or service delivery (55%), export activities (45%). Less frequently: procurement (33%), distribution (26%) and after-sales service (14%). Nine clusters declared collaboration across five or more value chain stages, whereas four clusters declared none.
Number of product and/or service categories sourced through joint group purchasing	Mean: 1.0 Median: 1.0 Benchmark: 4.0 Most frequently mentioned: expert, advisory and training services (55%). Other categories played a smaller role: production raw materials and components (12%), consumables (21%), and energy (17%). Additional categories indicated by clusters included insurance services, organisation of trade fair trips, and courier services.

Sub-area / Indicator	All clusters
Number of joint distribution channels in the cluster	Mean: 1.7 Median: 1.0 Benchmark: 6.0 Most frequently mentioned: joint trade fair stands (76%), joint tender submissions (29%), joint online sales (24%). Less common: joint points of sale (17%); jointly hiring an agent/export representative abroad (10%); delivering to retail/wholesale networks (7%); wholesale channels (5%).
Total sales revenues of enterprises in the cluster	Mean: 67,267.6 million PLN Median: 12,600.0 million PLN Benchmark: 888,230.9 million PLN The indicator is based on absolute values of enterprises' total sales revenues in 2022–2023. Overall cluster revenues increased by 14.2%, compared with 4.8% growth across the national economy (GUS data). The largest revenue increases were observed in: metal, machinery and materials industries (+26.2%), automotive, aviation and transport (+19.8%). Additionally, 36.7% of surveyed cluster members declared revenue growth attributable to cluster participation.
Share of cluster enterprises' sales via e-commerce	Mean: 7.8% Median: 0.0% Benchmark: 78.0% 16 clusters reported e-commerce revenues among their members.
Aktywność marketingowa	
Number of search engine results for the phrase "cluster name"	Mean: 1,404 Median: 143 Benchmark: 15,000 Measured using Google (other search engines, such as Bing/Yahoo, often produced inflated results). Clusters with simple, short names scored best.
Number of visits to the cluster's website	Mean: 76,871 Median: 12,345 Benchmark: 592,035 Around 70% of clusters were able to provide these statistics.
Number of joint promotional activities for the cluster and its members	Mean: 4.3 Median: 5.0 Benchmark: 8.0 Most frequently indicated (from a list of seven): cluster logo (100%), cluster brand (79%), advertising and public relations (60%). Less common: direct marketing (57%), sales promotion (55%), personal selling (10%). Additional actions included: industry patronage, joint cluster presentations, conference organisation, and participation in sectoral events.

Sub-area / Indicator	All clusters
Number of domestic trade fairs and exhibitions attended in the past two years	Mean: 6.2 Median: 3.0 Benchmark: 39.0 Only 9 clusters reported no activity in this area. Five clusters presented themselves at more than 10 fairs/exhibitions.
Number of other events (e.g. trade missions, study visits) attended in the past two years	Mean: 11.6 Median: 5.5 Benchmark: 73.0 Seven clusters reported no activity; 13 clusters reported more than ten events.
Innovation activity	
Number of pro-innovation services available in the cluster or via the cluster	Mean: 4.0 Median: 4.0 Benchmark: 10.0 Most frequently indicated (from a list of six): specialised training (86%), innovation advisory services (76%), technology audits (60%), technology trend monitoring (57%). Less common: intellectual property advisory (50%) and commercialisation plans (40%). Only one coordinator did not report any services. Additional examples: European Digital Innovation Hub services, R&D project incubation, conformity assessment, market validation services, acceleration of new ideas
Functioning of an institution supporting technology transfer between cluster members and/or with external entities (e.g. advisory services, development of databases containing cooperation offers, etc.)	Such an institution operates in 81% of clusters.
Purchase of knowledge and technology for cluster needs (licences, know-how)	In 37% of clusters, knowledge and technology are purchased.
Number of cluster members who used pro-innovation services in the past two years	Mean: 20.8 Median: 8.0 Benchmark: 165.0 Pro-innovation services were used in 69% of clusters. In 13 clusters, more than 20 members used such services.
Number of technology audits performed via the cluster in the past two years	Mean: 4.8 Median: 0.0 Benchmark: 83.0 Technology audits were conducted in 33% of clusters (hence the median of zero). Only five clusters reported more than ten audits.

Sub-area / Indicator	All clusters
Cluster digitalisation	
Number of IT systems used across the value chain	Mean: 7.7 Median: 9.0 Benchmark: 9.0 Most frequently indicated (from a list of nine): customer relationship management systems, resource management systems, document management systems (all 93%). Followed by: warehouse management (88%), time-tracking and business analytics (86%). Further: production resource management (83%), content management (76%), supply chain management (74%). High scores were recorded among ICT clusters and many industrial clusters (e.g. automotive, metal processing) and selected service clusters (e.g. medical).
Number and type of Industry 4.0 technologies used in the cluster (13 technologies assessed on a 0–2 scale: 0 = not used, 1 = initial initiatives, 2 = implemented; maximum score: 26)	Mean: 19.5 Median: 22.0 Benchmark: 26.0 Most commonly implemented technologies: IT systems (100%), cybersecurity (90%), digital platforms (86%), 3D production (74%). Moderate levels: artificial intelligence, cloud computing, autonomous robots (69%), Internet of Things and big data analytics (64%), industrial IoT and simulations (57%). Less common: artificial intelligence of things (48%), blockchain (38%). Further growth in AI-based technologies is expected in the short term.

12.1.3. Cluster results

Table 14. List of partial indicators – cluster results area

Sub-area / Indicator	All clusters
Development of collaboration in the cluster	
Number of start-ups, spin-offs/spin-outs and special purpose vehicles established within the cluster in the past two years	Mean: 1.9 Median: 0.0 Benchmark: 21.0 In fifteen clusters, this type of activity was recorded. Only in two clusters did the number of established enterprises and special purpose vehicles exceed ten.
Documented cooperation between technology-oriented start-ups and large enterprises within the cluster structures in the past two years	Mean: 1.9 Median: 0.0 Benchmark: 23.0 Nineteen clusters recorded this type of activity. Only in one cluster did the indicator exceed ten cases of cooperation. In most cases, however, these were isolated instances.

Sub-area / Indicator	All clusters
Number of jointly implemented projects within the cluster co-financed from public funds	Mean: 3.2 Median: 2.0 Benchmark: 20.0 Twenty-nine clusters declared the implementation of joint projects co-financed from public funds. Only in three clusters was the number of projects equal to or greater than ten.
Number of cluster members who participated in jointly implemented projects co-financed from public funds within the cluster	Mean: 20.1 Median: 5.0 Benchmark: 165.0 Approximately 40.7% of members across all surveyed clusters participated in joint projects. Only in ten clusters was the number of participating members equal to or greater than twenty.
Value of jointly implemented projects within the cluster co-financed from public funds	Mean: 26,887.2 thousand PLN Median: 699.8 thousand PLN Benchmark: 312,000.0 thousand PLN Seventeen clusters did not indicate the value of jointly implemented projects co-financed from public funds. There is, however, very substantial variation in project values. The lowest reported value was 10 thousand PLN; seven clusters reported values below 1 million PLN, while in fourteen clusters the value exceeded 10 million PLN.
Number of joint products and services introduced to the cluster's offering	Mean: 3.5 Median: 1.5 Benchmark: 30.0 Twenty-two clusters declared the introduction of joint products and services into their offering. In most cases, the number of such products and services did not exceed ten.
Number of cluster members who engaged in joint production or delivery of joint services	Mean: 6.9 Median: 2.0 Benchmark: 94.0 Twenty-two clusters reported the implementation of joint production or joint service delivery by cluster members. The total number of members involved in these activities did not exceed 300 entities (just under 5.5% of all members of the surveyed clusters), and only in seven clusters did the number of engaged members exceed ten. For this reason, joint production or joint service delivery can be regarded as having limited significance in cluster operations.
Value of joint sales (joint products and services) within the cluster	Mean: 12,874.0 thousand PLN Median: 0.0 thousand PLN Benchmark: 400,000.0 thousand PLN Only eleven clusters declared a value for the sales of joint products or services within the cluster (taking into account the previous indicator, a higher number of cases could likely be noted, but these values are very difficult for coordinators to calculate).

Sub-area / Indicator	All clusters
Number of orders obtained by the coordinator or cluster members for joint implementation	Mean: 9.0 Median: 0.0 Benchmark: 100.0 Sixteen clusters reported the acquisition of orders for joint implementation. In eight clusters, this involved ten or more orders.
Number of public–private partnerships (PPPs) undertaken through the cluster	Mean: 0.5 Median: 0.0 Benchmark: 7.0 Only six clusters recorded PPP initiatives in this area. Activity was noted exclusively among clusters with a very high or high position in the ranking developed as part of this edition of the benchmarking.
Development of innovation in the cluster	
Number of jointly implemented innovation projects and R&D projects resulting in (or expected to result in) innovative products or technologies within the cluster	Mean: 1.8 Median: 0.0 Benchmark: 11.0 Nineteen clusters declared the implementation of joint innovation projects. In most cases, the number of such projects did not exceed five, and only in two clusters was it equal to or greater than ten, amounting to 10 and 11 respectively. This represents a significant deterioration in results compared with the previous edition of the benchmarking. It is worth noting that the mean calculated only for clusters implementing innovation and R&D projects (18 structures) amounted to 4.0.
Number of cluster members who participated in jointly implemented innovation projects and R&D projects within the cluster	Mean: 7.6 Median: 1.0 Benchmark: 120 In eleven clusters, the number of members participating in joint projects was equal to or greater than ten. In most clusters, the share of members involved in projects was very low (approx. 6.5% when considering all clusters and their members, and 10.5% when considering only clusters declaring the implementation of joint projects).
Value of jointly implemented innovation projects and R&D projects within the cluster	Mean: 15,187.0 thousand PLN Median: 0.0 thousand PLN Benchmark: 200,000.0 thousand PLN Some clusters declaring the implementation of innovation and R&D projects were unable to precisely determine their value (resulting, among other factors, from the mismatch between project implementation periods and the years covered by the benchmarking). The values of implemented projects are significant, and in several clusters they exceed 5 million PLN (13 indications). The mean value calculated only for clusters declaring the implementation of such projects is 36.4 million PLN.

Sub-area / Indicator	All clusters
Number of implemented product innovations	Mean: 5.8 Median: 1.0 Benchmark: 133.0 Just over half of the clusters (22) reported the implementation of product innovations. In most cases, the number of innovations did not exceed five. One cluster emerged as the clear leader, declaring the implementation of 133 product innovations.
Number of implemented business process innovations	Mean: 4.2 Median: 0.0 Benchmark: 57.0 In seventeen clusters, the implementation of business process innovations was recorded. Only in four clusters did the number of innovations exceed ten. One cluster again appeared as the standalone leader, declaring the implementation of 57 business process innovations.
Number of technology transfers within the cluster carried out through the cluster	Mean: 2.0 Median: 0.0 Benchmark: 20.0 In fifteen clusters, technology transfers within the cluster were recorded. In three clusters, the number of transfers was equal to or greater than ten.
Number of patents / patent applications / utility model protection rights and industrial design registration rights filed and obtained by cluster enterprises with the cluster's involvement	Mean: 12.1 Median: 0.0 Benchmark: 146.0 Fewer than one-third of clusters (12) reported involvement in filing protection rights applications. The same number of clusters (12) declared that such rights had been granted. In total, 167 applications were filed and 343 protection rights were obtained in the surveyed clusters. The predominance of granted rights over filed applications may be explained by the long assessment periods for applications (often several years) as well as decreasing activity among clusters in this area. For this reason, it is also not possible to directly calculate a success indicator.

Sub-area / Indicator	All clusters
Development of competences in the cluster	
Number of initiatives (organised within the cluster) aimed at enhancing the competences of cluster members in the past two years	Mean: 27.6 Median: 19.0 Benchmark: 157.0 In three clusters, no activity was recorded in the area of competence development for cluster members. In 26 clusters, there were ten or more initiatives per cluster. Overall, the largest number of initiatives was recorded in the area of courses, training sessions and workshops (519), followed by conferences, seminars and webinars (429). The most frequently organised competence-building activities for cluster members focus on digital transformation and Industry 4.0, the green transition and the circular economy (CE), internationalisation, innovation financing, and the development of managerial and soft skills. These are complemented by specialist training in the fields of law, security, new technologies, ESG, cybersecurity and cooperation with the public sector.
Number of cluster entities that, in the past two years, participated in joint competence-building activities initiated by the cluster	Mean: 103.0 Median: 58.5 Benchmark: 401.0 It is worth noting the high level of participation of cluster entities in joint competence-building activities, reflected in both the high mean and the benchmark result. A total of 4,327 entities were reported as participating in such initiatives. It should be highlighted, however, that this indicator allows multiple counts of the same entity if it participated in more than one initiative. In eight clusters, the number of entities exceeded 200, and in another eight, it was equal to or above 100. Given the construction of the indicator, the highest levels of activity were recorded in large and very large clusters, particularly those operating in the ICT sector.
Number of competence-enhancing training sessions attended by employees of the cluster coordinator (delegated to support cluster operations) in the past two years	Mean: 8.4 Median: 3.5 Benchmark: 150.0 Only seven clusters reported no activity in the area of training for employees of the cluster coordinator. In contrast, in ten clusters, the number of training sessions was equal to or exceeded ten.

12.1.4. Cluster impact on the environment

Table 15. List of partial indicators – cluster impact on the environment area

Sub-area / Indicator	All clusters
Collaboration with the external environment	
Number of active cooperation agreements between the cluster and public authorities (local and national government)	Mean: 8.2 Median: 2.0 Benchmark: 250.0 One-third of clusters (14) do not have any active cooperation agreement with public authorities. This is partly a result of the relatively low engagement of public authorities in cluster activities (only 18 clusters include local government units among their members). It should be noted, however, that many areas of cooperation with local authorities are not always formalised (e.g. public consultations, promotional support during events organised by local authorities, etc.).
Forms of support provided to the cluster by public authorities	Mean: 1.8 Median: 2.0 Benchmark: 5.0 From the list of five forms of support, the most frequently indicated were: promotional support (57%), financial support (45%), and training/educational and organisational support (33% each). Legal support played a significantly smaller role (7%). Clusters could also indicate support not included in the predefined list. Additional forms mentioned included, among others: the CORNET initiative at the National Centre for Research and Development (NCBR) and support provided within jointly implemented projects.
Number of active cooperation agreements between the cluster and business support institutions	Mean: 3.8 Median: 2.0 Benchmark: 20.0 Two-thirds of clusters (28) have active cooperation with business support institutions (BSIs). The widespread presence of BSIs in cluster activities has several reasons. Often, BSIs act as the cluster coordinator. Additionally, BSIs are frequently interested in joining clusters themselves, for example to expand their pool of potential partners. At the same time, BSIs can provide a wide range of useful services to both the coordinator and cluster members. It is worth noting that in the most recent call for applications for the Key National Cluster (KKK) status, the presence of an innovation centre accredited by the Ministry of Development and Technology allowed applicants to obtain additional points during the substantive-parametric evaluation.

Sub-area / Indicator	All clusters
Intensity of cooperation with the R&D and education sector in the past two years	Mean: 2.6 Median: 3.0 Benchmark: 7.0 From the list of four possible areas of cooperation, the most frequently indicated were: cooperation with selected academic staff (81%), joint implementation of projects (64%), and cooperation in the field of teaching (60%). Cooperation involving the use of R&D infrastructure played a smaller role (48%). Clusters could indicate additional areas beyond the predefined list, which explains the benchmark exceeding the listed categories. These included, for example: initiatives to establish demonstration laboratories, development of research agendas, and organising joint participation in trade fairs.
Number of active cooperation agreements between the cluster and institutions from the R&D and education sector	Mean: 6.8 Median: 1.0 Benchmark: 137.0 One-third of clusters do not have an active cooperation agreement with institutions from the R&D sector. It is worth noting that in eight clusters only one agreement is in place. Other clusters adopt a broader approach to cooperation with this category of institutions. In eight clusters, the number of agreements was equal to or greater than ten.
Number of education programmes in which the cluster was involved in launching and implementing activities in the past two years (vocational education | secondary education | higher education | postgraduate education)	Mean: 3.0 Median: 2.0 Benchmark: 14.0 Twenty-eight clusters were involved in creating new study programmes. The highest number of clusters engaged at the higher education level (24 clusters; 51 study programmes launched) and at the secondary education level (16 clusters; 30 programmes). By contrast, relatively few clusters (12) engaged in programmes at the vocational education level.
Number of completed placements/internships or industrial doctorates (placements | internships | industrial doctorates)	Mean: 51.4 Median: 5.0 Benchmark: 1,227.0 The leading cluster implemented more than 1.2 thousand placements, internships or industrial doctorates, significantly distorting (substantially inflating) the mean value. Excluding this cluster, the mean number of placements/internships would be 22.3. At the same time, 17 clusters do not engage in this area at all. In total, the study recorded 1,642 internships, 460 placements and 57 industrial doctorates.
Number of active cooperation agreements between the cluster and other business associations	Mean: 2.0 Median: 0.0 Benchmark: 21.0 Twenty-six clusters have an active cooperation agreement with another domestic cluster. Only in three cases did the number exceed five, with values of 12, 15 and 21 (benchmark).

Sub-area / Indicator	All clusters
Influence on shaping external conditions	
Number of consultative bodies (economic, social, scientific) at national and regional level in which representatives of the cluster coordinator sit (representing the cluster, not their parent organisations)	Mean: 3.5 Median: 2.0 Benchmark: 25.0 Representatives of cluster coordinators quite frequently sit on various consultative bodies. Such activity was reported by 33 clusters. In three clusters, representatives participated in ten or more bodies.
Activities undertaken by the cluster with a positive impact on society (e.g. in line with Environmental, Social and Governance criteria – ESG; the Creating Shared Value concept – CSV; Corporate Social Responsibility – CSR; etc.)	A total of 62% of clusters declared taking actions with a positive social impact. These activities encompass a wide range of educational, charitable and pro-environmental initiatives. Clusters organise training sessions, webinars and campaigns promoting sustainable development, the green transition and ethical business practices, involving local communities and young people. They also support social initiatives such as tree planting, charity collections, aid for Ukraine, and activities for care homes and schools. Furthermore, they collaborate with universities, schools and foundations. Through such actions, clusters strengthen local communities, promote civic engagement and contribute to building social capital.
Number of initiatives undertaken by the cluster in the past two years aimed at improving the external conditions for business activity for cluster members	Mean: 2.9 Median: 1.5 Benchmark: 20.0 Twenty-six clusters declared carrying out such initiatives. Only in four clusters did the number of initiatives reach or exceed ten. The total number of initiatives across all surveyed clusters was 121.

Sub-area / Indicator	All clusters
Impact on the natural environment	
Number and type of cluster activities aimed at improving the state of the natural environment	Mean: 6.4 Median: 6.0 Benchmark: 16.0 From the list of six types of activities, the most frequently indicated were: application of the circular economy (CE) concept (69%), R&D work in the area of low-emission technologies and the production and distribution of renewable energy (57% each). Less frequently applied were: implementing solutions based on energy efficiency audits (52%), implementing low-carbon economy projects (48%), and holding and implementing environmental certificates related to technologies (ETV) or products (Ecolabel) or equivalent certificates (38%). Clusters could also identify other environmental certificates, including: ISCC Plus, Blue Angel, TÜV Austria OK compost HOME/INDUSTRIAL, EuCertPlast, KZR INiG, Certificate of Product Chain of Custody CU-COC-861999, BREEAM, EcoVadis, EPD 459/2023 and 460/2023, EMAS, PEFC™, ISO 14001. In addition, clusters could indicate the application of the circular economy concept in six different areas. The most frequently reported were: production and waste management (76% each), followed by design and raw material management (69% each). CE was applied less frequently in distribution (55%) and consumption (45%). Clusters also had the option to indicate additional activities beyond the predefined list. Examples included training aimed at reducing negative environmental impacts (e.g. through improved production efficiency), forest planting, and strategic diagnostic work in the area of circular economy.
Specialisation and advanced technologies	
Number of cluster enterprises conducting business activity within the dominant National Smart Specialisation (Krajowa Inteligentna Specjalizacja – KIS) relevant to the cluster	Mean: 61.0 Median: 48.5 Benchmark: 365.0 This indicator and the following three are based on counting enterprises operating in a given area. Benchmarks therefore reflect the size of the very large clusters. As added value, the average share of enterprises active in each area was calculated (thus accounting for cluster size). On average, 61% of cluster enterprises conduct activity aligned with the cluster's dominant National Smart Specialisation (KIS). Only two clusters reported 100%.
Number of cluster enterprises conducting business activity within the dominant Regional Smart Specialisation (Regionalna Inteligentna Specjalizacja – RIS) relevant to the cluster	Mean: 55.1 Median: 43.5 Benchmark: 365.0 On average, 62% of cluster enterprises conduct activity aligned with the cluster's dominant Regional Smart Specialisation (RIS). Only in two clusters did this value reach 100%.

Sub-area / Indicator	All clusters
Number of cluster enterprises conducting business activity within the cluster's dominant industry (according to NACE/PKD divisions)	Mean: 60.6 Median: 42.0 Benchmark: 365.0 On average, 65% of cluster enterprises conduct activity aligned with the cluster's dominant industry (according to NACE/PKD divisions). Again, only two clusters reported 100%.
Number of cluster enterprises conducting business activity using technologies essential for the future economic development of the EU (Key Enabling Technologies – KET: micro- and nanoelectronics, photonics, biotechnology, advanced materials, advanced manufacturing, artificial intelligence, security and connectivity)	Mean: 32.7 Median: 17.0 Benchmark: 191.0 On average, 33% of cluster enterprises conduct activity based on technologies essential for the future economic development of the EU. Only two clusters reported 100%.

12.1.5. Cluster internationalisation

Table 16. List of partial indicators – cluster internationalisation area

Sub-area / Indicator	All clusters
Internationalisation potential	
Number of services offered by the cluster and/or through the cluster to support internationalisation (offer from the last two years)	Mean: 5.1 Median: 3.0 Benchmark: 60.0 A total of 34 clusters declared an offer of services supporting internationalisation. In 5 clusters this included 10 or more services. The most frequently indicated services included organising trade fair visits and economic missions. Participation in trade fairs could take various forms (e.g. a joint exhibition of cluster entities at fairs aligned with the cluster's industry, or individual organisation of a trade fair visit for a specific entity or a group of entities). Additional services included brand and product promotion abroad as well as soft support areas (such as advisory and training services).

Sub-area / Indicator	All clusters
Number of cluster members who, in the last two years, have used services supporting internationalisation (offered by the cluster and/or through the cluster)	Mean: 25.8 Median: 7.5 Benchmark: 162.0 In 12 clusters, the number of cluster members using internationalisation services equalled or exceeded 20. In five clusters it was at least 100 members. A total of 1,085 entities used such services, representing approx. 22.0% of all members of the analysed clusters. At the same time, a significant level of interest in internationalisation services can be observed among cluster members. The average level of interest is around 4.5 on a scale of 1 to 5 – where 5 indicates a very high level of interest (with the exception of establishing a foreign cluster representation, where interest is moderate). Given this interest, the 9 clusters that do not yet offer such services should consider introducing them.
Number of language versions (other than Polish) of the cluster's website	Mean: 1.7 Median: 1.0 Benchmark: 14.0 The number of language versions was verified by the research contractor’s team. It is worth noting that 12 clusters do not have a foreign-language version of their website. This edition once again includes the leader offering 14 foreign-language versions. In that case, Google tools were used to automatically translate the website’s content. Given the increasing quality of machine translation algorithms, this approach may be of interest to clusters that do not currently have any foreign-language website version. Due to the war in Ukraine, it is not surprising that on some websites the previously available Russian version has been removed entirely or replaced with a Ukrainian version.
International activity	
Number of active cooperation agreements with foreign entities	Mean: 6.0 Median: 3.0 Benchmark: 72.0 More than two-thirds of clusters (31) have signed cooperation agreements with foreign entities. In 6 clusters, the number of agreements is 10 or more.
Number of international projects implemented in the cluster (in partnership with foreign entities) in the last two years	Mean: 2.1 Median: 1.0 Benchmark: 14.0 A smaller number of clusters (23), compared to the previous indicator, implemented international projects in partnership with foreign entities. It can be assumed that some of the signed agreements are directly linked to these projects (e.g. establishment of a consortium requiring formal written agreements). The total number of implemented projects was 90.

Sub-area / Indicator	All clusters
Value of international projects implemented in the cluster (in partnership with foreign entities) in the last two years	Mean: 9,811.0 thousand PLN Median: 0.0 thousand PLN Benchmark: 86,275.0 thousand PLN A total of 18 clusters reported the value of international projects. It should be noted that such projects do not necessarily have budgets exceeding one million PLN, despite the high average value. Four clusters reported project values below 1 million PLN.
Number of international events organised or co-organised by the cluster in the last two years	Mean: 7.1 Median: 3.0 Benchmark: 120.0 A total of 29 clusters organised or co-organised international events. The leader in this category significantly inflates the average by declaring the organisation of 120 events. In 7 clusters the number of events was 10 or more.
Number of cluster entities that show the involvement of foreign units in the form of equity, branches or other forms (inward foreign direct investment in the cluster) in the last two years	Mean: 5.3 Median: 0.0 Benchmark: 68.0 Twenty clusters declared that among their members there are entities subject to inward foreign direct investment. The average number of entities showing foreign involvement among these clusters was 11.1 (though this value is inflated by the leader, with 68). Clusters with high values represent a range of industries, including ICT, automotive, manufacturing and construction.
Number of cluster entities that show involvement in units abroad in the form of equity, branches or other forms (outward foreign direct investment undertaken by cluster enterprises abroad) in the last two years	Mean: 2.7 Median: 0.0 Benchmark: 27.0 Outward foreign direct investment undertaken by cluster enterprises was declared by 19 clusters. Among these, the average number of entities showing involvement abroad was 5.9.
Export and pro-export activities	
Number of cluster enterprises that, in the last two years, conducted export activities (i.e., generated revenue from foreign sales)	Mean: 45.6 Median: 30.0 Benchmark: 229.0 Most coordinators (35) declared that cluster enterprises generate revenue from foreign sales. Among these clusters, the average number of enterprises generating foreign sales revenues was 49.0. In total, 1,731 cluster enterprises generated foreign sales revenues, representing approx. 42.0% of all enterprises in the clusters.

Sub-area / Indicator	All clusters
Share of export revenues of enterprises belonging to the cluster in the total sales revenues of enterprises that generated export revenues in the last year	Mean: 36.8% Median: 32.5% Benchmark: 86.0% A total of 23 clusters were able to indicate or estimate the share of export revenues in total sales revenues. For this group, the average export share was 40.0%. Clusters from the ICT sector as well as larger clusters in manufacturing stood out in this respect.
Number of foreign markets (countries) in which cluster enterprises are present	Mean: 32.7 Median: 20.0 Benchmark: 131.0 The most frequent foreign markets for clusters (with 10 or more indications from coordinators) were Germany, the USA, France, the Czech Republic, Norway, Portugal, Sweden and Spain. Some clusters also declare activity in broader terms (e.g. the entire European Union, North America, East and Southeast Asia such as Japan, South Korea, China, India, Vietnam, Singapore, the UAE). Responses also indicate the presence of cluster firms in less obvious and harder-to-access markets such as Kyrgyzstan, Tajikistan, Uzbekistan, Turkmenistan, Iran, Cameroon, Yemen, Paraguay, Venezuela, Ghana, Tanzania, Myanmar and Bhutan, usually as single cases. This may indicate increasing willingness to explore non-standard markets and growing readiness to internationalise beyond traditional export destinations.
Number of foreign trade fairs and exhibitions in which the cluster participated in the last two years	Mean: 10.0 Median: 4.0 Benchmark: 109.0 A total of 29 clusters declared participation in foreign trade fairs and exhibitions. Eleven clusters participated in 10 or more events, and in 5 clusters the number exceeded 20.
Number of cluster members who, through the cluster, took part in foreign trade fairs and exhibitions in the last two years	Mean: 17.9 Median: 9.0 Benchmark: 112.0 A total of 753 cluster members (15.2% of all members) participated in the events covered by the previous indicator. Eleven clusters declared that more than 20 members took part in these trips.
Number of other foreign events in which the cluster participated in the last two years	Mean: 8.1 Median: 4.0 Benchmark: 58.0 A total of 28 clusters indicated participation in other foreign events, with 9 clusters reporting more than 10 events.

Sub-area / Indicator	All clusters
Number of visits received by the cluster from foreign clusters	Mean: 2.7 Median: 2.0 Benchmark: 24.0 A total of 25 structures indicated hosting visits from foreign clusters. Only in two cases was the number of visits greater than or equal to 10. One cluster was a clear leader, reporting 24 visits from foreign clusters.

12.2. Results of the cluster coordinators’ survey (normalised values)

The tables included in this chapter present normalised indicator values at the level of sub-areas, areas and the overall result.

Table 17. Overview of results (all clusters)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.01	0.01	0.00	0.01	0.14	0.01	0.03	0.00	0.00	0.05	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.06
First quartile	0.12	0.08	0.02	0.08	0.42	0.22	0.16	0.20	0.25	0.58	0.31	0.04	0.00	0.13	0.08	0.13	0.17	0.08	0.14	0.20	0.13	0.02	0.14	0.13	0.17
Median	0.22	0.14	0.11	0.21	0.65	0.35	0.28	0.28	0.34	0.78	0.44	0.15	0.11	0.30	0.13	0.27	0.42	0.38	0.25	0.30	0.23	0.24	0.28	0.28	0.28
Mean	0.30	0.28	0.26	0.28	0.61	0.41	0.33	0.31	0.41	0.74	0.45	0.23	0.25	0.34	0.25	0.29	0.41	0.40	0.32	0.33	0.30	0.26	0.31	0.29	0.32
Third quartile	0.48	0.39	0.46	0.46	0.79	0.60	0.47	0.42	0.61	0.97	0.57	0.38	0.44	0.53	0.44	0.38	0.54	0.69	0.43	0.45	0.40	0.42	0.41	0.38	0.42
Benchmark	0.87	1.00	1.00	0.79	0.96	0.94	0.97	0.80	0.94	1.00	0.80	0.96	1.00	0.83	0.90	0.94	1.00	1.00	1.00	0.92	0.88	0.99	0.78	0.83	0.85

Source: own elaboration based on the cluster coordinators’ survey (N = 42).

Table 18. Overview of results (clusters established before 2010)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.01	0.03	0.00	0.01	0.14	0.12	0.03	0.00	0.00	0.22	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.03	0.06
First quartile	0.13	0.12	0.02	0.20	0.54	0.30	0.24	0.17	0.34	0.61	0.38	0.05	0.08	0.20	0.10	0.16	0.10	0.28	0.15	0.21	0.15	0.08	0.21	0.17	0.21
Median	0.35	0.28	0.32	0.35	0.69	0.39	0.36	0.33	0.46	0.84	0.48	0.16	0.34	0.30	0.27	0.31	0.46	0.50	0.25	0.32	0.31	0.29	0.30	0.30	0.36
Mean	0.35	0.38	0.33	0.36	0.65	0.46	0.41	0.32	0.46	0.77	0.49	0.28	0.35	0.35	0.32	0.31	0.40	0.47	0.35	0.35	0.37	0.33	0.35	0.34	0.37
Third quartile	0.57	0.63	0.51	0.53	0.80	0.63	0.53	0.42	0.68	0.99	0.58	0.43	0.56	0.54	0.44	0.40	0.54	0.66	0.44	0.45	0.50	0.44	0.50	0.43	0.44
Benchmark	0.67	0.97	1.00	0.79	0.93	0.94	0.97	0.80	0.94	1.00	0.80	0.96	0.87	0.80	0.90	0.94	1.00	1.00	1.00	0.92	0.88	0.99	0.78	0.83	0.85

Source: own elaboration based on the cluster coordinators’ survey (N = 42).

Table 19. Overview of results (clusters established in 2010–2014)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.03	0.01	0.00	0.03	0.24	0.01	0.04	0.07	0.02	0.21	0.18	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.07	0.06	0.00	0.00	0.00	0.01	0.07
First quartile	0.08	0.06	0.03	0.07	0.37	0.19	0.16	0.20	0.26	0.58	0.28	0.02	0.00	0.09	0.07	0.10	0.28	0.11	0.14	0.15	0.07	0.00	0.04	0.04	0.15
Median	0.17	0.11	0.15	0.12	0.59	0.29	0.24	0.23	0.32	0.78	0.41	0.18	0.07	0.22	0.11	0.23	0.43	0.25	0.27	0.26	0.19	0.11	0.22	0.18	0.24
Mean	0.28	0.26	0.27	0.26	0.58	0.35	0.29	0.28	0.43	0.74	0.42	0.21	0.25	0.31	0.23	0.25	0.43	0.34	0.33	0.30	0.22	0.17	0.29	0.23	0.29
Third quartile	0.36	0.31	0.43	0.44	0.75	0.52	0.45	0.33	0.59	0.91	0.57	0.32	0.43	0.48	0.47	0.39	0.55	0.64	0.47	0.47	0.29	0.38	0.39	0.35	0.48
Benchmark	0.87	1.00	1.00	0.69	0.96	0.89	0.71	0.70	0.88	1.00	0.74	0.62	1.00	0.79	0.65	0.71	1.00	0.94	0.95	0.63	0.82	0.53	0.78	0.61	0.60

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 20. Overview of results (clusters established in 2015–2020)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and techological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.12	0.03	0.01	0.04	0.20	0.17	0.04	0.16	0.08	0.05	0.26	0.00	0.00	0.05	0.04	0.11	0.16	0.00	0.04	0.18	0.08	0.00	0.00	0.06	0.15
First quartile	0.16	0.03	0.05	0.10	0.48	0.21	0.11	0.23	0.18	0.57	0.30	0.09	0.00	0.15	0.08	0.23	0.30	0.05	0.09	0.23	0.14	0.16	0.09	0.21	0.22
Median	0.21	0.09	0.08	0.13	0.59	0.39	0.18	0.41	0.26	0.70	0.40	0.13	0.00	0.41	0.12	0.30	0.38	0.19	0.21	0.31	0.27	0.32	0.23	0.24	0.28
Mean	0.21	0.11	0.07	0.12	0.58	0.40	0.24	0.36	0.27	0.67	0.40	0.18	0.04	0.38	0.16	0.33	0.41	0.35	0.23	0.34	0.29	0.27	0.24	0.26	0.26
Third quartile	0.23	0.12	0.09	0.15	0.75	0.53	0.39	0.43	0.30	0.87	0.46	0.21	0.07	0.55	0.19	0.34	0.52	0.77	0.31	0.40	0.35	0.37	0.38	0.34	0.30
Benchmark	0.39	0.33	0.13	0.21	0.82	0.72	0.52	0.57	0.67	1.00	0.59	0.48	0.14	0.83	0.40	0.85	0.75	0.81	0.57	0.66	0.65	0.45	0.47	0.45	0.33

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 21. Overview of results (clusters with KKK status)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.17	0.03	0.07	0.10	0.64	0.28	0.08	0.12	0.22	0.70	0.38	0.00	0.00	0.11	0.07	0.17	0.09	0.31	0.24	0.24	0.13	0.06	0.27	0.20	0.26
First quartile	0.28	0.16	0.28	0.33	0.68	0.37	0.33	0.24	0.37	0.79	0.53	0.17	0.09	0.27	0.26	0.28	0.46	0.50	0.37	0.39	0.28	0.30	0.33	0.33	0.33
Median	0.45	0.33	0.41	0.48	0.80	0.51	0.48	0.33	0.68	0.95	0.59	0.44	0.47	0.46	0.47	0.33	0.53	0.69	0.45	0.46	0.40	0.40	0.44	0.39	0.47
Mean	0.44	0.44	0.46	0.45	0.80	0.56	0.49	0.37	0.61	0.91	0.60	0.40	0.46	0.47	0.43	0.41	0.55	0.67	0.53	0.48	0.44	0.42	0.49	0.46	0.48
Third quartile	0.58	0.73	0.52	0.61	0.90	0.70	0.69	0.45	0.79	1.00	0.72	0.55	0.80	0.66	0.62	0.42	0.66	0.75	0.65	0.61	0.65	0.43	0.63	0.54	0.59
Benchmark	0.87	1.00	1.00	0.79	0.96	0.94	0.97	0.70	0.94	1.00	0.80	0.96	1.00	0.80	0.90	0.94	1.00	1.00	1.00	0.92	0.88	0.99	0.78	0.83	0.85

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 22. Overview of results (clusters without KKK status)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.01	0.01	0.00	0.01	0.14	0.01	0.03	0.00	0.00	0.05	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.06
First quartile	0.08	0.03	0.01	0.06	0.37	0.17	0.14	0.16	0.08	0.54	0.27	0.02	0.00	0.07	0.06	0.09	0.08	0.00	0.09	0.11	0.07	0.00	0.04	0.05	0.15
Median	0.13	0.08	0.03	0.10	0.47	0.26	0.20	0.23	0.28	0.59	0.33	0.09	0.00	0.22	0.10	0.16	0.33	0.13	0.15	0.20	0.14	0.09	0.17	0.16	0.19
Mean	0.20	0.17	0.12	0.16	0.48	0.30	0.22	0.27	0.28	0.62	0.34	0.12	0.10	0.25	0.13	0.22	0.32	0.22	0.17	0.23	0.20	0.15	0.18	0.17	0.21
Third quartile	0.24	0.17	0.10	0.20	0.62	0.36	0.30	0.40	0.34	0.83	0.45	0.16	0.13	0.36	0.15	0.31	0.51	0.25	0.22	0.31	0.30	0.28	0.24	0.24	0.26
Benchmark	0.81	0.86	0.80	0.68	0.82	0.72	0.53	0.80	0.63	1.00	0.50	0.40	0.65	0.83	0.44	0.85	0.75	0.81	0.50	0.66	0.82	0.53	0.75	0.52	0.43

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 23. Overview of results (biotechnology and medicine)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.17	0.08	0.00	0.24	0.17	0.17	0.03	0.12	0.33	0.58	0.23	0.08	0.00	0.11	0.13	0.00	0.00	0.00	0.25	0.06	0.06	0.06	0.14	0.12	0.16
First quartile	0.36	0.14	0.21	0.31	0.52	0.27	0.07	0.12	0.35	0.71	0.35	0.11	0.10	0.19	0.13	0.13	0.07	0.38	0.34	0.20	0.23	0.12	0.24	0.18	0.24
Median	0.48	0.32	0.32	0.35	0.66	0.40	0.16	0.17	0.36	0.77	0.40	0.15	0.23	0.27	0.19	0.18	0.10	0.50	0.39	0.25	0.28	0.28	0.28	0.28	0.29
Mean	0.45	0.30	0.29	0.35	0.54	0.48	0.20	0.23	0.39	0.77	0.39	0.21	0.25	0.36	0.25	0.17	0.19	0.42	0.36	0.24	0.28	0.27	0.25	0.26	0.30
Third quartile	0.57	0.48	0.40	0.39	0.68	0.61	0.30	0.28	0.40	0.84	0.43	0.24	0.38	0.44	0.31	0.22	0.22	0.55	0.41	0.29	0.34	0.43	0.30	0.35	0.36
Benchmark	0.66	0.49	0.52	0.48	0.68	0.94	0.44	0.44	0.49	0.97	0.53	0.46	0.56	0.80	0.49	0.32	0.54	0.69	0.44	0.39	0.50	0.44	0.31	0.37	0.45

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 24. Overview of results (chemical industry, construction and circular economy)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.07	0.01	0.00	0.03	0.24	0.01	0.09	0.07	0.30	0.59	0.20	0.02	0.12	0.05	0.07	0.07	0.13	0.25	0.13	0.11	0.00	0.00	0.00	0.02	0.09
First quartile	0.29	0.20	0.40	0.28	0.45	0.14	0.24	0.18	0.37	0.64	0.34	0.21	0.19	0.19	0.20	0.16	0.36	0.34	0.33	0.25	0.09	0.06	0.12	0.09	0.24
Median	0.30	0.40	0.48	0.46	0.75	0.44	0.45	0.31	0.61	0.83	0.58	0.44	0.44	0.56	0.48	0.44	0.49	0.69	0.46	0.57	0.22	0.32	0.36	0.32	0.51
Mean	0.35	0.44	0.53	0.42	0.66	0.37	0.47	0.34	0.56	0.79	0.52	0.39	0.47	0.45	0.42	0.43	0.56	0.59	0.46	0.47	0.33	0.31	0.36	0.34	0.43
Third quartile	0.48	0.69	0.72	0.61	0.89	0.58	0.65	0.46	0.70	0.90	0.69	0.59	0.75	0.64	0.61	0.65	0.84	0.75	0.60	0.63	0.51	0.42	0.57	0.54	0.59
Benchmark	0.58	0.92	1.00	0.68	0.96	0.64	0.97	0.70	0.79	1.00	0.78	0.67	0.87	0.79	0.75	0.82	1.00	0.94	0.79	0.75	0.88	0.80	0.78	0.74	0.73

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 25. Overview of results (education and advisory, food, tourism)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.04	0.03	0.00	0.04	0.20	0.11	0.04	0.03	0.02	0.05	0.18	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.07
First quartile	0.08	0.03	0.00	0.05	0.33	0.17	0.06	0.22	0.04	0.23	0.22	0.00	0.00	0.11	0.03	0.02	0.01	0.02	0.06	0.06	0.02	0.00	0.01	0.04	0.09
Median	0.08	0.06	0.04	0.07	0.39	0.22	0.17	0.33	0.15	0.39	0.29	0.03	0.01	0.25	0.06	0.07	0.04	0.06	0.14	0.09	0.14	0.00	0.07	0.06	0.13
Mean	0.10	0.11	0.07	0.09	0.40	0.31	0.22	0.29	0.19	0.42	0.29	0.10	0.04	0.34	0.12	0.23	0.14	0.11	0.11	0.20	0.16	0.03	0.12	0.09	0.16
Third quartile	0.12	0.15	0.10	0.11	0.50	0.39	0.33	0.41	0.27	0.56	0.34	0.13	0.06	0.52	0.12	0.30	0.26	0.11	0.14	0.25	0.30	0.02	0.17	0.13	0.21
Benchmark	0.17	0.33	0.20	0.21	0.61	0.72	0.53	0.42	0.52	0.89	0.45	0.39	0.14	0.83	0.40	0.85	0.42	0.44	0.23	0.66	0.36	0.15	0.36	0.23	0.30

Source: own elaboration based on the cluster coordinators’ survey (N = 42).

Table 26. Overview of results (ICT – information technology, electronics, digital technologies, cybersecurity)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.01	0.03	0.00	0.01	0.14	0.12	0.07	0.00	0.00	0.54	0.17	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.08	0.06	0.00	0.00	0.00	0.03	0.06
First quartile	0.12	0.04	0.04	0.07	0.42	0.17	0.22	0.20	0.08	0.63	0.29	0.07	0.00	0.07	0.04	0.11	0.35	0.00	0.15	0.20	0.09	0.09	0.09	0.10	0.15
Median	0.22	0.13	0.09	0.15	0.52	0.30	0.30	0.23	0.32	0.95	0.43	0.09	0.06	0.23	0.10	0.17	0.42	0.06	0.21	0.25	0.13	0.30	0.22	0.24	0.25
Mean	0.27	0.20	0.23	0.23	0.55	0.42	0.37	0.25	0.37	0.83	0.43	0.23	0.23	0.24	0.22	0.23	0.39	0.24	0.33	0.29	0.18	0.29	0.24	0.25	0.28
Third quartile	0.28	0.24	0.17	0.41	0.74	0.67	0.39	0.33	0.63	1.00	0.48	0.40	0.54	0.36	0.44	0.36	0.51	0.38	0.39	0.34	0.22	0.46	0.31	0.29	0.41
Benchmark	0.81	0.67	1.00	0.53	0.90	0.81	0.82	0.42	0.77	1.00	0.73	0.74	0.67	0.58	0.69	0.42	0.66	1.00	1.00	0.61	0.49	0.75	0.78	0.71	0.65

Source: own elaboration based on the cluster coordinators’ survey (N = 42).

Table 27. Overview of results (automotive, aviation and transport)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.15	0.03	0.00	0.06	0.43	0.26	0.13	0.18	0.22	0.22	0.34	0.00	0.00	0.01	0.07	0.09	0.08	0.00	0.04	0.08	0.14	0.01	0.08	0.18	0.20
First quartile	0.19	0.08	0.02	0.10	0.65	0.34	0.17	0.32	0.28	0.68	0.45	0.11	0.00	0.35	0.10	0.24	0.21	0.25	0.06	0.24	0.31	0.24	0.25	0.32	0.26
Median	0.39	0.12	0.13	0.17	0.79	0.42	0.23	0.40	0.34	0.83	0.47	0.19	0.00	0.46	0.15	0.26	0.51	0.38	0.18	0.28	0.38	0.39	0.47	0.45	0.31
Mean	0.43	0.28	0.22	0.31	0.73	0.49	0.28	0.43	0.45	0.77	0.50	0.22	0.20	0.43	0.25	0.24	0.42	0.45	0.27	0.29	0.48	0.31	0.44	0.39	0.35
Third quartile	0.60	0.33	0.48	0.53	0.82	0.65	0.33	0.51	0.54	0.97	0.57	0.34	0.35	0.54	0.36	0.29	0.54	0.69	0.24	0.38	0.71	0.42	0.56	0.51	0.43
Benchmark	0.87	0.86	0.58	0.68	0.93	0.89	0.52	0.80	0.88	1.00	0.74	0.48	1.00	0.78	0.62	0.32	0.75	0.81	0.95	0.51	0.82	0.45	0.75	0.54	0.59

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 28. Overview of results (metal, machinery and materials industries)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.07	0.06	0.01	0.08	0.37	0.21	0.12	0.07	0.04	0.41	0.29	0.00	0.00	0.12	0.06	0.27	0.33	0.13	0.07	0.23	0.12	0.00	0.14	0.10	0.15
First quartile	0.08	0.11	0.03	0.11	0.61	0.29	0.24	0.21	0.25	0.63	0.36	0.06	0.00	0.17	0.09	0.31	0.45	0.47	0.18	0.34	0.18	0.12	0.19	0.18	0.23
Median	0.17	0.12	0.14	0.16	0.71	0.31	0.46	0.23	0.49	0.82	0.45	0.15	0.19	0.22	0.12	0.36	0.60	0.66	0.31	0.45	0.23	0.26	0.37	0.30	0.32
Mean	0.23	0.36	0.25	0.29	0.69	0.36	0.40	0.29	0.49	0.78	0.49	0.26	0.31	0.27	0.28	0.43	0.63	0.59	0.35	0.46	0.31	0.30	0.36	0.33	0.37
Third quartile	0.32	0.53	0.40	0.35	0.81	0.38	0.49	0.37	0.71	0.94	0.60	0.28	0.53	0.24	0.35	0.44	0.74	0.78	0.49	0.47	0.41	0.35	0.42	0.35	0.39
Benchmark	0.49	1.00	0.86	0.79	0.93	0.64	0.69	0.64	0.94	1.00	0.80	0.96	0.86	0.76	0.90	0.94	1.00	0.88	0.80	0.92	0.73	0.99	0.74	0.83	0.85

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 29. Overview of results (small clusters – 20–49 members)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.01	0.01	0.00	0.01	0.14	0.01	0.04	0.00	0.00	0.21	0.17	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.06
First quartile	0.07	0.05	0.01	0.07	0.36	0.14	0.14	0.11	0.24	0.36	0.22	0.02	0.00	0.08	0.04	0.10	0.06	0.03	0.05	0.11	0.08	0.00	0.01	0.04	0.11
Median	0.12	0.10	0.02	0.10	0.39	0.28	0.21	0.28	0.29	0.82	0.39	0.08	0.00	0.26	0.09	0.14	0.37	0.19	0.11	0.20	0.17	0.01	0.11	0.10	0.16
Mean	0.24	0.19	0.09	0.18	0.45	0.32	0.22	0.31	0.27	0.67	0.35	0.10	0.05	0.27	0.11	0.17	0.33	0.28	0.10	0.19	0.17	0.14	0.12	0.14	0.19
Third quartile	0.35	0.16	0.08	0.16	0.57	0.48	0.25	0.40	0.33	0.93	0.46	0.14	0.01	0.44	0.13	0.26	0.53	0.34	0.14	0.25	0.24	0.31	0.20	0.22	0.26
Benchmark	0.81	0.86	0.53	0.68	0.82	0.67	0.53	0.80	0.52	1.00	0.50	0.37	0.40	0.56	0.42	0.32	0.75	0.81	0.16	0.38	0.36	0.45	0.29	0.33	0.43

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 30. Overview of results (medium clusters – 50–79 members)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.03	0.03	0.00	0.05	0.17	0.15	0.03	0.03	0.02	0.41	0.20	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.07	0.06	0.00	0.00	0.04	0.01	0.07
First quartile	0.08	0.03	0.01	0.06	0.44	0.17	0.15	0.15	0.06	0.55	0.27	0.02	0.00	0.10	0.06	0.07	0.10	0.00	0.16	0.13	0.07	0.02	0.12	0.14	0.16
Median	0.12	0.08	0.04	0.09	0.52	0.26	0.21	0.22	0.26	0.58	0.31	0.09	0.08	0.22	0.09	0.17	0.35	0.19	0.22	0.28	0.13	0.16	0.20	0.18	0.19
Mean	0.16	0.15	0.11	0.15	0.53	0.27	0.24	0.23	0.28	0.63	0.35	0.12	0.16	0.19	0.14	0.21	0.31	0.21	0.24	0.24	0.17	0.19	0.19	0.19	0.21
Third quartile	0.20	0.12	0.10	0.17	0.69	0.30	0.35	0.29	0.50	0.64	0.43	0.17	0.21	0.22	0.17	0.37	0.46	0.34	0.25	0.33	0.25	0.29	0.24	0.26	0.26
Benchmark	0.55	0.67	0.59	0.53	0.74	0.57	0.51	0.46	0.63	1.00	0.48	0.40	0.65	0.47	0.44	0.48	0.66	0.56	0.50	0.46	0.43	0.53	0.36	0.39	0.42

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 31. Overview of results (large clusters – 80–149 members)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.17	0.03	0.07	0.10	0.38	0.06	0.12	0.16	0.22	0.05	0.27	0.03	0.00	0.05	0.08	0.07	0.09	0.06	0.06	0.16	0.07	0.00	0.00	0.02	0.17
First quartile	0.21	0.14	0.15	0.21	0.67	0.29	0.29	0.23	0.29	0.76	0.39	0.15	0.11	0.18	0.12	0.27	0.27	0.34	0.28	0.25	0.14	0.19	0.31	0.26	0.30
Median	0.28	0.33	0.38	0.27	0.68	0.37	0.44	0.25	0.37	0.92	0.53	0.39	0.32	0.27	0.36	0.32	0.46	0.50	0.38	0.39	0.22	0.33	0.36	0.33	0.33
Mean	0.31	0.42	0.34	0.35	0.69	0.41	0.42	0.31	0.45	0.81	0.49	0.34	0.35	0.32	0.33	0.32	0.46	0.51	0.37	0.37	0.29	0.28	0.35	0.31	0.37
Third quartile	0.36	0.61	0.45	0.53	0.79	0.49	0.50	0.41	0.61	1.00	0.58	0.47	0.55	0.40	0.47	0.35	0.58	0.75	0.45	0.45	0.35	0.38	0.43	0.37	0.46
Benchmark	0.67	1.00	0.80	0.69	0.88	0.81	0.76	0.45	0.81	1.00	0.70	0.62	0.85	0.83	0.65	0.71	1.00	0.88	0.57	0.63	0.72	0.44	0.53	0.51	0.55

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 32. Overview of results (very large clusters – 150 or more members)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.13	0.03	0.00	0.04	0.20	0.32	0.04	0.12	0.24	0.58	0.31	0.00	0.00	0.01	0.07	0.09	0.08	0.00	0.36	0.08	0.28	0.00	0.00	0.06	0.23
First quartile	0.33	0.16	0.23	0.34	0.69	0.53	0.18	0.32	0.43	0.72	0.44	0.18	0.00	0.58	0.14	0.27	0.38	0.58	0.50	0.42	0.37	0.22	0.43	0.39	0.34
Median	0.56	0.28	0.48	0.44	0.88	0.64	0.45	0.39	0.74	0.84	0.66	0.34	0.44	0.62	0.48	0.41	0.53	0.69	0.79	0.57	0.54	0.42	0.68	0.53	0.53
Mean	0.48	0.36	0.50	0.43	0.77	0.64	0.45	0.41	0.65	0.84	0.60	0.39	0.43	0.60	0.44	0.48	0.56	0.62	0.70	0.53	0.56	0.44	0.57	0.51	0.50
Third quartile	0.60	0.48	0.79	0.59	0.92	0.72	0.64	0.51	0.86	0.99	0.74	0.62	0.81	0.78	0.67	0.74	0.84	0.84	0.88	0.65	0.73	0.67	0.75	0.69	0.64
Benchmark	0.87	0.97	1.00	0.79	0.96	0.94	0.97	0.70	0.94	1.00	0.80	0.96	1.00	0.80	0.90	0.94	1.00	1.00	1.00	0.92	0.88	0.99	0.78	0.83	0.85

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 33. Overview of results (no written cluster strategy)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.03	0.01	0.00	0.03	0.20	0.01	0.04	0.07	0.02	0.41	0.20	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.04	0.06	0.00	0.00	0.00	0.01	0.07
First quartile	0.07	0.03	0.02	0.06	0.29	0.13	0.13	0.16	0.20	0.56	0.24	0.01	0.00	0.08	0.07	0.08	0.15	0.05	0.10	0.15	0.06	0.00	0.03	0.02	0.15
Median	0.10	0.08	0.07	0.09	0.40	0.24	0.16	0.21	0.31	0.59	0.29	0.10	0.03	0.19	0.10	0.14	0.33	0.13	0.23	0.24	0.14	0.09	0.06	0.12	0.20
Mean	0.16	0.08	0.16	0.11	0.39	0.33	0.17	0.25	0.29	0.66	0.32	0.10	0.06	0.25	0.11	0.25	0.33	0.20	0.24	0.27	0.13	0.18	0.12	0.15	0.19
Third quartile	0.23	0.12	0.13	0.15	0.45	0.59	0.22	0.28	0.38	0.72	0.42	0.17	0.12	0.38	0.14	0.32	0.53	0.25	0.34	0.32	0.18	0.34	0.20	0.24	0.25
Benchmark	0.39	0.17	0.80	0.27	0.65	0.72	0.30	0.57	0.56	1.00	0.47	0.22	0.15	0.58	0.19	0.85	0.59	0.81	0.50	0.66	0.33	0.53	0.35	0.39	0.28

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 34. Overview of results (cluster strategy available as a written document but not updated)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.01	0.03	0.00	0.01	0.14	0.12	0.03	0.00	0.00	0.58	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.06	0.00	0.00	0.00	0.03	0.06
First quartile	0.08	0.04	0.00	0.07	0.17	0.17	0.18	0.07	0.23	0.80	0.23	0.00	0.00	0.07	0.01	0.09	0.00	0.00	0.11	0.06	0.06	0.00	0.00	0.04	0.14
Median	0.17	0.08	0.02	0.08	0.36	0.21	0.22	0.12	0.26	0.88	0.29	0.07	0.00	0.17	0.06	0.11	0.33	0.00	0.15	0.20	0.07	0.00	0.14	0.10	0.15
Mean	0.32	0.13	0.02	0.17	0.33	0.27	0.21	0.15	0.26	0.84	0.30	0.06	0.03	0.16	0.06	0.14	0.26	0.10	0.15	0.16	0.10	0.04	0.10	0.08	0.15
Third quartile	0.55	0.13	0.03	0.24	0.37	0.21	0.25	0.21	0.32	0.95	0.33	0.09	0.00	0.22	0.10	0.23	0.41	0.13	0.16	0.23	0.13	0.09	0.14	0.10	0.16
Benchmark	0.81	0.39	0.05	0.41	0.62	0.67	0.38	0.32	0.49	1.00	0.46	0.12	0.13	0.36	0.13	0.27	0.53	0.38	0.25	0.25	0.23	0.14	0.21	0.12	0.25

Source: own elaboration based on the cluster coordinators' survey (N = 42).

Table 35. Overview of results (cluster strategy available as a written document and regularly updated)

Measure	Human resources	Infrastructure resources	Financial resources	Cluster resources – overall for the area	Management processes	Cluster communication	Market activity	Marketing activity	Innovation activity	Cluster digitalisation	Cluster processes – overall for the area	Development of collaboration	Development of innovation	Development of competences	Cluster results – overall for the area	Collaboration with the external environment	Influence on shaping the environment	Impact on the natural environment	Specialisation and technological advancement	Impact on the environment – overall for the area	Internationalisation potential	International activity	Exports and pro-export activities	Cluster internationalisation – overall for the area	Overall result across all areas
Minimum	0.04	0.03	0.00	0.05	0.38	0.11	0.04	0.03	0.04	0.05	0.18	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.04	0.09
First quartile	0.17	0.11	0.08	0.12	0.64	0.30	0.21	0.23	0.28	0.59	0.39	0.08	0.00	0.19	0.10	0.19	0.21	0.25	0.16	0.24	0.22	0.15	0.25	0.23	0.26
Median	0.28	0.28	0.28	0.33	0.73	0.37	0.43	0.34	0.42	0.79	0.48	0.30	0.32	0.35	0.30	0.31	0.49	0.56	0.36	0.38	0.31	0.33	0.36	0.33	0.34
Mean	0.33	0.36	0.32	0.34	0.72	0.45	0.40	0.36	0.47	0.74	0.51	0.30	0.34	0.39	0.33	0.33	0.46	0.51	0.38	0.38	0.38	0.32	0.39	0.36	0.38
Third quartile	0.54	0.53	0.49	0.53	0.82	0.61	0.51	0.44	0.70	0.97	0.60	0.46	0.56	0.58	0.49	0.40	0.62	0.75	0.54	0.50	0.50	0.42	0.53	0.45	0.47
Benchmark	0.87	1.00	1.00	0.79	0.96	0.94	0.97	0.80	0.94	1.00	0.80	0.96	1.00	0.83	0.90	0.94	1.00	1.00	1.00	0.92	0.88	0.99	0.78	0.83	0.85

Source: own elaboration based on the cluster coordinators' survey (N = 42).

12.3. Results of the cluster members' opinion survey

A total of 733 entities participated in the cluster members' opinion survey. Each cluster included in the study was represented by at least five members. The summary below presents the aggregated results of the opinion survey conducted among members of all analysed clusters.

Table 36. Results of the cluster members' opinion survey

Question	Answers
1. Role in the cluster:	
▪ Cluster membership without participation in the work of specialized bodies of the cluster (cluster board, cluster council, scientific council, audit committee, working group, etc.)	79.5%
▪ Delegating an employee/employees to 1 specialized body of the cluster	15.3%
▪ Delegation of employees to 2 or more specialized bodies of the cluster	5.2%
2. Representing the cluster in economic, social and scientific consultative bodies (e.g. NCBR[165], NCN[166]):	
▪ Yes	9.3%
▪ No	78.8%
▪ I don't know / hard to say	11.9%
3. Participation in shaping the cluster's strategy:	
▪ Yes, we were part of the cluster strategy team	18.6%
▪ Yes, we consulted the cluster strategy (although we were not members of the cluster strategy team)	30.6%
▪ No	50.8%
4. Participation in the implementation of the cluster project[167]:	
▪ Yes	40.0%
▪ No	60.0%
[if there was an affirmative answer to question 4] 5. Participation in the implementation of an innovative and/or research and development project in the cluster:	
▪ Yes	49.7%
▪ No	50.3%

[165] National Centre for Research and Development Poland.

[166] National Science Center Poland.

[167] With the participation of the coordinator and min. 2 members or with the participation of min. 3 cluster members without a coordinator. This approach to the cluster project also applies to questions 6-8.

Question	Answers
6. Employees of the organization participated in joint forms of raising professional competences initiated in the cluster (such as training, workshops, courses) in the last 2 years:	
▪ Yes	**59.8%**
▪ No	**40.2%**
7. Participation in the following forms of joint market activity in the cluster:	"Yes" | "No, but we would like to in the future" | "No, and we don't want to in the future"
▪ Product and/or service development and planning	**35.8% | 53.9% | 10.4%**
▪ Procurement (in raw materials and semi-finished products)	**13.6% | 50.2% | 36.2%**
▪ Production and/or performance of the service	**20.8% | 60.6% | 18.6%**
▪ Marketing and sales	**34.9% | 52.8% | 11.0%**
▪ Distribution	**8.7% | 47.9% | 43.4%**
▪ after-sales service	**20.7% | 57.7% | 21.5%**
▪ Export activities	**34.4% | 42.5% | 23.0%**
8. Using the following pro-innovation services provided in the cluster by or through the cluster:	"Yes" | "No, but we would like to in the future" | " No, and we don't want to in the future"
▪ Monitoring of technological trends	**34.4% | 42.5% | 23.0%**
▪ Technological audit	**15.2% | 58.4% | 26.4%**
▪ Commercialization plans	**16.8% | 51.4% | 31.9%**
▪ Consulting in the field of industrial protection	**13.1% | 53.2% | 33.7%**
▪ Specialized training	**46.0% | 47.5% | 6.5%**
▪ Digital transformation and the use of Industry 4.0 technologies (such as: Internet of Things, Big Data, Intelligent Industrial Robots, Data Cloud, Simulations, 3D Printing, automated, robotic and digitized production systems, etc.)	**31.1% | 56.7% | 12.2%**
▪ Green transformation (e.g.: use of the circular economy concept in operations, possession and implementation of environmental certificates for technologies (ETV) or for products (Ecolabel) and others, implementation of solutions resulting from energy efficiency audits, R&D works in the field of low-emission technologies or innovations technologies in the area of green economy, production and distribution of energy from renewable sources (e.g. own photovoltaic installations, heat pumps, biogas plants), implementation of low-emission economy projects conducted by the cluster coordinator or members.	**24.2 | 57.7% | 18.1%**
▪ Other technological consultancy	**26.4% | 57.6% | 16.0%**

Question	Answers
9. Using services for internationalization provided in the cluster by or through the cluster:	
▪ No - we have not received an offer of internationalization services	**32.5%**
▪ No - we received an offer of services for internationalization, but we did not take it up	**36.6%**
▪ Yes - we have used internationalization services provided by or through the cluster	**30.9%**
10. Assessment of the achievement of development goals in the cluster:	"Achieved" | "Average" | "Not achieved" | "Don't know / hard to say"
▪ Building a network of relations with cluster enterprises	**69.6% | 17.0% | 2.1% | 11.4%**
▪ Gaining access to tangible and intangible resources	**42.5% | 26.3% | 7.8% | 23.4%**
▪ Increasing the quality of products and services and/or reducing the cost of running a business.	**37.2% | 22.0% | 10.5% | 30.4%**
▪ Impact on public authorities and other institutions (e.g. educational)	**36.5% | 21.3% | 10.9% | 31.3%**
▪ Development of cooperation between cluster members	**64.2% | 18.9% | 4.0% | 13.0%**
▪ Creating local supply chains - faster access to production materials and the ability to choose a supplier, lower transport costs	**24.7% | 23.8% | 14.8% | 36.7%**
▪ Joint marketing activities with partners from the cluster and greater possibilities of product distribution	**49.7% | 21.6% | 8.9% | 19.9%**
11. The scale of benefits from participation in the cluster for the period 2022-2023:	
▪ Large benefits	**55.3%**
▪ Small benefits	**21.8%**
▪ None	**2.2%**
▪ Don't know / hard to say	**20.8%**
12. Assessment of the adequacy of the contribution to the benefits obtained by the organization from participation in the cluster:	
▪ We get more than we expected with this amount of premium	**14.8%**
▪ What we get is adequate to the amount of the premium	**62.9%**
▪ We get less than we expected with this amount of premium	**7.3%**
▪ Not applicable (we do not pay a cluster membership fee)	**15.0%**

Question	Answers
13. Readiness to pay higher membership fees provided that the coordinator provides additional services:	
▪ No	**91.3%**
▪ Yes	**8.7% (representing 22 clusters)**
○ up to the amount (annually)[168]:	**6 750 PLN**
○ in exchange for the following services:	**The most frequently indicated areas included: support in acquiring clients and contracts (including the creation of purchasing groups); lobbying and representative activities towards public institutions; organisation of trade fairs, business missions and promotional events; advisory and training services (including in EU funding, intellectual property protection, digitalisation and AI); as well as support for foreign expansion and internationalisation.**
14. Improvement of the organization's activity on the market thanks to participation in the cluster:	"Yes" | "No" | "Don't know / hard to say"
▪ Regional market	**52.7% | 19.1% | 28.2%**
▪ Domestic market	**45.6% | 23.1% | 31.3%**
▪ Foreign market	**26.5% | 38.6% | 35.0%**
15. Improvements in the organisation's performance in the following areas:	"Yes" | "No" | "Don't know / hard to say"
▪ Number of subcontractors	**26.9% | 43.8% | 29.4%**
▪ Production volume / service volume	**26.6% | 42.6% | 30.8%**
▪ Revenue growth	**36.8% | 32.0% | 31.2%**
▪ Number of innovations introduced	**36.9% | 34.5% | 28.6%**
▪ Level of digitalisation and use of Industry 4.0 technologies (such as the Internet of Things, Big Data, intelligent industrial robots, cloud computing, simulations, 3D printing, automated, robotised and digitalised production systems, etc.)	**30.0% | 40.9% | 29.1%**
▪ Green transition (e.g. application of circular economy concepts; possession and implementation of environmental technology certificates (ETV) or product-related certificates (Ecolabel) or others; implementation of solutions resulting from energy efficiency audits; R&D work in low-	**24.7% | 43.9% | 31.4%**

[168] The average value across all responses.

Question	Answers
emission technologies or technological innovations in the field of the green economy; generation and distribution of energy from renewable sources (e.g. own photovoltaic installations, heat pumps, biogas plants); implementation of low-emission economy projects carried out by the cluster coordinator or cluster members)	
▪ Number of business partners / contractors	**45.5% | 28.4% | 26.1%**
▪ Number of new investments	**26.6% | 45.2% | 28.3%**
▪ Increase in technological advancement	**37.1% | 34.8% | 28.1%**
▪ Level of expenditure on research and development	**23.3% | 46.7% | 30.0%**
▪ Export volume	**20.6% | 51.6% | 27.8%**
▪ Acquisition of new clients / markets	**48.5% | 26.5% | 25.0%**
▪ Ability to meet challenges related to disruptive change	**28.7% | 29.5% | 41.9%**
16. As a result of participation in the cluster, the organisation introduced product innovations or business process innovations:	
▪ Product innovations (a service or product that is new or significantly improved)	**25.5%**
▪ Business process innovations (including new or improved methods of production; logistics, supply or distribution processes; service creation and delivery; as well as new organisational methods)	**29.8%**
▪ We did not introduce any innovations	**44.7%**
17. As a result of participation in the cluster, the organisation established and/or intensified cooperation with research institutions:	
▪ Yes	**44.7%**
▪ No	**36.4%**
▪ I don't know / hard to say	**18.9%**
18. As a result of participation in the cluster, the organisation established business relations with foreign partners:	
▪ Yes	**37.2%**
▪ No	**44.3%**
▪ I don't know / hard to say	**18.5%**

Question	Answers
19. Assessment of the availability of resources in the cluster: [rating scale from 1 – low rating to 5 – high rating][169]	
▪ Research infrastructure	**3.9**
▪ Production infrastructure	**3.5**
▪ Communication platform	**4.3**
▪ IT equipment and software	**3.9**
▪ Financial instruments (e.g. loan and guarantee funds, venture capital, seed capital)	**3.4**
20. Assessment of the suitability of the cluster's research and production infrastructure for the organisation's needs: [rating scale from 1 – low rating to 5 – high rating]	
▪ Research infrastructure	**3.8**
▪ Production infrastructure	**3.5**
21. Assessment of the number of staff employed by the cluster coordinator to support cluster operations:	
▪ Sufficient	**54.4%**
▪ Insufficient	**16.4%**
▪ Hard to say / no opinion	**29.1%**
22. Needs or satisfaction surveys were carried out among cluster participants:	
▪ Yes, carried out regularly (i.e. at regular intervals)	**37.8%**
▪ Yes, carried out ad hoc	**44.5%**
▪ No, not carried out	**17.7%**
[if "yes" selected in question 22] 23. Following the needs or satisfaction surveys, the cluster implements improvement actions (aimed at better addressing participants' needs and increasing their satisfaction):	
▪ Yes, numerous actions are implemented	▪ 54.7%
▪ Yes, but only a few actions are implemented	▪ 16.3%
▪ No actions are implemented	▪ 0.2%
▪ I don't know / hard to say	▪ 28.8%

[169] In the survey, the available response options were: "Low rating", "Average", "High rating", and "Don't know / hard to say". To enhance the clarity of the analysis, the responses were quantified and presented numerically, where 1 indicates a low rating, 3 an average rating, and 5 a high rating. An average value was calculated for the responses provided by cluster members. The responses to questions 20 and 24 were presented in the same way.

Question	Answers
24. Assessment of the cluster coordinator's activities in the following areas: [rating scale from 1 – low rating to 5 – high rating]	
▪ Integration and development of relationships within the cluster	4.7
▪ Market activity (e.g. joint products/services, procurement, distribution)	4.1
▪ Marketing activity (e.g. joint promotion)	4.4
▪ Innovation activity (e.g. pro-innovation services, innovation development)	4.2
▪ Actions supporting cluster digitalisation / implementation of Industry 4.0 technologies	4.3
▪ Actions supporting the cluster's green transition	4.2
▪ Development of collaboration within the cluster (e.g. joint projects)	4.3
▪ Development of the cluster's cooperation with external entities (e.g. R&D sector, business support institutions, other clusters)	4.4
▪ Development of competences within the cluster (e.g. training, courses)	4.5
▪ International activity (e.g. services supporting internationalisation)	4.3
▪ Response to challenges related to disruptive change	4.1
25. Priority areas for the organisation over the next two years: [rating scale from 1 – no to 5 – yes][170]	
▪ Integration and development of relationships within the cluster	4.6
▪ Market activity (e.g. joint products/services, procurement, distribution)	4.4
▪ Marketing activity (e.g. joint promotion)	4.6
▪ Innovation activity (e.g. pro-innovation services, innovation development)	4.5
▪ Actions supporting cluster digitalisation / implementation of Industry 4.0 technologies	4.4
▪ Actions supporting the cluster's green transition	4.0
▪ Development of collaboration within the cluster (e.g. joint projects)	4.6
▪ Development of the cluster's cooperation with external entities (e.g. R&D sector, business support institutions, other clusters)	4.6
▪ Development of competences within the cluster (e.g. training, courses)	4.6
▪ International activity (e.g. services supporting internationalisation)	4.5
▪ Preparation for challenges related to sudden disruptive situations (e.g. as in the case of the COVID-19 pandemic, the war in Ukraine, etc.) – enhancing economic resilience	4.1

[170] In the survey, the available response options were: "No", "Average", "Yes", and "Don't know / hard to say". To improve the clarity of the analysis, the responses were quantified and presented numerically, where 1 indicates "no", 3 "average", and 5 "yes". An average value was calculated for the responses provided by cluster members. The responses to question 26 were presented in the same way.

Question	Answers
26. Activities that the cluster should undertake to support the internationalisation of its members over the next two years: [rating scale from 1 – no to 5 – yes]	
▪ Participation in international trade fairs	**4.8**
▪ Organisation of international industry events	**4.5**
▪ Participation in foreign business trips (including business missions)	**4.7**
▪ Initiation of international projects	**4.6**
▪ Activities stimulating exports	**4.5**
▪ Establishment of a foreign cluster representative office	**2.9**
▪ Provision of services supporting the internationalisation of activities	**4.4**
▪ Cooperation with foreign entities	**4.7**

Source: own elaboration based on the cluster members' survey (N = 733).

PARP

Grupa PFR

ul. Pańska 81/83
00-834 Warszawa, Poland
Tel: +48 22 432 80 80
Fax: +48 22 432 86 20
www.parp.gov.pl

Information: 801 332 202
info@parp.gov.pl