Clusters as platforms for business-research (B2R)/research-business (R2B) relations

Country Report – Poland

Visegrad Fund

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Reviewer:

dr hab. inż. Anna Lis, prof. PG

Proofreading:

Firma Usługowa „MOLGA" Joanna Molga

Authors:

dr hab. Mariola Grzybowska-Brzezińska, prof. UWM

dr Małgorzata Kędzior-Laskowska

dr hab. Arkadiusz Kowalski, prof. SGH

dr Dominika Kuberska

dr hab. Wiesława Lizińska, prof. UWM

dr Marta Mackiewicz

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List of abbreviations

B2R	business to research
CI	cluster initiative
CO	cluster organization
IDI	in-depth interview
KNC	Key National Cluster
NDA	non-disclosure agreement
R	researcher or another person employed by a university or a research organization
R2B	research to business
R&D	research and development
R&D&I	research, development, and innovation
RO	research organization
UNIV	university
V4	Visegrad

Summary

This report presents the results of the Polish part of the research conducted as part of the project “Clusters as platforms for business-research (B2R)/research-business (R2B) relations” under Visegrad Grant No. 22030333. The aim of this report is to identify models, motives, forms and benefits of collaboration between business and research sectors facilitated by cluster organizations in Poland. The research methods used included: in-depth interviews with cluster organizations’ managers, a survey of research organizations engaged in collaboration under clusters, and additional interviews with the representatives of the research organizations to expand on the information collected in the survey.

The report begins with an examination of the current state of business-research collaboration, based on the statistical analysis of data from Statistics Poland (GUS). It is followed by an overview of cluster development in Poland in recent years, which is closely tied to the country’s membership in the European Union – both in terms of strategic directions and the financing tools, which are primarily based on structural funds. The Polish cluster policy has evolved along the lines of increasingly emphasizing maintenance of established cluster organizations while marginalizing emerging clusters. Since 2015, clusters deemed globally competitive and strategic to the Polish economy have been classified as National Key Clusters (NKCs).

Cluster policy in Poland is, to huge degree, an element of innovation policy, as clusters are recognized as a way to increase the level of collaboration between companies, as well as between the science and business sectors. Consequently, development of Polish clusters may be an effective method to overcome one of the primary impediments to the economy's innovativeness, namely the low degree of collaboration. This assumption is confirmed by the statistical analysis included in this report, which demonstrates that collaboration between innovation-active enterprises and universities/other higher education institutions is more common than collaboration with government or public research institutes, and that collaboration also occurs more frequently between innovation-active enterprises then between non-innovative entities. Furthermore, cluster collaboration was greater among large firms, which are more innovative than small and medium-sized businesses.

According to the research findings of the project, all cluster organizations in Poland that participated in the study had developed partnerships with both universities and other research institutions, such as technology transfer centers, science/technology parks, regional innovation forums, and so on. Developing science-business cooperation was part of the clusters' strategic approach, since nearly all of cluster organizations created a strategic plan emphasizing the necessity of collaboration with research units.

The results point to factors that motivate researchers to pursue collaboration with the cluster organizations and their members, while also shedding light on the benefits to stakeholders. Opportunities to expand personal networks was the most crucial motivator for scientists to pursue collaboration with businesses in Polish clusters, followed by new avenues of commercializing research results. Other incentives for collaboration include non-financial research benefits (such as access to data, information exchange with professionals, and technological development), as well as gaining research funds and personal financial rewards. Furthermore, respondents identified a number of additional criteria that drove them to pursue collaboration with the cluster organization and its members, including: maintaining close ties to business practice, opportunities for experience exchange, participation in projects, relationship building with other entities, prestige, study visits, and the utility of performed research in the commercial world.

In fact, B2R/R2B in cluster organizations can take several forms, including local and international joint projects, as well as participation in seminars, information exchange forums, and the utilization of resources at research organizations or universities. Implementation of industrial doctorate programs and liaison offices, on the other hand, are still less popular among cluster managers. Consulting, training, conducting research, preparing project applications or offers, gaining membership in a cluster organization's management board, and supervising commissioned bachelor's/master's/doctoral theses were the modes of collaboration with a cluster organization most frequently reported by representatives of the research units. Business-related activities are the most common type of business collaboration within the cluster structure of academia-business collaboration, followed by research-related activities and education-related activities.

The study pinpoints factors that promote B2R/R2B collaboration in cluster organizations, with communication between cluster members, mutual trust, and personal relationships between cluster members being the most important. The study also identifies other drivers, specifically: financial resources, human resources, facilities, geographic proximity, cross-sector similarities, capacity and fields of research of UNIV/RO matching the needs of firms in the cluster, and reputation/prestige gains. Conversely, the most significant barrier to collaboration lies in its cost (due to administrative overheads) and, to a relatively smaller extent, cross-sector differences and capacity constraints to R&D&I among SMEs.

The study sheds light on the most significant benefits of B2R/R2B in cluster organizations, such as identifying and resolving technological issues raised by businesses, increasing mutual trust between scientists and entrepreneurs, expanding academia-industry collaboration, facilitating knowledge transfer from academia to industry with mutual benefit, and increasing opportunities for various types of activities, such as: postgraduate studies, sectoral conferences, internships, doctoral implementations, strategic alliances, joint research projects,

the ability to influence university curricula, the use of laboratories and other university facilities to solve real technological problems encountered by businesses, development of technological processes, access to expertise, increased opportunities for knowledge sharing/upskilling, and the acquisition of information/knowledge about new technological trends.

The findings of the study show that one of the outcomes of cooperation in Polish clusters was the opening of and participation in various international R&D&I projects, which resulted in a variety of benefits such as: solving technological problems, deploying technologies, and networking, as well as gaining competences, experience, knowledge, and skills. This demonstrates that internationalization is becoming a significant tendency in the growth of Polish clusters, which are expanding outside their local collaboration frameworks and into worldwide collaboration networks. This indicates that clusters have reached a new stage of life in which, following a period of primarily local collaboration, the time has come to establish trans-regional and cross-border collaboration networks.

The study also identifies and present best B2R/R2B practices in cluster companies in Poland, like Sano Center, AERONET Aviation Valley Center of Advanced Technology, and the business cycle barometer. These practices demonstrate the systemic character of collaboration between enterprises and research organizations, the cluster manager's active participation in the partnership's inception, and the potential for replication by other cluster organizations. The essential feature of the presented best practices is that they promote collaboration between research and business, resulting in information sharing and technology transfer. The final section of the report contains recommendations for cluster policy (especially in the area of stimulating science-business cooperation) based on the findings of the study.

Introduction

This national report was written under the project "Clusters as platforms for business-research (B2R)/research-business (R2B) relations co-financed by the Governments of Czechia, Hungary, Poland and Slovakia" through Visegrad Grants from International Visegrad Fund (Visegrad Fund project No. 22030333).

The research goal of the project is to identify models of collaboration between business and research facilitated by cluster organizations, based on the mapping of best practice across V4 countries. According to theoretical cluster model, such collaboration should emerge in every cluster as one of the cornerstones of its existence. The project also seeks to demonstrate why both companies and research organizations benefit from working together.

The project focuses on cluster organizations and avenues for collaborative efforts between business and research within the territorial ecosystems in Czechia, Hungary, Poland and Slovakia, in accordance with the quadruple helix model. Additional goals of the project are:

- to examine the motives for B2R/R2B partnerships between business and research institutions in cluster organizations,
- to identify factors which shape B2R/R2B in cluster organizations,
- to identify forms of B2R/R2B in cluster organizations,
- to define the best practices of B2R/R2B in cluster organizations that can be transplanted and implemented in other V4 countries.

According to the project's methodology, the research presented in this national report was conducted in three steps:

1. Carrying out in-depth interviews with cluster organizations' managers to define the role of research organizations in clusters organizations.
2. Conducting a survey among research organizations to collect data on the different forms of collaboration and their main benefits.
3. Conducting interviews with the representatives of research organizations to expand on the data collected in the survey.

The purpose of the in-depth interviews was to gather qualitative information on the role of research organizations in cluster organizations, to assess the added value of collaboration, and to identify forms of collaboration that work well. The interviews provided information on (i) the lessons learned so far and (ii) the expectations and needs for policy instruments that may improve B2R/R2B partnerships. This part of the study served to identify the main motives for partnering up, the outcomes of collaboration, and the factors that may determine its forms and

scope. The interviews helped diagnose the most important challenges and barriers to be taken into account when designing prospective support instruments. The subsequent steps of the study built upon the interviews with cluster organizations' managers. The purpose of the survey among research organizations was to gather up-to-date, comparable data on the forms of collaboration with enterprises, as well as the resultant benefits for research organizations and universities. To further explore collaboration from the perspective of the science sector, semi-structured interviews were carried out with employees of the research organizations that deal directly with companies belonging to cluster organizations. The research methods and the sample were presented in the inception report. The data was collected between May and October 2021. It was supplemented by a comprehensive analysis of secondary data and web scraping.

The present national report elaborates upon the data collected during the study. The whole project encompasses four national reports: for Czechia, Hungary, Poland and Slovakia. The purpose of the reports was to analyze the role of cluster organizations in facilitating partnerships between enterprises and research organizations. The national reports present key findings about such partnerships and good practice that can be disseminated.

The national report is structured as follows. The first chapter provides an analysis of the current status of collaboration between business and research institutions. The second chapter gives an overview of the cluster landscape in the country, as well as the national cluster policy in recent years. It also includes a profile of cluster organizations that took part in the study. The third chapter provides information on the motives for pursuing B2R/R2B in cluster organizations and the related benefits for the stakeholders, including factors that have motivated researchers to pursue collaboration with a cluster organization and its members. The fourth chapter gives an overview of the forms of B2R/R2B functioning in practice among cluster organizations. The fifth chapter discusses the factors shaping (and, in particular, promoting) B2R/R2B collaboration in cluster organizations. The challenges, barriers and detrimental factors were analyzed in the following chapter to answer the question of what can hinder B2R/R2B. In the respondents' opinion, the cost of collaboration brought on by administrative overheads is the most significant barrier. The seventh chapter presents good practices of collaboration in cluster organizations that can be transplanted and implemented in other V4 countries. Finally, the last chapter provides recommendations and conclusions, focusing on suggested measures to improve cluster policy and to support cluster organizations.

The Authors of the report would like to express their sincerest gratitude to all the respondents that kindly agreed to participate in the study and to share their knowledge, opinions and thoughts.

Current status of cooperation between business and research organizations

Cooperation of enterprises in Poland

The share of enterprises in Poland that cooperated with other enterprises or organizations in 2017–2019 stood at 6.8%. According to Główny Urząd Statystyczny (2021) (Statistics Poland) the share was different among NUTS2 regions, with the highest share recorded in Podkarpackie voivodeship (10.4%), followed by Śląskie voivodeship (8.2%), and Mazowieckie voivodeship (8.1%). The lowest shares were recorded in Kujawsko-Pomorskie voivodeship (5.0%), Warmińsko-Mazurskie voivodeship (4.7%), and Pomorskie voivodeship (4.6%).

5.1% of enterprises collaborated with other enterprises and organizations in innovation activities. In this regard, the largest shares among voivodeships were recorded in Podkarpackie voivodeship (7.9%), Opolskie voivodeship (6.5%) as well as Podlaskie and Śląskie voivodeships (both at 6.1%), whereas the lowest were noted for Pomorskie voivodeship (3.9%), Warmińsko-Mazurskie voivodeship (3.0%), and Zachodniopomorskie voivodeship (2.9%) (Główny Urząd Statystyczny 2021).

4.0% of enterprises engaged with other enterprises and organizations in research and development (R&D) activities. Podkarpackie voivodeship (6.8%), Opolskie voivodeship (5.6%) as well as Lubelskie, Podlaskie, and Śląskie voivodeships (all at 5.0%) recorded the highest shares, whereas Dolnośląskie and Warmińsko-Mazurskie voivodeships (both at 2.6%) as well as Zachodniopomorskie voivodeship (1.7%) ranked the lowest (Główny Urząd Statystyczny 2021).

Partnerships are more frequent among innovation active enterprises. 23.4% of them cooperated in the field of innovation in 2017–2019. At the same time, the share of innovation active enterprises which undertook R&D-centered partnerships equaled 18.6%. Results for the respective NUTS2 regions in Poland are presented in Table 1.

Table 1. Innovation active enterprises cooperating in 2017–2019 [in % of innovation active enterprises]

Voivodeship	Innovation active enterprises which cooperated with other enterprises or organizations in innovation activity	Innovation active enterprises which cooperated with other enterprises or organizations in R&D activity
Dolnośląskie	22.0	11.1
Kujawsko-pomorskie	22.3	19.9
Lubelskie	29.2	26.7
Lubuskie	23.9	20.9
Łódzkie	21.3	15.2
Małopolskie	20.0	17.8
Mazowieckie	24.2	19.8
Opolskie	27.7	23.6
Podkarpackie	27.6	24.1
Podlaskie	19.8	16.2
Pomorskie	20.3	16.6
Śląskie	28.2	23.4
Świętokrzyskie	27.2	15.6
Warmińsko-mazurskie	13.7	11.6
Wielkopolskie	22.7	17.8
Zachodniopomorskie	18.9	10.9

Source: own elaboration based on Główny Urząd Statystyczny 20

Collaboration in innovation activities can take place between various cooperants, which include educational and research organizations. Innovation active enterprises are more likely to partner up with universities or other higher education institutions than with government or public research institutes (Figure 1). In 2017–2019 13.2% of innovation active enterprises collaborated with the former and 7.8% with the latter.

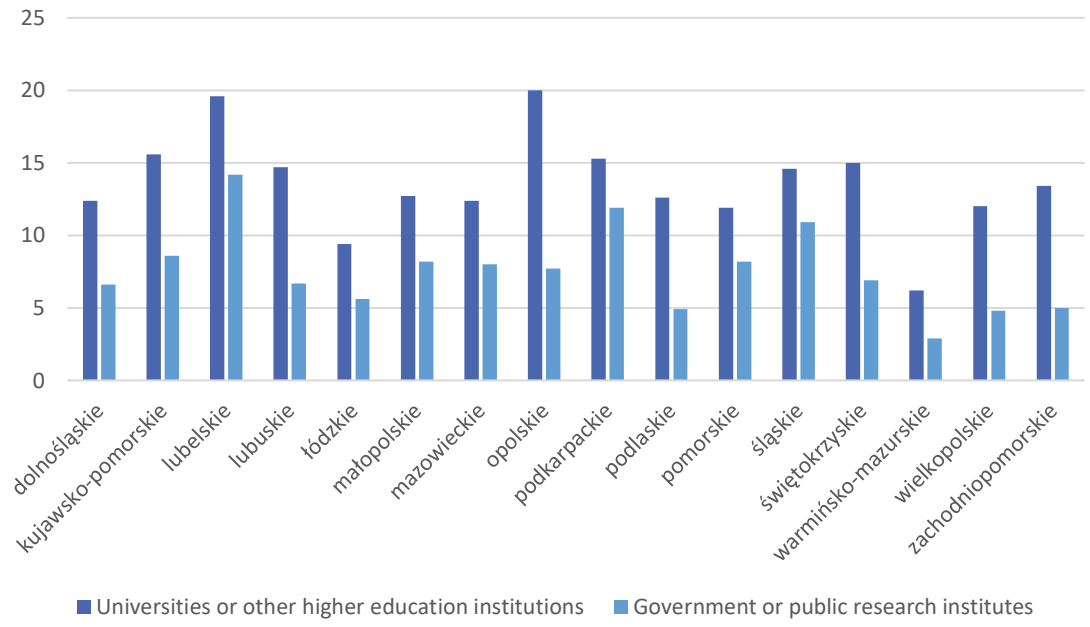


Figure 1. Innovation active enterprises in innovation activities with universities and other education and/or research organizations [in % of innovation active enterprises]

Source: own elaboration based on Główny Urząd Statystyczny

In 2017–2019, the share of enterprises collaborating in clusters in Poland amounted to 3.2% for industrial enterprises and 2.5% in the service sector (Table 2). Large companies were more open to this type of partnership. Among enterprises employing between 10 and 49 people, the share of companies cooperating in clusters stood at 1.9% for the industry sector and 2.1% for the service sector. For enterprises employing between 50 and 249 people the ratios were 5.8% and 4.1% respectively, whereas for enterprises employing 250 people and more the results were 10.6% and 6.0% respectively.

Table 2. Enterprises cooperating within clusters in 2017–2019 [in % of all enterprises]

Specification	Enterprises engaged in cluster cooperation
Industry and services	2.9
industry	3.2
services	2.5

Source: own elaboration based on Główny Urząd Statystyc

The share of industrial enterprises collaborating within clusters exceeded 5% in three out of 16 voivodeships (Figure 2), including: Podkarpackie voivodeship (7.7%), Podlaskie voivodeship (5.8%), and Zachodniopomorskie voivodeship (5.4%).

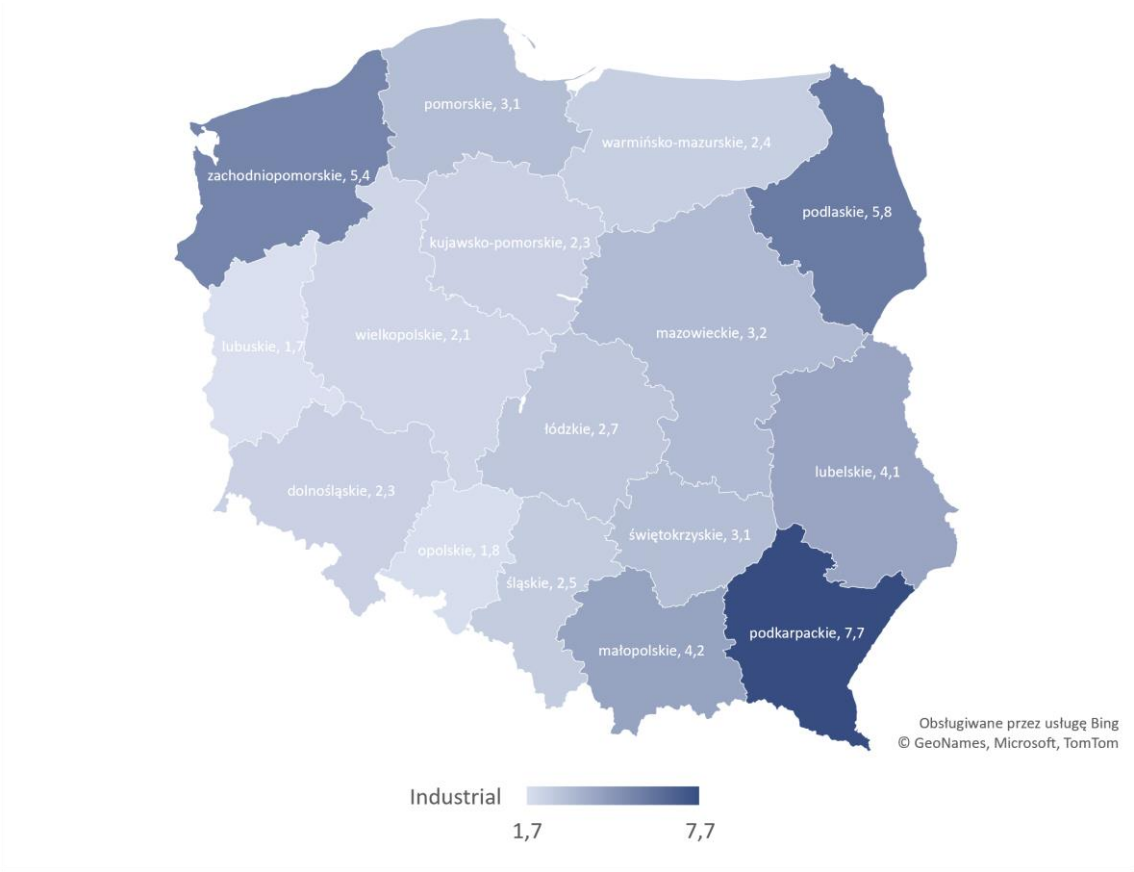


Figure 2. Industrial enterprises cooperating within clusters in 2017–2019 by voivodeships (in %)

Source: own elaboration based on Główny Urząd Statystyc

In general, collaboration within clusters was less frequent among service enterprises than industrial enterprises (Figure 3), and no cooperation within clusters among service companies was found in one voivodeship (Opolskie). The share of service enterprises exceeded the share of industrial enterprises collaborating within clusters in five voivodeships (Dolnośląskie, Łódzkie, Pomorskie, Warmińsko-Mazurskie, and Wielkopolskie).

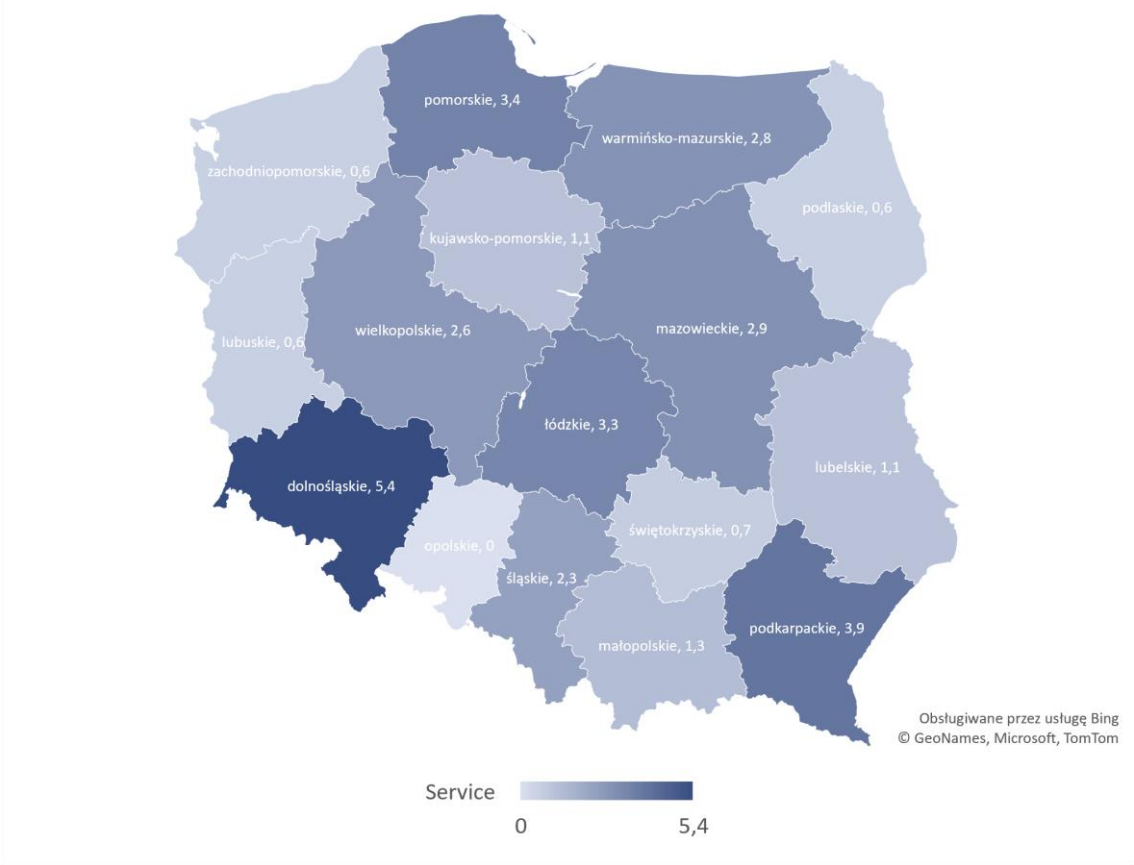


Figure 3. Service enterprises cooperating within clusters in 2017–2019 by voivodeships (in %)

Source: own elaboration based on Statystyki przestrzenne GUS 2021.

When analyzing openness to collaboration within clusters by NACE classification, highest proportion of enterprises engaging in collaboration in Poland occurs within the following NACE divisions (Główny Urząd Statystyczny 2021):

- among industrial enterprises: mining of coal and lignite (17.6%), mining of metal ores (16.7%), manufacture of coke and refined petroleum products (16.3%);
- among service enterprises: scientific research and development (21.2%), architectural and engineering activities; technical testing and analysis (8.4%), financial service activities (7.9%).

B2R/R2B collaboration: cluster organizations'

The study conducted under the Project provided in-depth information on the state of collaboration between business and research organizations within cluster organizations (COs) in the Visegrad countries. All cluster organizations participating in the study in Poland had established relationships with universities and other research organizations. These relationships were supported by either formal agreements, under which these organizations became members of the cluster organization, or by other forms of agreements. According to the respondents, the number of research organizations engaged in collaboration with cluster organizations ranged between 6 and 21 (Figure 4). Interestingly, for 7 of the cluster organizations, the number of partner research organizations other than universities was higher than the number of partnered universities.

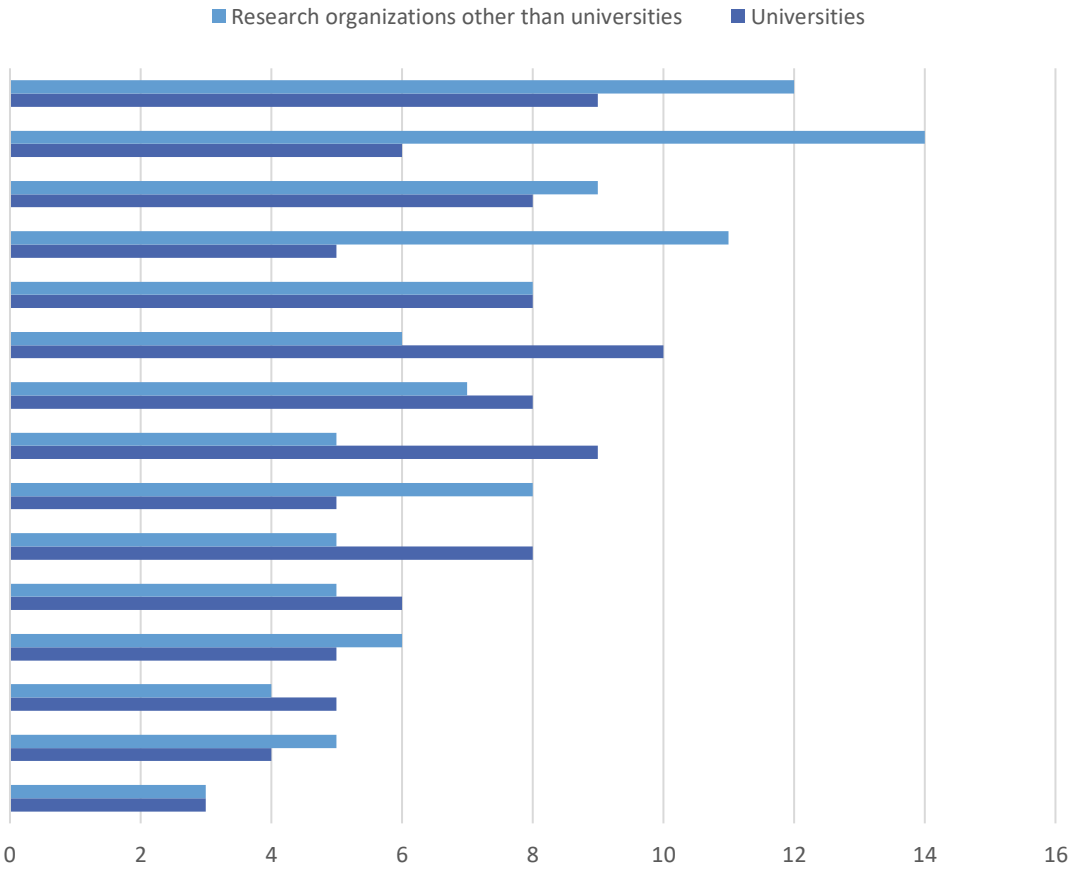


Figure 4. Number of universities and other research organizations cooperating with cluster organizations

Source: own elaboration based on the interviews with cluster managers (N=15)

The cluster organizations participating in the study also had developed relationships with other organizations within the innovation ecosystem (Table 3). Respondents were asked to indicate the types of the organizations with which their cluster organizations collaborated: technology transfer centers, science/technology parks, regional innovation forums, and other. All but one cluster organization seem to cooperate with at least one of such organizations. 10 cluster organizations had established links with technology transfer centers and 11 cooperated with science/technology parks. Notably, such collaboration often took place with various technology transfer centers and science/technology parks.

Table 3. Cluster organizations with other organizations within the innovation ecosystem

Technology transfer center	Science/ technology park	Regional innovation forum	Other	Number of COs
yes	yes	yes	yes	1
yes	yes	yes	no	1
yes	yes	no	yes	2
no	yes	yes	yes	2
yes	yes	no	no	3
yes	no	no	yes	2
yes	no	no	no	1
no	yes	no	no	2
no	no	no	no	1
(10)	(11)	(4)	(7)	(15)

Source: own elaboration based on the interviews with cluster managers (N=15)

The results are in line with the outlook of the participant cluster organizations towards their strategic goals (Figure 5). All cluster organizations had prepared a strategic development document. Moreover, 14 out of 15 COs incorporated cooperation with research organizations as part of these strategic plans. What is worth mentioning, the cluster organization which was an outlier in this regard, did not report any cooperation with other organizations of the innovation ecosystem in Poland.

Figure 5. Strategic outlook at B2R/R2B cooperation in cluster organizations

Source: own elaboration based on the interviews with cluster managers (N=15)

The in-depth interviews conducted as part of the study revealed how cluster organization managers viewed the initial stage of B2R/R2B cooperation (initiation) (Figure 6). According to nine out of 14 CO managers, in the majority of cases, the B2R/R2B collaboration was initiated by the companies (CO members). In one CO, all collaborative efforts were believed to had been initiated by the companies, whereas in three of the COs, 90% of the collaboration was reported as business-initiated. None of the CO managers indicated that, to their knowledge, the research organization was the one to initiate the partnership. Nevertheless, managers in three of the cluster organizations believed that research organizations are just as active as firms (cluster members) in initiating collaborations. There were only two cases where the cluster management was responsible for initiating the most B2R/R2B partnerships. These results indicate that the participant cluster organizations are mature enough that cluster managers are no longer highly involved in initiation partnerships between CO members.

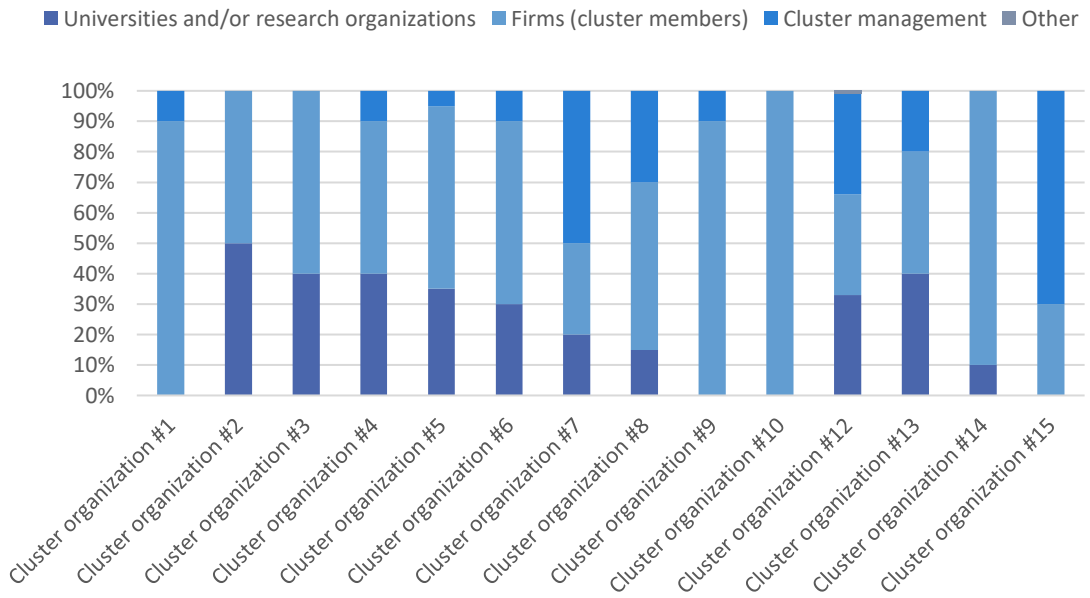


Figure 6. Types of entities that initiate B2R/R2B

Source: own elaboration based on the interviews with cluster managers (N=15)

* – Cluster organization #11 – the CO manager is not directly involved as special interest groups create ideas for new R&D&I projects and handle most of the collaboration projects. As a result, the data for this cluster organization was not obtained.

As previously reported, based on Główny Urząd Statystyczny data, not many firms in Poland are involved in R&D&I collaboration with universities or other types of research organizations. Interestingly, the results of the study show that cluster members are more inclined to pursue this type of partnership (Figure 7). Eight CO managers believed that the share of firms (cluster members) actively involved in R&D&I cooperation with research organizations within the scope of their cluster organization equaled or surpassed 50%, and it was believed to be between 30% and 45% in four of the COs. Only two CO managers indicated that the proportion was less than 20%.

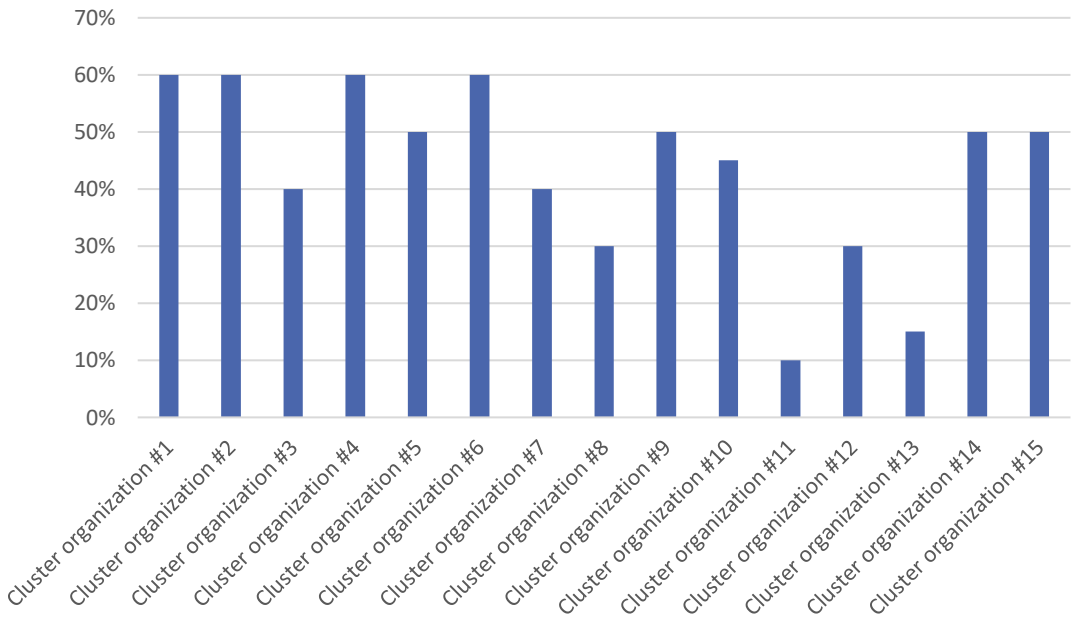


Figure 7. Share of cluster members (firms) actively involved in R&D&I cooperation between firms and UNIV/RO: CO managers' perspective

Source: own elaboration based on the interviews with cluster managers (N=15)

Collaboration within the surveyed cluster organizations led to various international R&D&I projects being carried out. All but one cluster organization reported participating in at least one project of such kind (Table 4). Benefits for cluster members varied, but in most cases included: solving technological problems, deploying technologies, networking, gaining competences/experience/knowledge/skills.

Table 4. R&D&I projects in cluster organizations:

Number of international R&D&I projects which the cluster organization participated in	Benefits for CO members
several	New solutions to respond to technological problems reported by companies; gaining competences; processing technologies
a few	Cooperation and coordination of R&D&I projects; help with organizing funds for R&D&I
20	Building international networks; knowledge spillover; benchmarking; efficiency increase

Number of international R&D&I projects which the cluster organization participated in	Benefits for CO members
19	Product/service improvement; cooperation; access to research infrastructure; competence improvement
13	Networking; development of skills; trust building
8	Fast implementation of new solutions in the industry; solving technological problems
8	Networking; access to new knowledge (especially foreign); possibility to develop new products; increasing skills
7	Gaining information; integration; cooperation
7	Publication opportunities for researchers; a business opportunity for cluster members
6	Gaining experience; new knowledge; developing cooperation (also with foreign partners)
6	Access to new technologies; knowledge transfer
5	Networking; access to new knowledge and experts; possibility to develop new products and technologies
2	Did not disclose
1	Implementation of technologies
0	Does not apply

Source: own elaboration based on the interviews with cluster managers (N=15)

Cluster organization managers are not always directly involved in R&D&I joint projects, which is why their knowledge on the outcomes of R&D&I partnerships can be limited (Table 5). Respondents often could not easily identify specific instances of completed collaborative efforts that led to a solution of joint research or technical problem/issue (implemented by at least 3 CO members) or solutions of complex R&D&I projects that produced tangible results such as patents (a filed patent application), industrial design, pilot plant, verified (proven) technology, utility model, prototype, certified methodology, software, etc. Various CO managers could not provide the exact number, or even an estimate, of such cases, as collaboration in their cluster organizations often takes place outside of their direct involvement.

Table 5. Outcomes of R&D&I projects in cluster or

Completed cooperation that led to a solution of joint research or technical problem/issue, which is used by at least 3 cluster members	Solution of complex R&D&I projects that achieved results such as patents (filed patent application), industrial design, pilot plant, verified (proven) technology, utility model, prototype, certified methodology, software, etc.
various, difficult to tell	various, difficult to tell
various, difficult to tell	various, difficult to tell
CO manager does not know the exact number (it is in the sphere of cluster members activity)	CO manager does not know the exact number (it is in the sphere of cluster members activity)
CO manager does not know the exact number (contracts are protected)	CO manager does not know the exact number (NDA; patents go to the headquarters which usually are located abroad)
CO manager does not know the exact number	15
CO manager does not know the exact number	CO manager does not know the exact number
CO manager does not know the exact number	CO manager does not know the exact number
CO manager does not know the exact number	CO manager does not know the exact number
50	61
12	CO manager does not know the exact number
8	CO manager does not know the exact number
7	14
6	21
5	Did not disclose
6%	20

Source: own elaboration based on the interviews with cluster managers (N=15)

Collaboration between business and research organizations can take different forms. However, the majority of companies in Poland do not actively interact with research organizations. This situation can be altered by intermediary institutions whose role is to enable collaboration. Cluster organizations serve as such intermediaries and build bridges between firms and research organizations. As institutions for collaboration, they aim to actively engage their members to cooperate with each other.

In general, collaboration between business and research organizations within cluster organizations can be initiated by different actors. We can, therefore, identify the following modes of initiating collaboration:

- collaboration initiated by cluster organizations (including CO manager):
  - CO2B – cluster organizations to business,
  - CO2R – cluster organizations to research organizations,
- collaboration initiated by business,
  - B2CO – business to cluster organizations,
  - B2R – business to research organizations,
- collaboration initiated by research organizations (including researchers),
  - R2CO – research organizations to cluster organizations,
  - R2B – research organizations to business.
- other.

Our analysis of how establishment of collaboration is approached by research organizations in Poland revealed that, in the majority of cases, cluster managers had been the ones responsible for initiating partnerships between research organizations and the cluster organization, as well as between companies within the cluster organization (Figure 8). Their role as initiators was validated by 55% of respondents. In 40% of cases the partnership was initiated by the research organization (either by researchers, supervisors/managers, or other people working within the research organization). None of the respondents representing research organizations cited any instances of collaboration initiated by companies from the cluster organization. This confirms that cluster managers take an active role in building linkages within the cluster organization ecosystem.

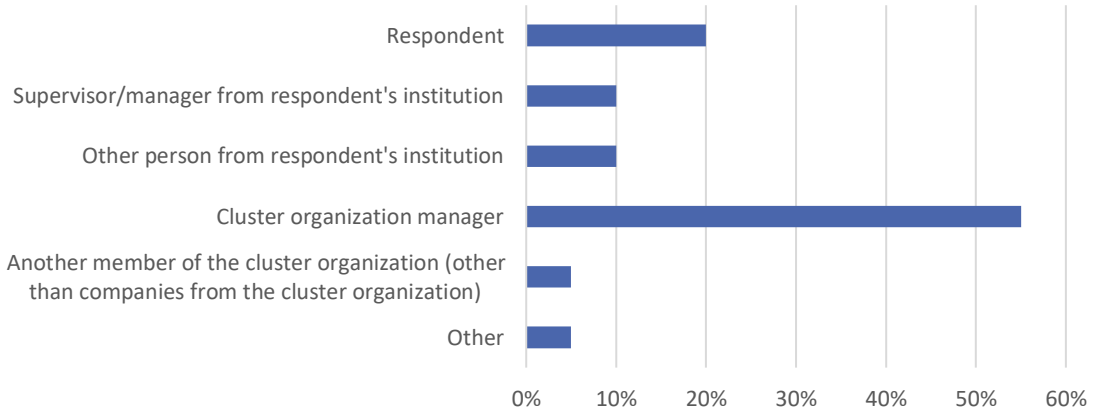


Figure 8. Initiation of cooperation between research organizations and cluster organizations and their members: research organizations' pe

Source: own elaboration based on survey data (N=20)

The sum of results does not equal 100% due to the fact that one of the respondents indicated that the cooperation was initiated by himself/herself and the cluster organization manager

Overview of cluster development in recent years

Overview of the cluster landscape in Poland

In Poland, cluster organizations have established themselves as institutions for collaboration. Throughout the years their number has fluctuated, increasing during the times in which they benefited from various support measures and decreasing when support measures were scarce or barely existent.

Their state of development has been regularly monitored by the Polish Agency for Enterprise Development (PAED; pl. Polska Agencja Rozwoju Przedsiębiorczości or PARP) through a series of benchmarking studies. The studies were held consecutively in 2010, 2012, 2014, 2018, and, most recently, in 2020 (the last study took place in 2021 but covered the situation of cluster organizations from 2018 to 2019).

41 cluster organizations took part in the last study, which included, but was not limited to, interviews with cluster organization managers and a survey of 435 cluster organization members. Selected conclusions from the 2020 benchmarking study on the state of cluster organization development in Poland included (Polska Agencja Rozwoju Przedsiębiorczości 2021):

- cluster resources:
  - on average, 3 people were involved in COs' operations (apart from their managers),
  - on average, COs reported working with 12 scientists,
  - IT platforms were deployed in 84% of COs,
  - 27 COs acquired approximately 295 million PLN funding from external sources;
- cluster processes:
  - 70% of COs participating in the study formulated a strategy in the form of a written document,
  - CO members were split with regard to the benefits of joining a CO (approximately half of them perceived small or no benefit),
  - about 33% of the COs' members established linkages with foreign entities due to their participation in a CO;
- cluster results:
  - 19 COs implemented joint projects co-financed from EU funds,
  - a total of 131 R&D&I projects were executed in 23 COs,
  - a joint offer was created in almost 50% of COs,

- collaboration within COs produced innovations (350), knowledge transfers (176), and intellectual property protection applications (307);

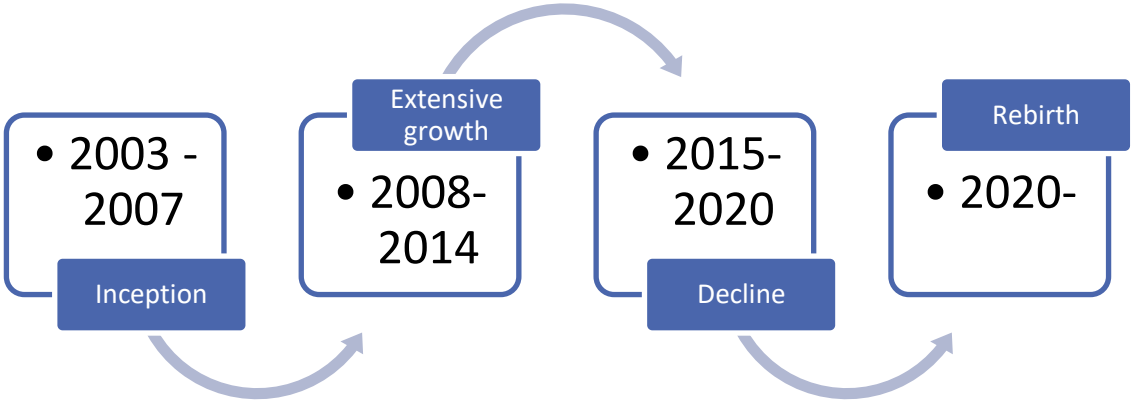
– environmental impact:
  - collaborations and partnerships were formed with public authorities (16 COs), business support institutions (24 COs), educational institutions (73 contracts), other national COs (27 contracts), and foreign COs (104 contracts),
  - almost 2/3 of COs participating in the study worked with the science sector;

– cluster internationalization:
  - support aimed at internationalization activities was offered to members of more than 70% of COs participating in the study,
  - almost 50% of the participant COs had experience with implementing at least one international project.

Cluster policy in recent years

Since the inception of cluster policy in Poland, cluster organizations – which are "specialized institutions that run cluster initiatives" (Kuberska 2021) – have become part of the country's ecosystem. Cluster initiatives, on the other hand, are "organized efforts to increase the growth and competitiveness of a cluster within a region, involving cluster firms, government and/or the research community" (Sölvell, Lindqvist, Ketels 2003).

Poland has been pursing cluster policy for several years, during which it went through numerous stages of its cluster policy life cycle. Kuberska and Mackiewicz (2022) define cluster policy life cycle as "a cycle of transformation that a cluster policy undergoes between its emergence (introduction into the policy mix) and decline (removal from the policy mix)". The authors identified four stages of the cluster policy life cycle in Poland (Scheme 1).



Scheme 1. Cluster policy life cycle in Poland

Source: own elaboration based on Kuberska, Mackiewicz 2022

The respective stages of the Polish cluster policy life cycle are characterized by the following features (Kuberska, Mackiewicz 2022):

- inception:
  - promotion of clustering,
  - incubation of cluster initiatives (CI),
  - training of CO managers;
- extensive growth:
  - financial support – EU funding allocated directly to clusters,
  - rapid increase in the number of cluster organizations;
- decline:
  - limited public support for clusters,
  - gradual extinction of cluster organizations,
  - professionalization of several cluster organizations;
- rebirth:
  - cluster-based economic development policy;
  - new instruments dedicated to clusters.

One of the most prominent developments since the introduction of cluster policy into the Polish policy mix was the creation of the Key National Cluster (KNC) program (during the decline stage) which is managed at the central level (currently by the Ministry of Economic Development and Technology). Through an open competition a cluster organization can receive the status of a KNC, provided that the cluster has been proven to have a significant importance to the economy and is internationally competitive. Cluster organizations which choose to participate in the competition are assessed based on six criteria: human resources, infrastructure and financial resources, economic potential of the cluster, knowledge creation and transfer, actions for public policies, and customer orientation (Choińska-Jackiewicz, Lubos, Łata, Mackiewicz, Wancio 2020).

To date, five competitions for the KNC label have been held. Seven cluster organizations were awarded the KNC status in the first round (for this round, the status was valid until December 31st 2018), and nine in the second (status valid until October 31st 2019). Only four cluster organizations became Key National Clusters as a result of the third competition (all of which had previously held this title as a result of the first round; the status was valid until December 31st 2021). The fourth round (whose results are valid until August 28th 2022) resulted in 11 cluster organizations becoming Key National Clusters, whereas the fifth round resulted in eight cluster organizations receiving the recognition (certificate valid until December 31st 2024).

2020 brought a new outlook for the Polish cluster policy (stage: rebirth). It is now being redesigned to follow the principles of (Choińska-Jackiewicz, Lubos, Łata, Mackiewicz, Wancio 2020):

- support for clusters adjusted to the level of cluster development,
- public support at the national and regional level (depending on the intervention objectives),
- double-track policy consisting of a subjective and functional approach,
- a flexible demarcation line of the support level and sources of financing,
- supra-regional and cross-border nature of the policy,
- long-term cluster policy,
- building social capital around the idea of cooperation and clustering.

The Polish cluster policy is considered to be a mature one among European countries. Based on the methodology employed by the European Cluster Collaboration Platform, Poland has received the maximum score in all four of the considered areas: policy scope, consistency of cluster policies, evidence of performance, and instruments[1]. The results indicate that Poland:

- has developed a dedicated cluster policy,
- the duration of cluster policy exceeds 10 years and the policy has developed in clear continuity,
- has established monitoring and evaluation mechanisms (which applies both to past and ongoing policies as well as the country established ex ante and/or ex post evaluations),
- provides support instruments in the form of financial and/or technical assistance.

Cluster organizations that took part in the study

Two surveys were conducted with the intention to explore the most recent developments in Polish cluster organizations, the results of which are presented in this Report. The first survey was carried among managers of 15 cluster organizations in the form of in-depth individual interviews. 14 of them were granted the "Key National Cluster" status at the time of the study. The remaining one – MedSilesia – Silesian Medical Cluster – was granted this status after the completion of the survey.

Analyzed cluster organizations represent different industries (Table 6). Their comparative portfolio (based on the approach employed by the European Secretariat for Cluster Analysis) is as follows:

- Aviation and space – 2 cluster organizations,

[1] https://cluster-collaboration.eu/sites/default/files/2021-12/eccp-factsheet-poland.pdf (accessed 5 January 2022)

- Construction – 2 cluster organizations,
- Energy and environment – 1 cluster organization,
- Health and medical science – 2 cluster organizations,
- ICT – 2 cluster organizations,
- Mobility: Vehicles, rail, traffic systems – 2 cluster organizations,
- New materials and chemistry – 1 cluster organization,
- Production and engineering – 2 cluster organizations,
- Transportation and mobility – 1 cluster organization.

The oldest cluster organization in the sample – Aviation Valley – was founded in 2003, while the Polish Automotive Group (the last to be founded among the cluster organizations in the sample) was established in 2016. 8 of the cluster organizations were founded between 2006 and 2007.

Table 6. Cluster organizations participating in IDIs (in alphabetical order)

Cluster organization	Legal form	Predominant field(s) of activity	Year of foundation	Number of members
Aviation Valley (*Klaster Dolina Lotnicza*)	Association	Aviation and space	2003	148
Bydgoszcz Industrial Cluster (*Bydgoski Klaster*)	Association	Production and engineering	2006	137
ICT Pomeranian Cluster – Interizon (*Pomorski Klaster ICT Interizon*)	Partnership	ICT	2009	97
LifeScience Krakow Cluster (*Klaster LifeScience*)	Foundation	Health and medical science	2006	63
Mazovia Cluster ICT (*Mazowiecki Klaster ICT*)	Cooperation agreement	ICT	2007	282
MedSilesia – Silesian Medical Cluster (*MedSilesia – Śląska Sieć Wyrobów Medycznych*)	Does not have	Health and medical science	2007	105
Metal Processing Cluster (*Klaster Obróbki*)	Cooperation agreement	Production and engineering	2007	112
North-South Logistic Transportation Cluster (*Klaster Logistyczno Transportowy Północ-Południe*)	Limited liability company	Transportation and mobility	2012	200
Polish Construction Cluster (*Polski Klaster Budowlany*)	Association	Construction	2011	328

Cluster organization	Legal form	Predominant field(s) of activity	Year of foundation	Number of members
Polish Automotive Group (*Polska Grupa Motoryzacyjna*)	Association	Mobility: Vehicles, rail, traffic systems	2016	53
Silesia Automotive & Advanced Manufacturing	Joint-stock company	Mobility: Vehicles, rail, traffic systems	2011	138
Silesian Aviation Cluster (*Śląski Klaster*)	Association	Aviation and space	2006	88
Sustainable Infrastructure Cluster (*Klastwenro wZarżóona Infrastruktura*)	Limited liability company	Construction	2011	131
Waste Management and Recycling Cluster (*Klaster Gospodarki Odpadowej i Recyklingu*)	Limited liability company	Energy and environment	2007	103
West Pomeranian Chemical Cluster "Green Chemistry" (*Zachodniopomorski Klaster Chemiczny "Zieli*	Association	New materials and chemistry	2007	180

Source: own elaboration

Cluster organizations in the sample vary in size, with the number of their members ranging between 53 and 328. 20% of cluster organizations reported their number of members to exceed 200, whereas 27% of cluster organizations had less than 100 members.

All cluster organizations in the sample employ a strategic approach to development. Their growth is supported by strategic documents, which are prepared and consulted in a collaborative process directed by the cluster managers. The scope of these documents is updated to reflect the changes in the respective industries, as well as other external and internal circumstances. What is worth mentioning is that 14 out of the 15 cluster organizations consider collaboration with research organizations and/or universities to be an important factor of cluster growth and include it in their strategy. This approach proves that both cluster managers and members support the idea of collaboration between firms and research organizations/universities.

Companies in cluster organizations differ in many respects, and this heterogeneity is demonstrated by their approach to R&D. When inquired about companies in their respective cluster organizations, 8 out of the 14 surveyed cluster managers recognized that companies which can be described as technology recipients (i.e. who do not conduct their own R&D

activities) are more numerous than those who carry out continuous R&D and can be described as strategic innovators (Figure 9). However, in four of the cluster organizations, the share of strategic innovators exceeded the share of technology recipients.

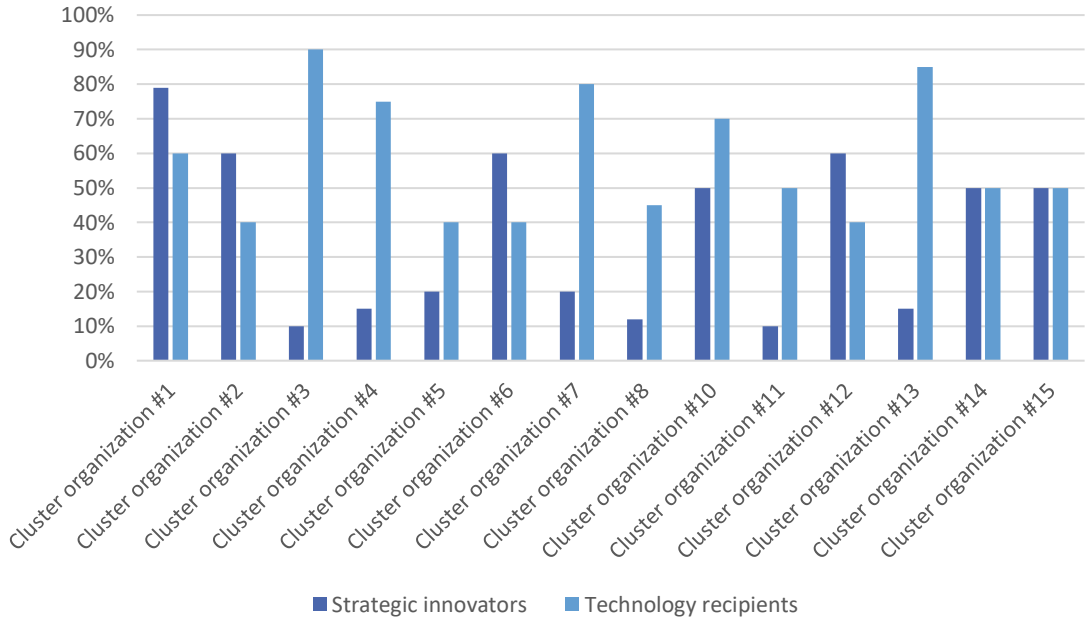


Figure 9. Companies in cluster organizations: CO

Source: own elaboration based on the interviews with cluster managers (N=15)
* – Cluster organization #9 – the manager did not disclose this information

An inquiry into the trends in CO membership in the last 3 years reveals that cluster organizations have either sustained their levels of membership within this timeframe (through with reported fluctuations in the number of members in the range of -10% to +10%) or reported growth (in some cases by around 30–40%).

The COVID-19 pandemic has affected the EU economy, including its various industries. It has remained a not insignificant factor for cluster organizations whose role as platforms for collaboration is being put to the test. Even at the initial stage of the pandemic, Polish cluster organizations served this purpose by providing various forms of support (e.g. sharing information, coordinating resources). The intensity of their efforts varied depending on the industrial profile(s) of their members.

When asked about the influence of the COVID-19 pandemic on cluster members (firms), cluster managers made it clear that it varied depending on their sectoral focus. As a consequence, all cluster organizations were operating under different circumstances than those before the pandemic, but not all cluster organization members were affected to the same extent. Among

the issues that their members had to deal with, the following were mentioned: increasing prices of natural resources, lower demand, lower turnover, financial problems, and adapting to remote work.

The COVID-19 pandemic brought both positive and negative impacts for the cluster organizations' business (Table 7).

Table 7. COVID-19 and cluster organizations: CO manager

Examples of positive impact	Examples of negative impact
Acceleration of digitalization and development of online forms of communication	Delay of projects under implementation/putting ongoing projects on hold
More active cooperation between cluster members	Limited external relations/limited networking/less direct contact
New forms of cooperation between cluster members	Decrease in the number of implemented projects

Source: own elaboration based on the interviews with cluster managers (N=15)

Cluster managers reported that the COVID-19 pandemic accelerated digitalization efforts and allowed them to expand online forms of communication. Moreover, the new circumstances brought by the pandemic motivated companies to become more actively involved in collaboration with other cluster members. Some of cluster managers observed new forms of collaboration emerging between cluster members.

Among the most negative impacts of the pandemic, as indicated by the CO managers, were issues arising from restraints on networking, which impeded active engagement in activities by some firms within the cluster organizations. In addition, various cluster managers reported that they were unable to keep ongoing projects on-schedule (especially with regard to internationalization projects) while also observing a decrease of the number of implemented projects.

According to representatives of research organizations/universities the COVID-19 pandemic tended to limit their collaboration with cluster organizations (Figure 10). 73% of respondents indicated that their cooperation with cluster organization and its members had either decreased (53%) or strongly decreased (20%) throughout the pandemic, whereas 47% of respondents did not notice any change in this regard. Only 13% of respondents reported that the collaboration had increased during that time.

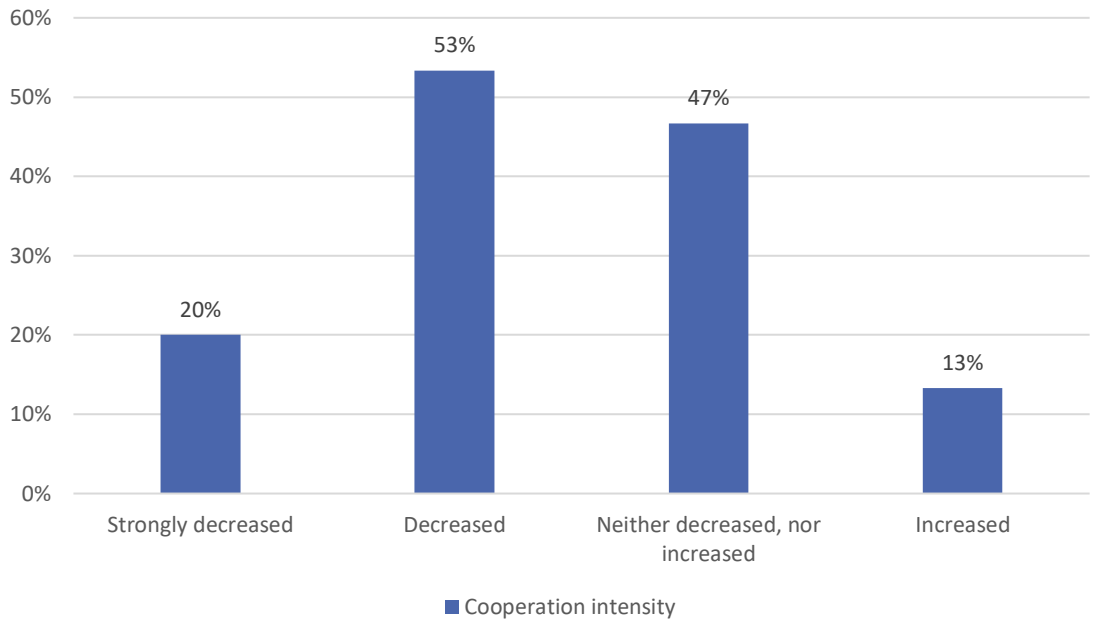


Figure 10. Cooperation with cluster organizations during COVID-19 pandemic: research organizations' perspective

Source: own elaboration based on survey data (N=20)

Motives for B2R/R2B cooperation in cluster organizations and benefits for the stakeholders

One of the main assumptions of the cluster policy is to create a basis for economic growth based on promoting cooperation between science and business. This is why government support is usually funneled through cluster organizations to encourage different types of collaborative actions between cluster members, like undertaking common Research and Development (R&D) projects, or to benefit the whole cluster, e.g. by collecting and processing know-how and information in the areas of interest to the cluster, or by pursuing specialized research (Kowalski 2020). B2R/R2B partnerships are, in fact, one of the factors fueling creation and introduction of innovations to the economy. Overall, collaboration between industry and academia in clusters is motivated by the need to transfer knowledge and technologies that evolve throughout the process of commercializing goods and services. The establishment of a partnership benefits both the firm and the higher education institution. The objective of this section is to identify and assess the motives for B2R/R2B cooperation in cluster organizations, as well as its benefits for the stakeholders. The results of the survey related to this thematic area are presented in Table 8.

Table 8. Factors that have motivated researchers to pursue cooperation with the cluster organization and its members

Factor	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Ability to extend my network (networking)	2	0	1	6	11
Commercializing research findings	3	1	4	6	6
Receiving non-financial research assistance (e.g. access to data, exchange of knowledge with practitioners, developing technology)	3	1	5	8	3
Receiving research funding	7	1	5	6	1
Personal financial benefits	10	2	4	3	1
Gaining access to infrastructure (e.g. lab equipment)	10	3	6	1	0

Factor	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Necessity to undergo employee assessment at the university/research organization/other organization	9	6	4	1	0

Source: own elaboration based on survey data (N=20)

The most important motivation behind pursuing partnership with a cluster organization and its members is that it provides a researcher with the opportunity to extend their network. This corresponds with the theory of economic network, which emphasizes the importance of external resource mobilization, e.g. in research & innovation activity (Oerlemans, Meeus, Boekema 1998). The network approach enables us to comprehend the impact of social interactions on economic outcomes (Goyal 2007). In the context of research & innovation, networks help organizations develop their innovative capabilities by exposing them to new sources of ideas, enabling rapid access to resources, and facilitating knowledge transfer. Additionally, networking may enable a division of innovative labor that paves the way for goals that a single actor could not accomplish alone. One significant challenge for innovation networks is developing the capacity to enhance the flow of information among current members while remaining open to new entrants (Powell, Grodal 2005). It is worth noting that the success of innovation networking is contingent upon the partners' knowledge-based competencies, including their absorptive capacity, i.e. the capacity to recognize the value of external knowledge, assimilate it, and commercialize it (Cohen & Levinthal, 1989). Apart from valuing and integrating external knowledge, superior R&D capacity enables identification of new opportunities and, ultimately, more effective evaluation of collaborative R&D projects.

The second most important motivation behind pursuing cooperation with a cluster organization and its members is the opportunity to commercialize research findings. The importance of commercialization of research findings has emerged as a result of a shift in the traditional approach to innovation, which was shaped by the evolution of models of innovation processes (Rothwell, Rothwell, & Zegveld, 1985). As stated by the first generation of these models, which were derived from J. Schumpeter's linear model of innovation, innovation developed along a simple linear and sequential process that began with science and laboratory work and progressed through successive stages until the new knowledge could be commercially applied in practical industrial activity. When it comes to innovation processes, this model places a premium on research and development while overlooking the commercialization of R&D outcomes in business practice. Additionally, it assumes that innovation is implemented automatically as a result of actions taken by individual innovators or corporations. It is now

widely recognized that the commercialization stage is the most difficult phase of developing new technologies (Kowalski 2022). The key driver of innovation, according to this approach, should not be R&D, which is a source of so-called technological push, but rather the market, which determines research, development, and innovation trends and is a source of innovation pull, or demand-driven innovation. This idea fits into an open innovation strategy that looks for new product and service ideas outside of a company's walls. Finding and combining ideas that are complementary to existing R&D projects, as well as forming partnerships with other market players, are examples of these approaches. Because of the current dispersion of knowledge and capital, the most important aspect of innovation is to combine the intellectual resources and activities of various organizations, such as in the framework of clusters.

Further motivators behind pursuing collaboration with a cluster organization and its members are receiving non-financial research assistance (e.g. access to data, exchange of knowledge with practitioners, developing technology), as well as receiving research funding and personal financial benefits. For Polish respondents, the least important motives for such collaboration were gaining access to infrastructure (e.g. lab equipment) and needing to undergo employee assessment at a university/research organization/other institution. In addition, the respondents indicated several other factors that have motivated them to pursue collaboration with a cluster organization and its members, such as:

- maintaining close relations with business practice,
- networking, opportunity to exchange experience, participation in projects,
- building relationships with other entities,
- prestige, study visits,
- usefulness of conducted research/analysis to the business world,
- knowledge of the environment and willingness to integrate/engage with it,
- the need to carry out tasks for organizations in the region where I live, the desire to engage in issues relevant to the region,
- exchange of R&D experience.

It may be stated that one factor motivating scientists to work with entrepreneurs is the opportunity to create new knowledge and technological solutions, and contributing to a better world. Additionally, in-depth interviews revealed that other factors may play an important role in motivating researchers to collaborate with the industry, namely:

- reputation and status gains for scientists who collaborate within clusters,
- expert review of research results and the practical application thereof,
- greater opportunities for publishing research results,
- taking advantage of access channels to the technology market,

- access to channels for promoting and advancing science, such as seminars and conferences,
- discovery of new theories and their verification when applied in the industry,
- higher citation rates of scientific publications,
- public opinion pressure,
- rendering of services to businesses.

The current fragmentation of knowledge in the modern world economy means that the effectiveness of a given research and innovation activity relies, in large part, not on the internal resources of the organization but rather on an adequate mix of knowledge, skills, and activities of various actors who engage in different forms of cooperation. One of the best explored methods of cooperation is clusters, in which relations between different actors create a system that enables organizations with limited access to knowledge to acquire it from local partners, including regional universities (Kowalski, Mackiewicz 2021). This provides different types of mutual benefits, both for the enterprises and the research organizations. There is a growing recognition of universities as not only a source of technology and innovation, but also of human capital, reflecting university-business collaboration in the field of education (Orazbayeva et al. 2020). University-business collaboration is considered to be critical for regional economic growth and social prosperity, as they are playing an increasingly important role in technology transfer and the marketing of knowledge (Ripoll Feliu and Díaz Rodríguez 2017). According to the results of our research, conducted in Poland, the most important benefits of B2R/R2B partnerships in cluster organizations include:

- finding solutions to the technological problems faced and reported by companies,
- increasing mutual trust between scientists and entrepreneurs, as well as strengthening academia-industry collaboration,
- knowledge transfer from academia to industry, with mutual benefits,
- more opportunities to develop different types of activity, such as postgraduate studies, sectoral conferences, internships, implementation doctorates,
- creation of strategic alliances and common research projects, opportunities to influence the curricula, and use of laboratories and other facilities at universities in solving real technological problems faced by companies,
- development of technological processes, chance to reflect on previous actions, obtaining second opinions,
- access to expertise and more opportunities for knowledge sharing and upskilling,
- gaining information and knowledge about new technological trends,
- more opportunities for internationalization and participation in international projects thanks to collaborative efforts initiated as part of cluster activities.

Forms of B2R/R2B cooperation in cluster organizations

The most popular form of collaborative activities undertaken by cluster managers with research organizations or universities are joint projects (domestic and international) (Figure 11). This kind of activity is necessary to acquire financing for the development of new technologies and the on-going expenses of the cluster manager. There are also other popular activities to foster collaboration between firms and research organizations/universities. These include participation in seminars, information exchange fora, and the use of research organization/university facilities. It is clear that the majority of cluster managers pursue a wide spectrum of activities in collaboration between firms and ROs/UNIV. There are only two options that have proven less popular among cluster managers: implementation doctorates and liaison offices.

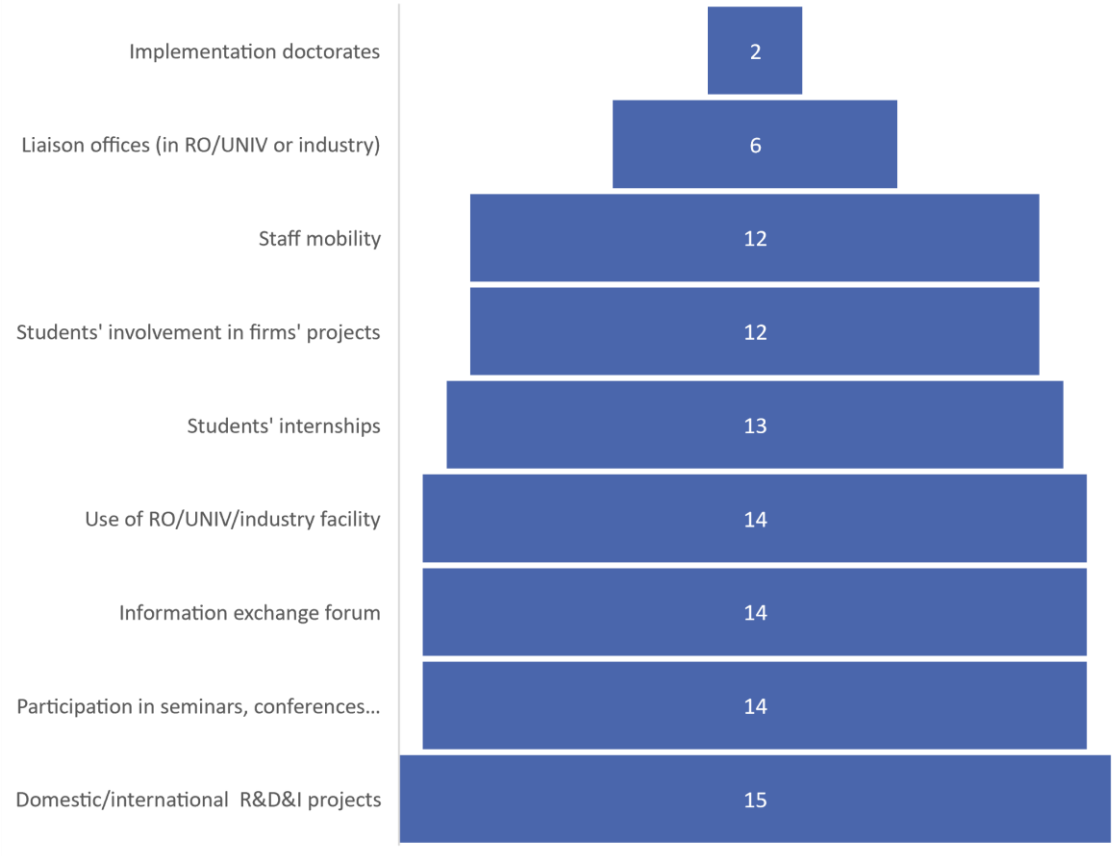


Figure 11. Types of activities undertaken by cluster manager in cooperation between firms and UNIV/RO within your cluster

Source: own elaboration based on the interviews with cluster managers (N=15)

A cluster organization is a platform for organizing meetings, seminars etc.

> *We often organize meetings attended by people from the technical university because, for example, they have private companies and they participate in the cluster as companies, while also representing the technical university. They can use the meetings, business trips, study tours, conferences that we organize to make new contacts.*

A common form of cooperation is the use of research infrastructures at the disposal of universities and research institutes. Science sector institutions are often equipped with sophisticated, expensive equipment and devices that would not be profitable for an enterprise to acquire – especially if the company does not have laboratories that use such research equipment on a regular basis. On the other hand, universities and research institutes have purchased a lot of infrastructure thanks to EU grants. If this infrastructure is not fully utilized, and often it is not, they share it with other members of the cluster.

> *We have infrastructure at the Polytechnic that we can share. (...) The Polytechnic is involved in the administration of the cluster, and it is in this capacity that the Polytechnic was the beneficiary of the project from the regional program to support the cluster. Thanks to that, we even have some commitments from the sustainability of project results rule, so we possess this kind of infrastructure and we can share it.*

> *Universities themselves send us proposals for cooperation in a specific area and the use of specific machines. They stand unused. (..) And they promise to do a certain kind of research at good price, because our companies need it. We cannot do everything in Poland, but there are some resources available – for example, a laboratory it is opening in Łódź right now, an aviation de has the appropriate certificates. We also received a grant for this laboratory and it will be furnished with our equipment. We are in the process of organizing all this. And our companies from the cluster will be able to do it with us*.

If a given collaboration between business and science takes place within the framework of the cluster structure, then companies are much more willing to accept students for internships and apprenticeships. Clusters also offer help in coordinating such activities in selecting topics of diploma theses.

> *As for students, we already have a tradition where every year we ask companies to submit topics for diploma and engineering theses in the field of computer science, telecommunications, electronics. This is also an interesting arrangement for the company, because someone who has studied a research problem in their company can be an, it can be a valuable intern or later – an employee. There was even a situation last*

week where a team of communication schools wanted us to ask the company whether they would accept high school students fr

Cluster managers were asked about the forms of collaboration pursued between firms and ROs/UNIV within their cluster. Not surprisingly, all of the cluster organizations include research organizations or universities in their membership, as it is one of the basic conditions to apply for the status of a National Key Cluster (Figure 12). Both occasional collaborations and long-term agreements are very popular. Common collaboration initiatives result from the need to acquire grants to solve technological problems faced by companies. Research organizations and universities are evaluated, which is why it is in their interest to collaborate with companies and undertake joint projects – these kinds of activities are considered in the evaluation process, after all. Some clusters (12 out of 15) have formed technology platforms, which are focused on the research agenda with regard to key technological fields, knowledge transfer, postgraduate studies, organizing sectoral conferences, training for research project management, etc.

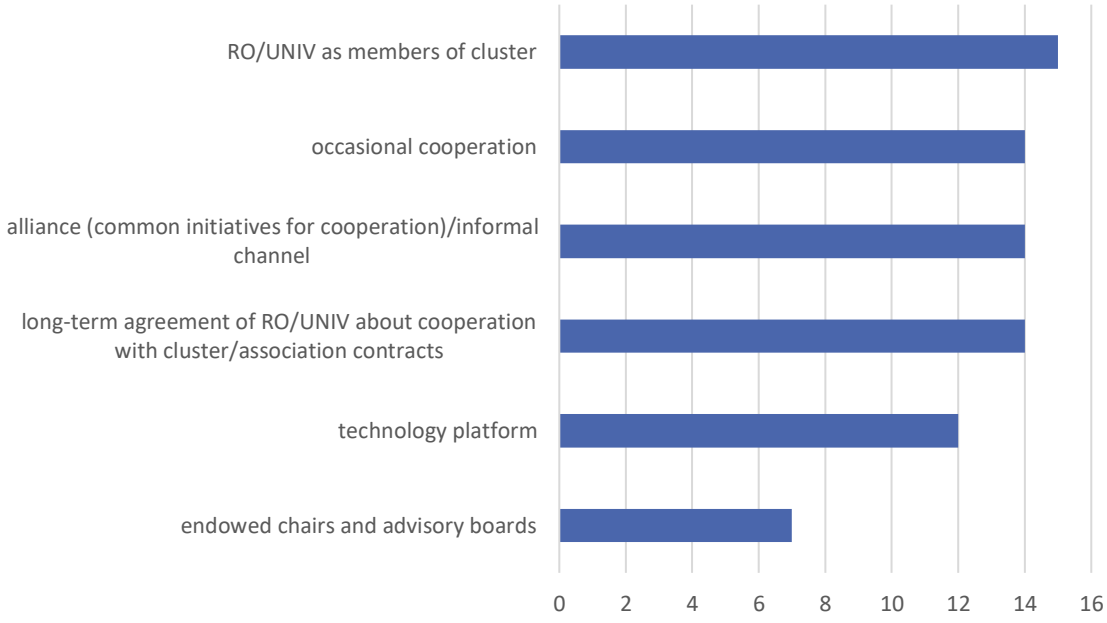


Figure 12. Forms of cooperation identified by cluster manages

Source: own elaboration based on the interviews with cluster managers (N=15)

We try to support our members in carrying out research works and building competence to manage R&D projects. I know that some members are interested, they do see why this is needed, they see that there are shortcomings in this area. The activity is centered around collaboration with the Łukasiewicz problems and solutions to those problems

We have some consulting companies in the cluster that help prepare applications or just manage such projects. We also do some projects on our own, though this is a bit of a new field for us and we are still evolving in this regard. We also help our members with fundraising.

For example, we run two faculties with the Silesian University of Technology. We even sponsor these two faculties. There are classes in English and a lot of students come from abroad.

When asked about the model of collaboration, the respondents often answered that different models function in parallel (Figure 13). One of them is open cluster centers, where everyone benefits from a common infrastructure, as well as collaboration focused on the execution of R&D projects organized and managed by members of the cluster organization. There are also joint projects organized and managed by the cluster manager. Joint projects work best, provided they are supported by mediation in contacts, knowledge, access, and quick identification of partners.

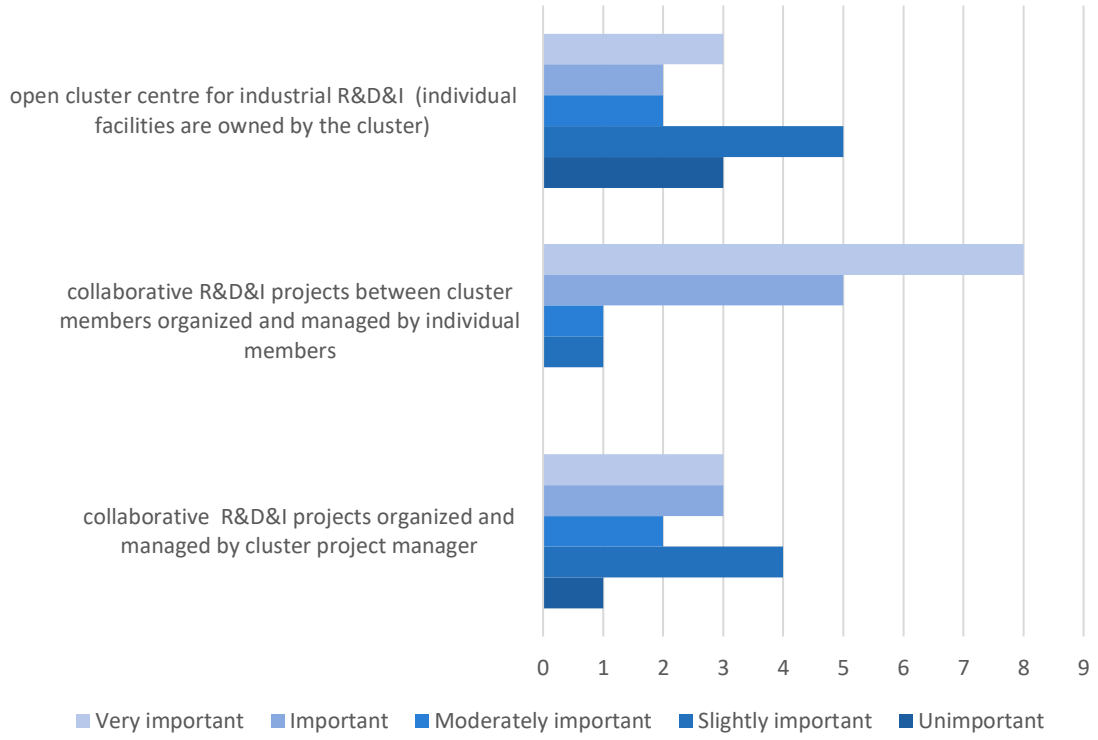


Figure 13. Models of cooperation – assessment by cluster organization managers

Source: own elaboration based on the interviews with cluster managers (N=15)

When asked about the forms of collaboration with a cluster organization, representatives of the science sector were asked about most commonly cited (Scheme 2):

- consulting,
- training,
- conducting research,
- preparing project applications or offers,
- membership in the management board of a cluster organization, and
- supervision of commissioned bachelor's/master's/doctoral theses.

Representatives of research organizations also take part in meetings organized by the cluster.

Scheme 2. Tasks/activities carried out by researchers when cooperating with the cluster organization

Source: own elaboration based on survey data (N=20)

The representatives of research organizations and universities were asked to indicate the relevance of the selected forms of collaboration with the cluster organization. The answers are presented in Figure 14.

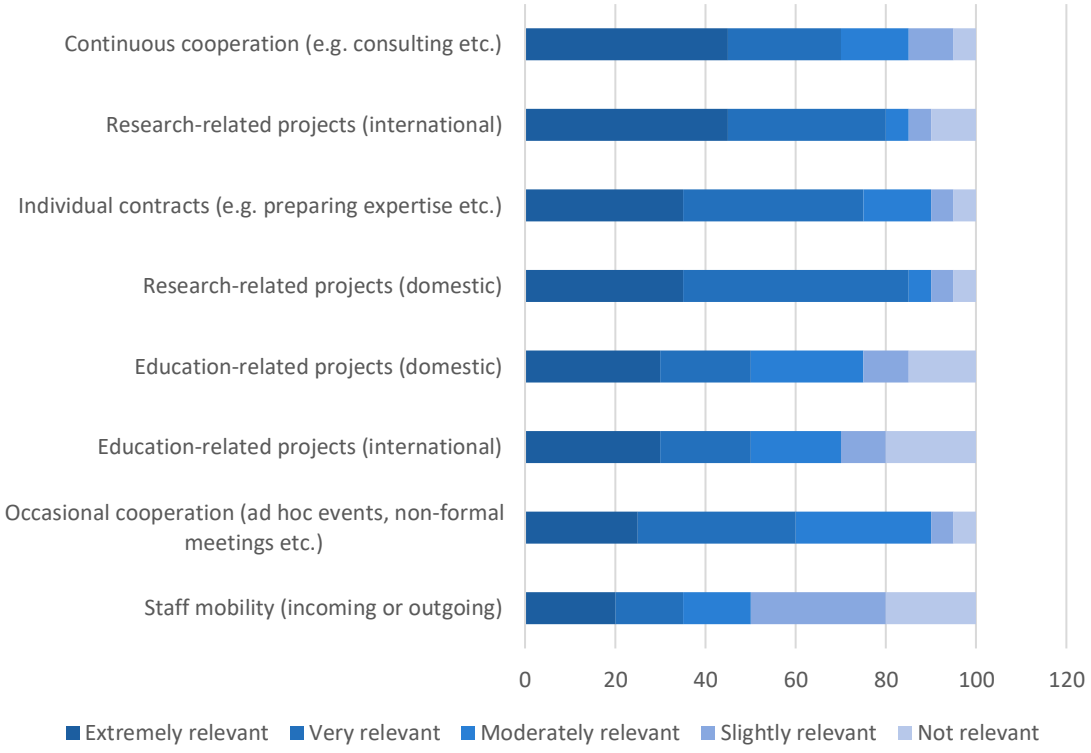
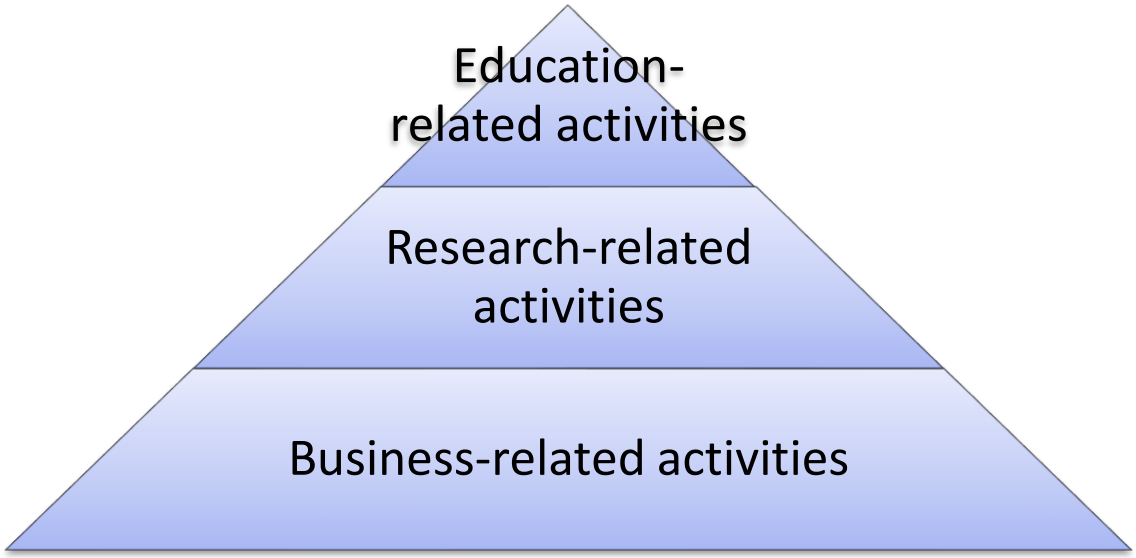


Figure 14. Assessment of the relevance of the selected forms of cooperation indicated by the researchers (in %)

Source: own elaboration based on survey data (N=20)

The representatives of research organizations and universities were asked to assess the share of time allocated to the different activities with regard to cooperation with the cluster organization and its members, to a total of 100% (Scheme 3). The answers show that business-related activities take slightly more time than research-related activities and education-related activities combined.



Scheme 3. Division of time among selected activities undertaken in cooperation with the cluster organization

Source: own elaboration

The answers given by the representatives of research organizations and universities indicate that all the models of R&D partnerships with the cluster organization and its members are employed in practice. The most frequently applied model is collaboration organized and managed or facilitated by the cluster organization manager (Scheme 4).

Scheme 4. Models of R&D cooperation with the cluster organization and its members applied by researchers

Source: own elaboration based on survey data (N=20)

Factors conditioning B2R/R2B cooperation in cluster organizations

University-business partnerships can take many forms, be it joint research, the creation of spin-off companies, the sale of patents, or the granting of licenses. The state should stimulate collaboration between universities and businesses by various means, including by ensuring the broad autonomy of universities on multiple levels, to make the process of applying for government funding more competitive on the part of the universities and less demanding on the budget (Firlej 2020).

The collaboration of higher education institutions with the industry should be encouraged and supported by appropriate mechanisms, including incentivization. It is important to understand that activities that can be developed in partnership are diverse, with myriad possible outcomes crucially affecting all stakeholders involved (Epure 2017). Eom and Lee (2010) identified the impact of university-business partnerships as a driver of innovation in its broad sense. Knowledge transfer between universities and organizations is essential, not only for the organizations involved but also for the broader innovation system.

As indicated by Mesjasz-Lech (2017), clusters are one of the forms of interaction between companies and other organizations. They are defined by the broad and open level of partnership. The importance of science-business network connections for regional development and clusters is unquestionable. As part of the Knowledge-Based Economy (KBE), it is one of the determinants of regional development processes, promoting the development of a strong, stable and competitive economy (Kot, Kraska 2016). According to their research, one of the factors influencing collaboration between cluster enterprises and the scientific environment is territorial proximity, as well as local, historically-shaped tradition and relationships with regional commercial institutions. Also of great import are initiatives taken by regional universities to strengthen cooperation with the most innovative and fast-growing companies in the region. Vertical and horizontal links, extending beyond the sector itself – producers working with companies that provide business services, as well as with R&D/scientific centers – is one of the key elements in defining a cluster (OECD 2007). Understanding the factors that drive or inhibit this process thus becomes a priority (Galán-Muros, Plewa 2016).

Managers in the clusters who participated in the study assessed 15 factors involved in shaping B2R/R2B partnerships in cluster organizations (Figure 15). In one of the clusters, an extra factor was indicated, which, according to the manager, was an important determinant of emergent collaboration – formal procedures at universities and research institutes, which lead to prolonged decision-making.

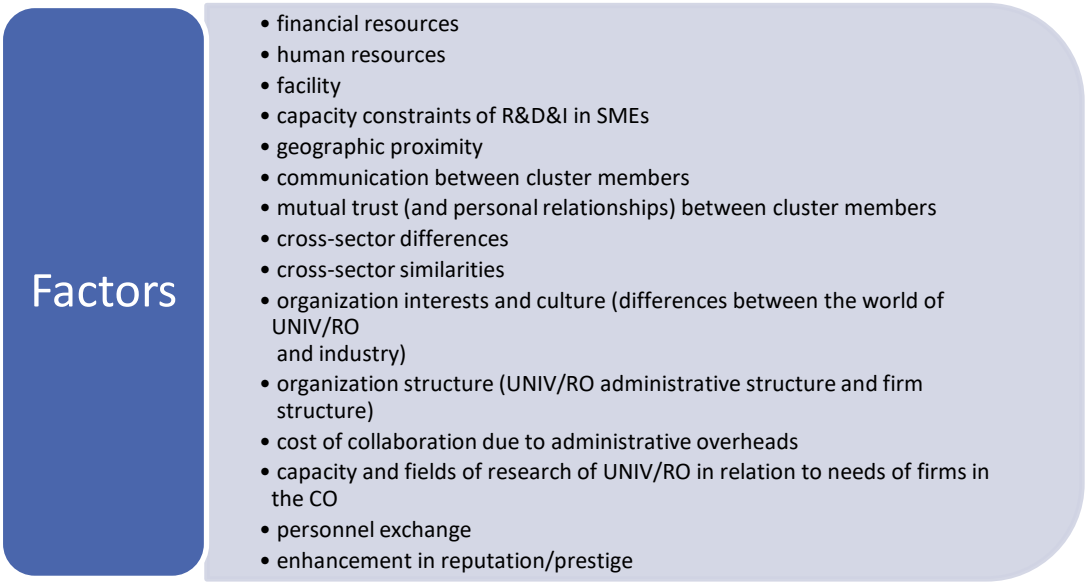


Figure 15. Factors conditioning cooperation between business and research organizations

Source: own elaboration based on the interviews with cluster managers (N=15)

The answers provided by managers indicate that the vast majority (73%) of the above-mentioned factors were viewed as favorable for collaboration in their eyes (Figure 16). Only in two clusters did the managers report that these factors are neutral or detrimental to the development of collaboration.

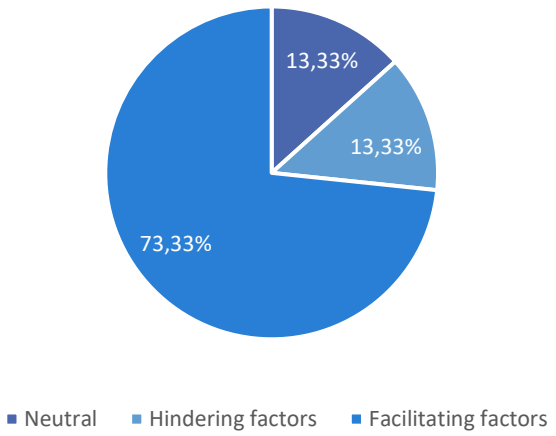
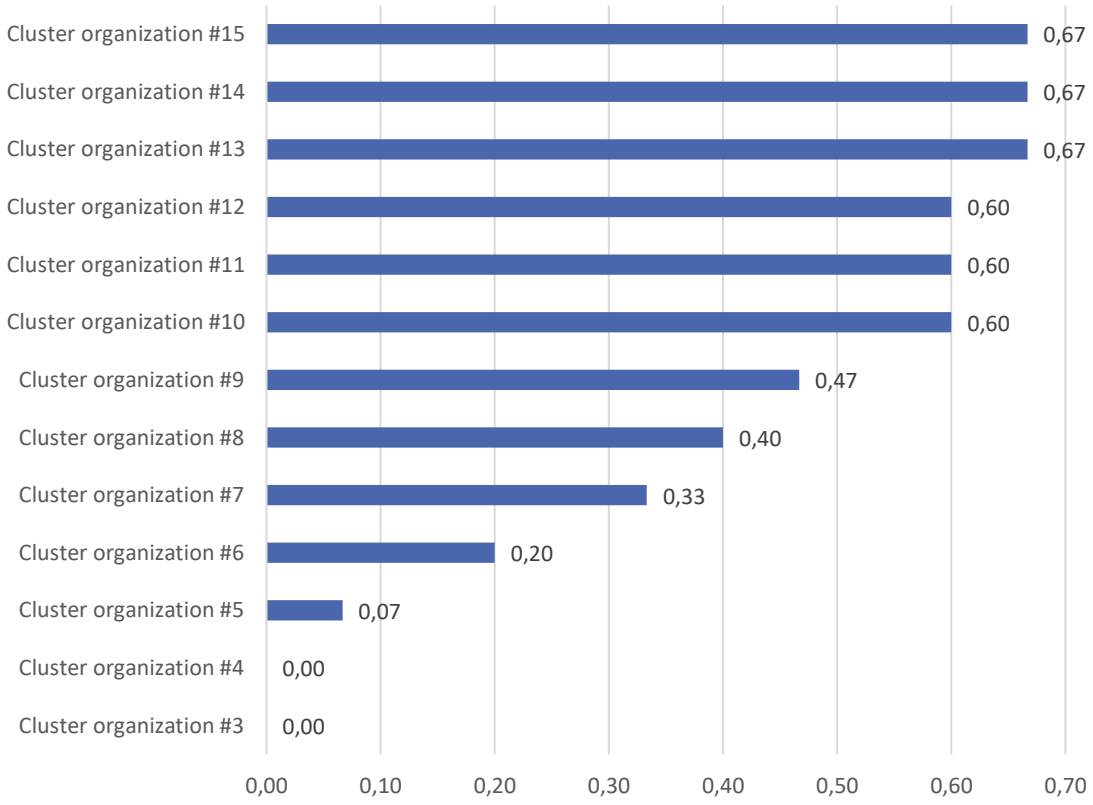


Figure 16. The average assessment of the factors conditioning cooperation between business and research organization in the opinion of the respondents

Source: own elaboration based on the interviews with cluster managers (N=15)

When analyzing the average scores for all factors that condition collaboration in clusters, as indicated by their managers, it becomes clear that in none of them the evaluation indicated a significant stimulating importance. All assessments placed factors between neutral and facilitating (Figure 17).



The assessment in the scale: 0 – neutral, 1 – facilitates, 2 – significantly facilitates

Figure 17. The average assessment of the factors facilitating cooperation between business and research organization in the opinion of the each respondent

Source: own elaboration based on the interviews with cluster managers (N=15)

A more detailed analysis of the scores shows a fairly varied range of reported values (Figure 18). Communication between cluster members and mutual trust (and personal relationships) between cluster members were the most frequently (80%) cited stimulating factors.

A smaller number of responses – through still more than 50% – pointed to the following as drivers of collaboration: financial resources, human resources, facilities, geographic proximity, cross-sector similarities, capacity and fields of research of UNIV/RO matching the needs of firms in the cluster, and reputation/prestige gains. The factors least frequently identified by cluster

managers as collaboration enablers were: capacity constraints of R&D&I in SMEs (13%) and cross-sector differences (20%).

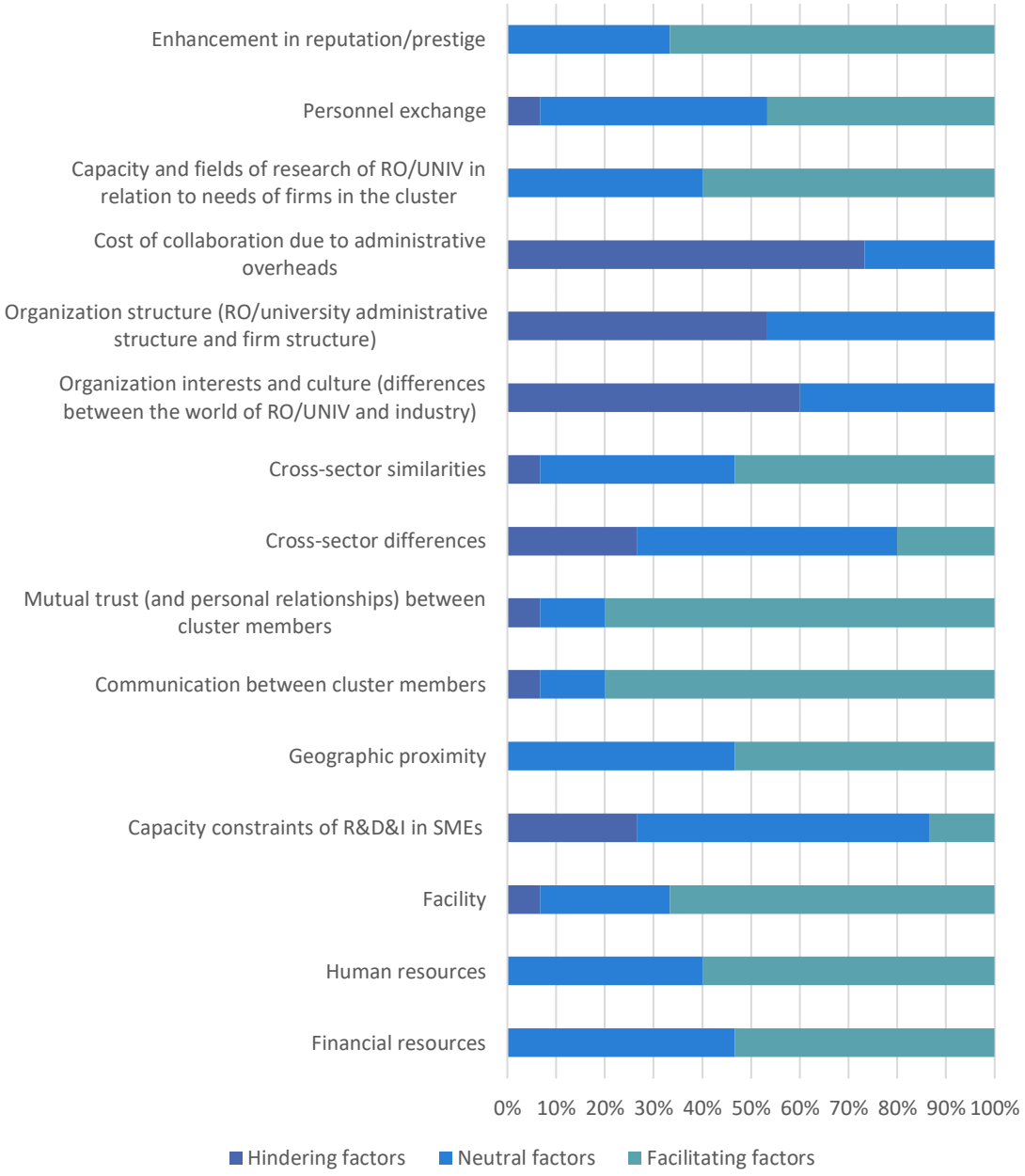
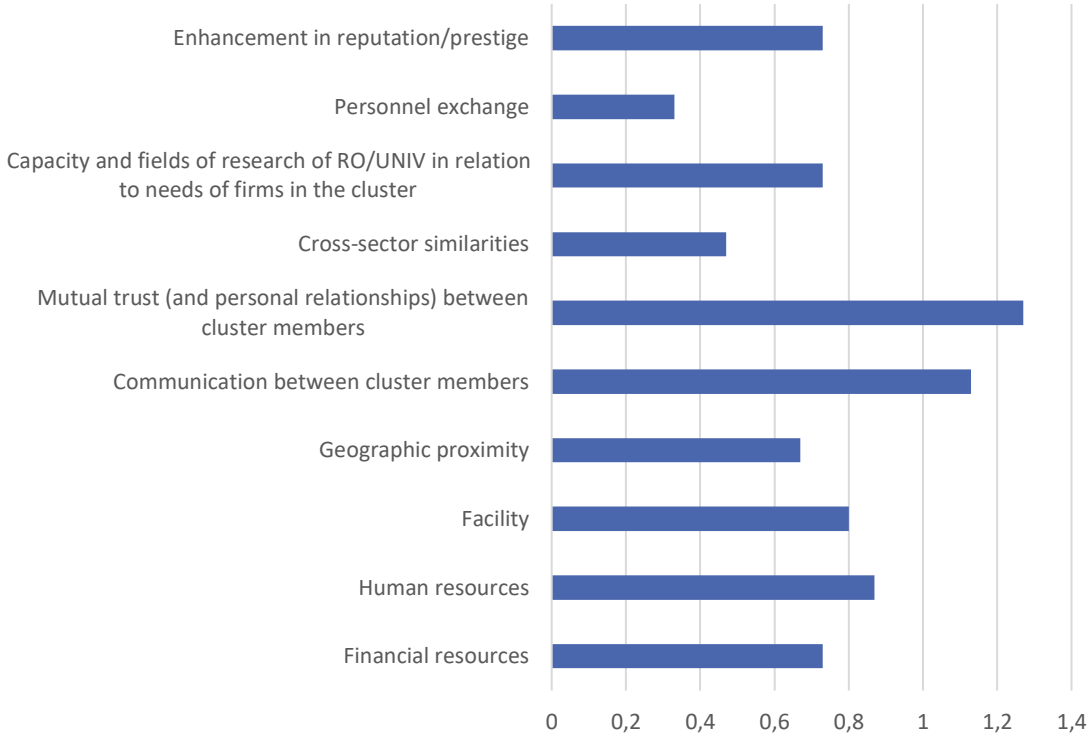


Figure 18. The assessment' structure of the factor business and research organization in the opinion of the respondents

Source: own elaboration based on the interviews with cluster managers (N=15)

On the other hand, some factors were never identified as facilitating collaboration: organizational interests and culture (differences between the world of UNIV/RO and industry), organizational structure (administrative structure of ROs/universities and corporate structure), and cost of collaboration due to administrative overheads.

Among all factors assessed by managers, 10 of them (67%) were identified as facilitating collaboration in clusters. The two highest ranked were: communication between cluster members, and mutual trust (and personal relationships) between cluster members (Figure 19). In the opinion of the respondents, personnel exchange and cross-sector similarities also promote collaboration, though to a relatively low degree.



The assessment in the scale: 0 – neutral, 1 – facilitates, 2 – significantly facilitates

Figure 19. The average assessment of the factors facilitating cooperation between business and research organization

Source: own elaboration based on the interviews with cluster managers (N=15)

The financial perspective is an important part of the functioning of all business entities. Having or the possibility of obtaining financial resources are important determinants of growth in any enterprise. The financial resources at a company's disposal allow it to invest in further development. This development may be pursued alone when the enterprise invests in its

resources or technology, but may also involve collaboration with other entities, including those from different industries and with different ownership structures. The nature of cluster organizations offers chances for collaboration which enables private enterprises and public entities to grow. Under these joint efforts, the activities of such entities are also conductive to the development of the cluster organization. There are three major forms of financing collaborative efforts:

- public sources,
- private sources,
- membership fees.

It seems that financial resources determine the possibility of investing in innovative development, as well as the quality and level of technological advancement of the investments. The indicated sources of funding were assessed by cluster managers to answer the question: what were the main sources of funding for collaborative R&D&I projects in last three years (on average).

According to the cluster managers, in the last three years, public sources were the main form of financing B2R/R2B. It should be emphasized that 4 out of 15 respondents were unable to clearly indicate the structure of the financing (answers are presented in Table 9). Further analysis of funding for B2R/R2B projects within the cluster organization is limited to 11 interviews.

Table 9. The answers given by the managers

Cluster organization	Answers
Cluster organization #1	Public sources are most important in the commercialization phase and private sources are most important in the research phase
Cluster organization #3	The majority of financial sources are private
Cluster organization #7	Public sources are main the main form of financing projects but respondent could not decide about private sources and membership fees
Cluster organization #11	Most of the projects are financed by public sources but cluster manager did not know the numbers

Source: own elaboration based on the interviews with cluster managers (N=15)

The results of the research show that public resources account for approximately 70% of funding for collaborative R&D&I projects (average=67%, median=70%). About one-third consists of private funds (average=36%, median=30%). On the other hand, membership fees were least frequently used to finance research and development projects (average=14%,

median=10%). Respondents could also indicate other sources of financing, but none of the managers used this option.

Figure 20 presents the structure of funding for R&D projects. As mentioned, this structure tends towards public sources, but its diversity is noteworthy.

In one out of 11 cases, 90% of collaborative efforts between science and business were financed by public sources. Two respondents indicated that 80% of the funding was public, whereas three reported that the proportion 70%.

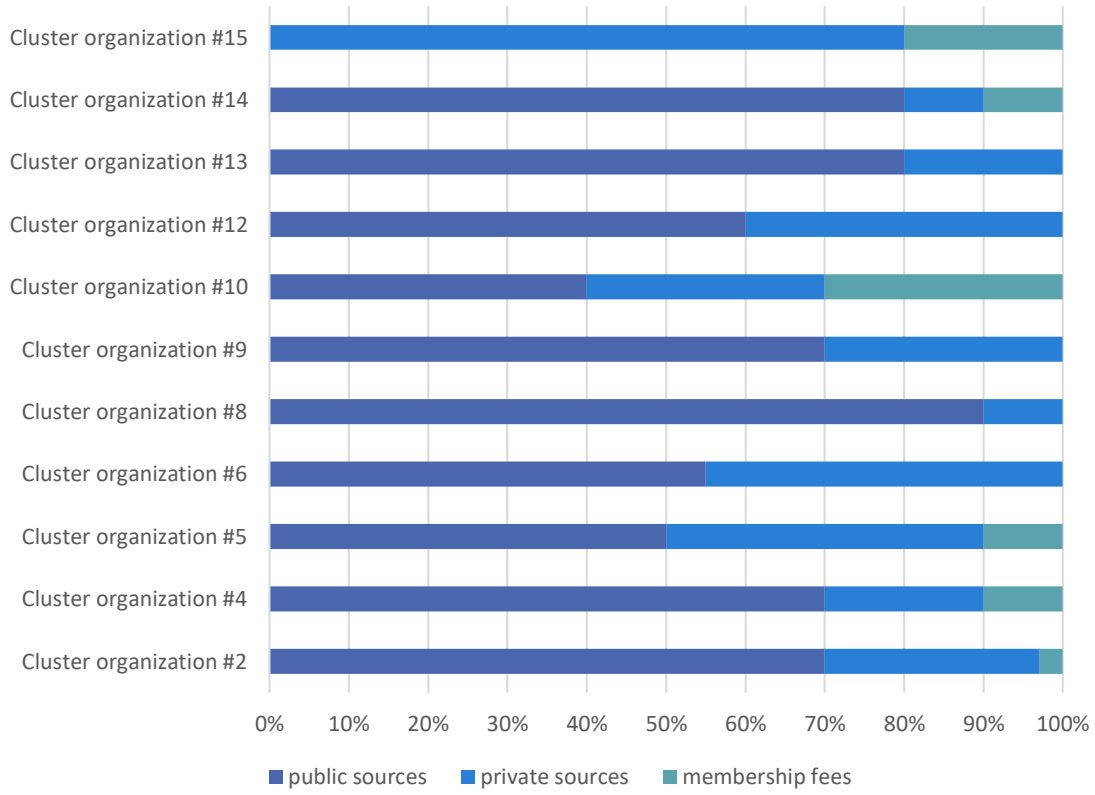


Figure 20. The structure of financial sources for collaborative R&D&I projects from cluster managers perspective

Source: own elaboration based on the interviews with cluster managers (N=15)

Only one cluster organization relied primarily on private funding (80%), and it was the only research organization that executed projects without any support from public sources. The remaining funds came from membership fees (20%).

The results of the survey confirmed that there was diversification of financial resources in all units, i.e. their funding came from more than one source (Figure 21). In over half of the surveyed

cluster organizations, two different sources of financing were used: public and private sources (reported by 83% of respondents). Only one organization reported using private sources and membership fees as their two sources of financing. In most cases, one of the sources is clearly dominant – public funding in most cases and private funding in one case.

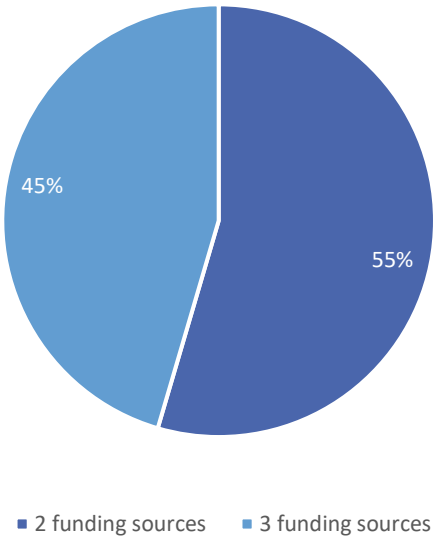


Figure 21. The structure of financial sources for collaborative R&D&I projects in the last three years – number of funding sources

Source: own elaboration based on the interviews with cluster managers (N=15)

Where three sources of financing were used, public funds remained the predominant source. Membership fees were found to be used less than private backing. There was only one cluster organization where the share of funds could be considered comparable. The funding of R&D&I projects comes 40% from public sources, 30% from private sources, and 30% from membership fees.

In order to obtain a more complete picture regarding the financing of science-business partnerships, the representatives of research organizations also referred to the financial aspects of collaboration with cluster organization and its members. Respondents were presented with seven sources of funding (Figure 22) and asked to indicate which three were the most important in their opinion.

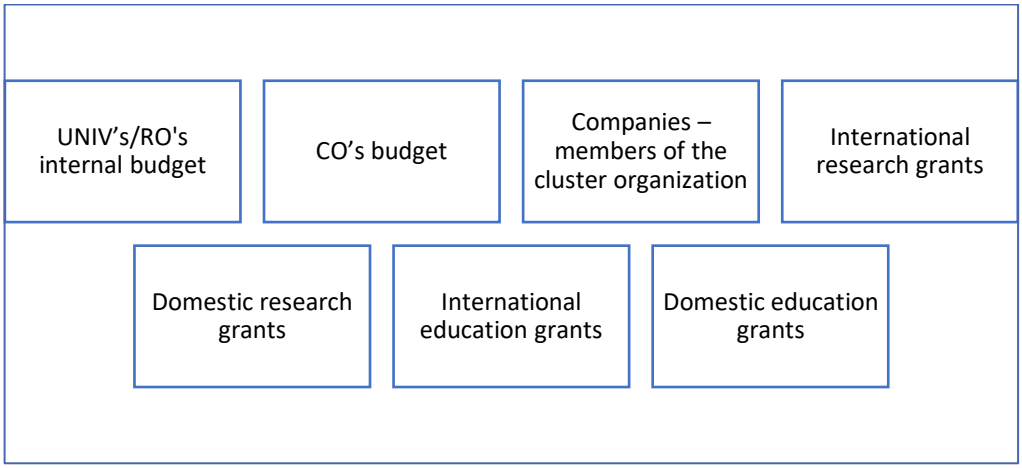


Figure 22. Types of funding sources for cooperation with cluster organization and its members

Source: own elaboration based on survey data (N=20)

The number of responses totaled 38. All respondents worked with the respective cluster organization within the last three years. In terms of legal status, only 1 out of 20 respondents held a position at a private institution – the remained represented the public sector, working at a university or a non-university scientific institution.

The UNIV's/RO's internal budget was the most frequently reported form of financing their collaborative efforts (Figure 23), being cited34% of all responses. The cluster organization's budget was indicated as the second most used form of financing (18% of the answers), followed closely by funding from members of the cluster organization (16%) and domestic research grants (16%). None of the respondents indicated using international education to finance joint efforts between science and business.

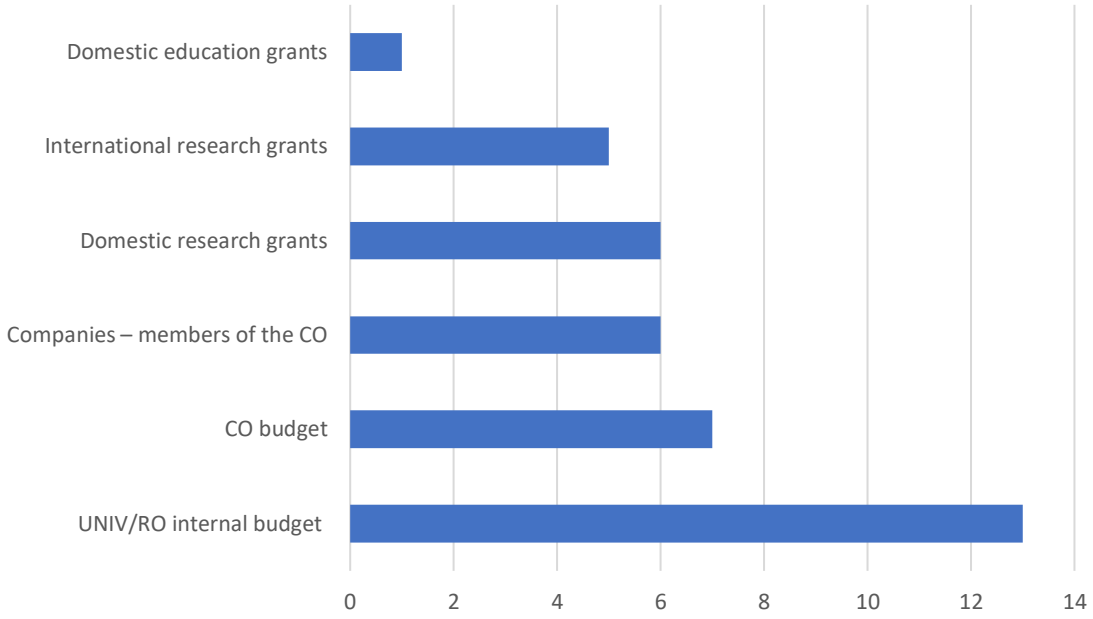


Figure 23. Funding sources for cooperation with cluster organization and its members from RO perspective – the number of indications

Source: own elaboration based on survey data (N=20)

Emphasis was placed on the quantitative and qualitative aspects of funding streams. It was noted that almost ¾ of the respondents used funds from their own budget in order to conduct collaboration and R&D&I research (Figure 24). Funds allocated from the budget of the cluster organization ranked as the second most frequently used source of financing, used by 40% of the research organizations. Corporate funding – capital from members of the cluster organization or research grants (domestic and international) – were used less frequently. Their contribution was more than two times lower (33%, 33%, 28% respectively) compared to funds sourced from the budget of the university/research unit.

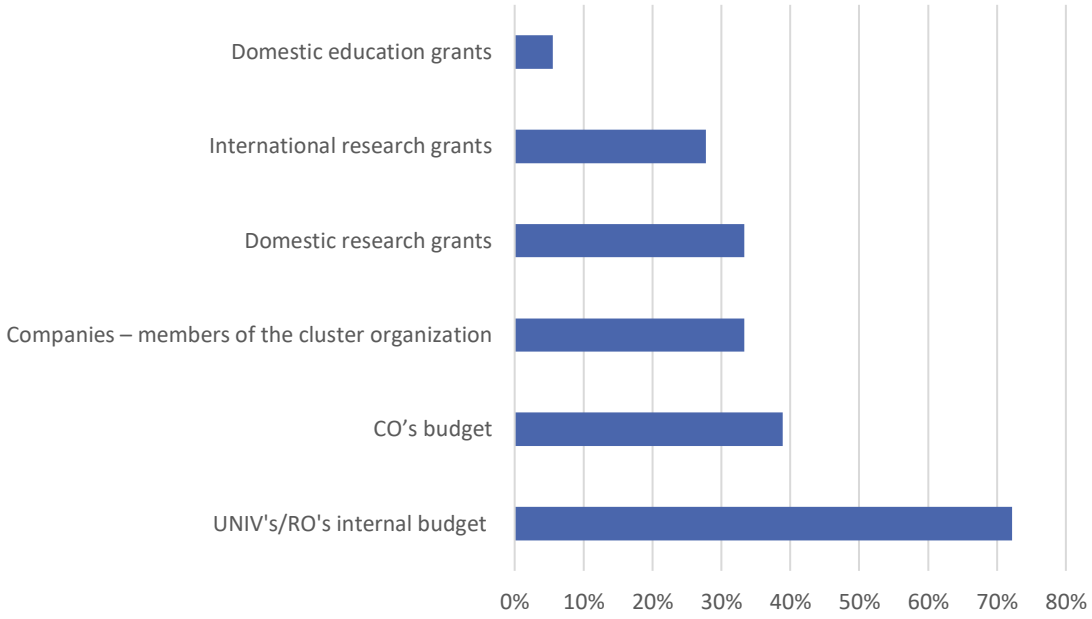


Figure 24. The percentage of indications of funding sources for cooperation with cluster organization and its members from RO perspective (multiple choice answer)

Source: own elaboration based on survey data (N=20)

A more detailed analysis shows that 20% of research organizations used the same sources of funding for collaboration between science and business. These include:

- the university's/RO's internal budget,
- the cluster organization's budget,
- companies – members of the cluster organization.

In contrast, 10% of respondents reported using the following forms of funding:

- the university's/RO internal budget,
- international research grants,
- domestic research grants.

About 1/3 of respondents from research organizations confirmed that the collaboration was financed from only one source, i.e.: university's/RO's internal budget, companies – members of the cluster organization, domestic research grants, or the cluster organizations' budget.

More detailed information about other combinations of funding sources is presented in Figure 25. The data shows answers of those respondents from research organizations who declared funding structures different than those listed above.

R2	UNIV's/RO's internal budget, international research grants, domestic education grants
R3	UNIV's/RO's internal budget, cluster organization's budget
R5	UNIV's/RO's internal budget, domestic research grants
R6	CO's budget, international research grants, domestic research grants
R7	UNIV's/RO's internal budget, domestic research grants
R13	Companies – members of the cluster organization, international research grants

Figure 25. The combination of different funding sources for cooperation with cluster organization and its members

Source: own elaboration based on survey data (N=20)

The results prove that funds from the budgets of research units and universities are the main financial engine of collaboration between science and business. The financing was also supported by other sources of funding (among 50% of respondents), often two additional ones (35%). It is also interesting to note that university's/research organization's budget was the sole source of funding in 3 of the research organizations.

The benefits of collaboration between business and science extended to multilateral links and activities. The basis for establishing collaboration between various market players may result, inter alia, from the willingness to implement innovative solutions and technologies in the given enterprise, which also serves to promote regional development. Moreover, collaboration in the field of R&D&I may also contribute to the scientific development of the research units and scientists involved. Joint activities should foster smart development of the region, with the cluster organization as the platform for such partnerships.

One of the determinants of collaboration between science and business is the potential for obtaining benefits specific to such partnerships. Achieving tangible results is a principle of business, which also extends to B2R/R2B. Defining these results can point to motivations behind pursuing science-business partnerships. The survey included 15 aspects associated with collaboration with the cluster organization and its members. These effects have a direct bearing on scientific activity, as well as being reflected in business practice.

Figure 26 presents a set of outcomes reviewed by respondents (working at research organizations). One of the respondents used the opportunity to indicate an additional result of joint R&D&I, namely participation in foreign missions and conferences.

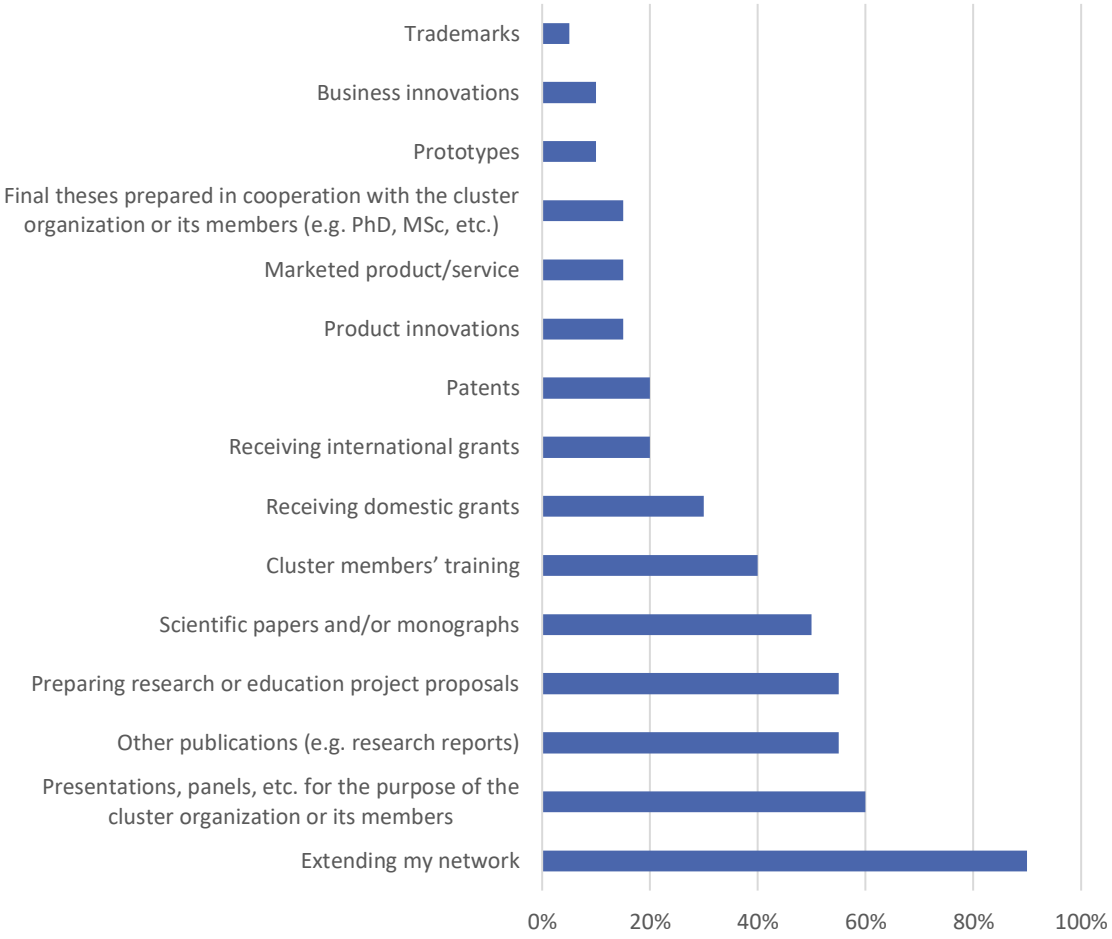


Figure 26. The results associated with cooperation with the cluster organization and its members – research organization perspective (multiple choice answer)

Source: own elaboration based on survey data (N=20)

It seems that expansion of the network of contacts is the primary upshot of research organizations collaboration with cluster organization and its members. This answer was indicated by 90% of the respondents. Networking helps build lasting relationships and opens up opportunities of working with various entities. Networking being the most frequently indicated result of collaboration should be considered to be a positive, with the hope that the expanded network of contacts will contribute to continued collaboration in the long term.

Presentations or panels, established for the purposes of the cluster organization or its members, hold an important place in the list. This effect has a practical dimension and directly relates to the activities of enterprises associated in the cluster organization.

Out of the 5 results of collaboration most frequently noted by the respondents, most are scientific in nature i.e. various types of publications and grant applications (including educational ones). On the other hand, the outcomes directly related to business practice (patents, trademarks, business and product innovations, marketed product/service) were in the minority.

Given the number of effects indicated by the respondents, it would seem that the answers provided are, again, highly varied (Table 10). This diversity may be a function of the forms of cooperation between members of the cluster organization, the sector/industry (degree of technological advancement), the level of economic development in the region, or other factors.

Table 10. The number of effects of cooperation with cluster organization and its members depending on the respondents

Number of respondents	Number of effects of cooperation
1	15
1	11
1	9
1	8
3	7
1	5
2	4
5	3
2	2
3	1

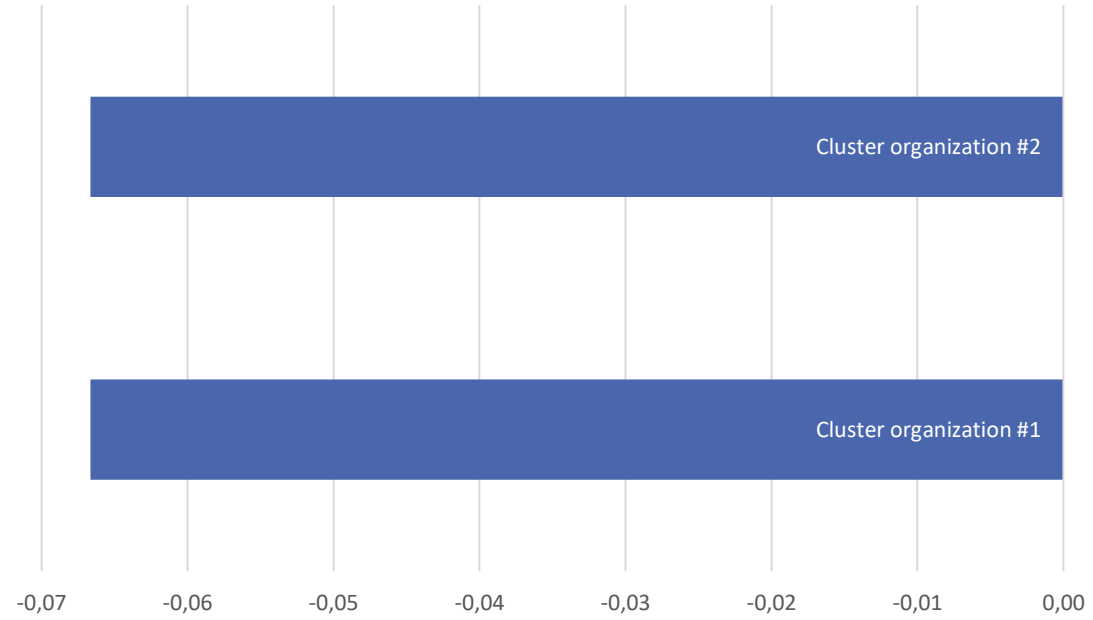
Source: own elaboration based on survey data (N=20)

One the extreme end, one respondent reported that the collaborative efforts produced all of the outcomes listed in Figure 26. One of the respondents noted 11 out of the 15 effects, none of which directly related to business activity, i.e. goods, product innovation/business processes, and marketed product / service. On the other side of the spectrum, three respondents indicated that their collaboration produced only one of the outcomes i.e. scientific papers and/or monographs, extension of network, or other publications (e.g. research reports).

Most respondents (5) reported experiencing three different effects of collaboration. Collaborations of research organizations with cluster organization and its members brought on, according to the respondents, an average of 6 (average=6.5, median=6.0) effects, which constituted about 40% of all effects. However, most of these effects are more scientific than commercial.

Challenges and barriers for B2R/R2B cooperation

In the current circumstances of the enterprises' operations and business environment institutions, there has certainly been growth in the different forms of mutual collaboration between them. Given the complexity of these conditions, such partnerships can be spurred on or limited by a number of factors. Of the clusters covered by the survey, only two indicated that the factors scored presented a barrier to collaboration (Figure 27).

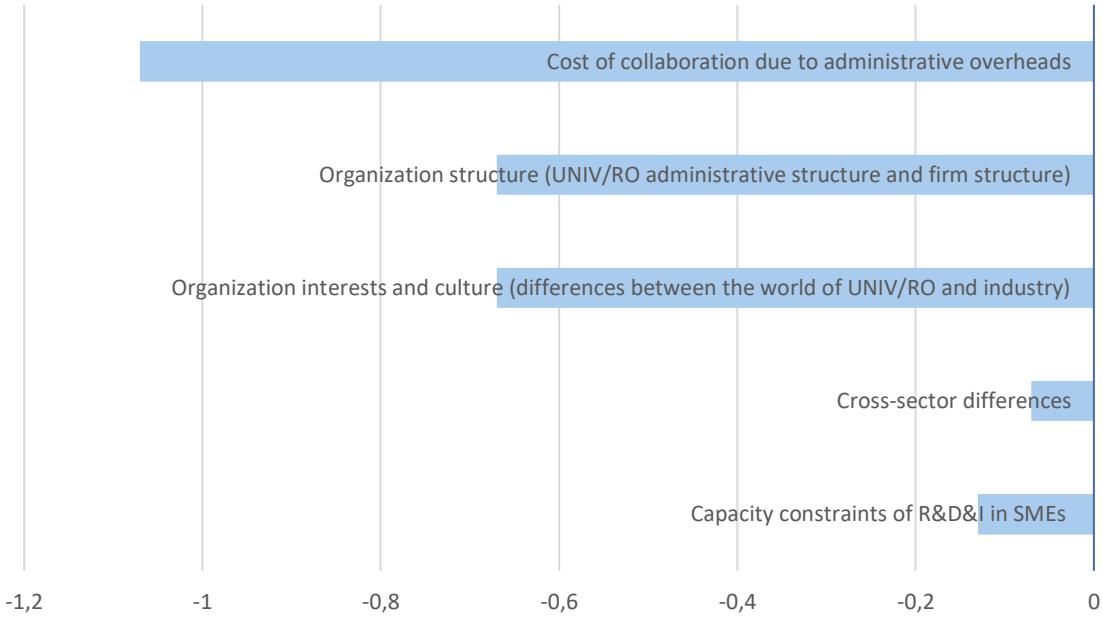


The assessment in the scale: 0 – neutral, 1 – hinders, 2 – significantly hinders

Figure 27. The average assessment of the factors hindering cooperation between business and research organization in the opinion of the each respondent

Source: own elaboration based on the interviews with cluster managers (N=15)

Among the factors analyzed, some (5 out of 15) were viewed by managers as a hindrance to joint work (Figure 28). The most significant barrier according to the respondents was the cost of collaboration brought on by administrative overheads. Cross-sector differences and capacity constraints of R&D&I in SMEs were cited as factors limiting collaboration, but to a relatively small extent.



The assessment in the scale: 0 – neutral, 1 – hinders, 2 – significantly hinders

Figure 28. The average assessment of the factors hindering cooperation between business and research organization

Source: own elaboration based on the interviews with cluster managers (N=15)

As indicated by Kot and Kraska (2016) in their paper, cooperation between the sphere of economy and the sphere of science will develop as a necessity of today's economic reality. Such partnerships are appreciated by enterprises located in clusters considered to be drivers of economic and regional development. However, the scale and forms of such partnerships are defined not only by the extent to which entrepreneurs are aware of the option, but also from economic development, which determines the ability to enjoy the effects of scientific research by enterprises located in the region.

The best practices of B2R/R2B cooperation in cluster organizations that can be transferred and implemented in other V4 countries

According to one of the interviewed cluster managers, a cluster initiative must be approached as a platform of cooperation to be successful. The platform must be based on its users, and the users have various needs, depending on the size of the business, its stage of development, and other factors. The key is to identify the needs the company would never fulfill on its own and to focus on them. Equally important is the personalization of services and information according to these needs.

The interviews with cluster managers provided many examples of B2R/R2B collaboration (Scheme 5), some being project-based, and others permanent. This information was used to select good practices – solutions that enable effective B2R/R2B collaboration and may be implemented on a wider scale.

Scheme 5. Examples of B2R/R2B collaboration

Source: own elaboration based on the interviews with cluster managers (N=15)

Best practices were identified and selected with potential implementation across cluster organizations in other V4 countries in mind. The basic criteria for selecting the best practices were:

- the collaboration between companies and research organizations is systemic,
- the cluster manager takes an active role in initiating the cooperation,
- the practice can be implemented by other cluster organizations (applicability at other clusters, including those from different industries),
- the practice is beneficial for the cluster members.

The selected good practices are of a different nature and can be adjusted to the needs.

Sano Center

> **The Sano Center is a non-profit research institute dedicated to the advancement of computational medicine. The main aim of the Center is to become a major, well-established Center of Excellence in the area of computational medicine, coordinating its substantial research and development e and worldwide. The strategic objectives of the Center relate to the five domains of: Academia, Translation, Education, Digital Health and Care, and Entrepreneurship. The objectives with regard to these areas are as follows:**
>
> - **To become Central Eastern Europe's fore identification, development, and implementation of techniques in Computational Medicine;**
> - **To combine academic, industry and clinical perspectives to inform innovative R&D processes, delivering competitive products and services to the marketplace, creating sustainability;**
> - **To deliver internal and external training programs to provide the next generation of healthcare technology innovators with the unique skill profile required by Computational Medicine;**
> - **To make a significant contribution to digitizing healthcare, confronting health challenges, improving wellbeing and meeting expectations for data utilization and treatment efficacy;**
> - **To foster an entrepreneurial culture within the Center to promote the translation of research and enhance innovation capacity.**

Source: https://sano.science/about-project/

The SANO Center was created mainly as a platform for commercialization of research results. The collaboration between companies and research organizations pursued by the Center is

focused on the development of new computational methods, algorithms, models and technologies related to medicine, introducing new diagnostic solutions to everyday healthcare practice, developing therapeutic methods based on computer simulations, stimulating the emergence and development of enterprises that create enabling technologies, introducing new diagnostic and therapeutic methods, and contributing to new educational programs for modern, personalized medicine.

Aeronet

> **The "AERONET Aviation Valley" Center of Advanced Technologies is a platform for collaboration aiming at: Undertaking, inspiring and supporting initiatives and activities in the field of specialized education and upskilling scientific, engineering and technical staff for the needs of aviation; Improving educational and research equipment of higher education units and airlines ; Organizing and developing educational partnerships for aviation-related specializations between universities, research units and enterprises in Poland and abroad, especially in Europe; Research for the aviation industry and industries related to the aviation industry; Analysing issues related to air transport and air traffic organization; Solving current problems related to the modernization and optimization of technologies used in the aviation industry, implementation of new products and technologies; Increasing and modernizing the technical capacity and securing the human resource capacity of the Center of Advance Technologies for the aviation industry and related industries.**

Source: own elaboration based on interviews with cluster managers

There are working groups in the Center responsible for creation of ideas and research on new technologies. The representatives of different types of institutions are engaged in joint research projects, inventing new technologies as well as providing technical assistance to the members of the Cluster

As part of the Aeronet project, the cluster members collaborate in the field of student education – companies offer student internships lasting 1.5 years. The Rzeszów University of Technology hosts lectures by experts from the aviation industry, and special trainings/internships are provided to university employees at member companies. The focus is on advanced education that meets the needs of technical staff of the cluster and related industries.

Barometer of the business cycle

> **The cluster's coordinator has developed an innovative tool for researching the economic situation of cluster members. The intention was to provide support to cluster members during the COVID-19 pandemic. The barometer is based on the methodology**

developed by the Central Statistical Office and tailored to the needs of the cluster's members, employing IT tool and a standardized survey. The tool has been implemented through a joint effort between the Institute of Management of the University of Białystok and. The readings of the barometer present a set of basic information to support decision-making processes at member companies, as well as the cluster manager.

Source: own elaboration based on interviews with cluster managers and Cluster Benchmarking in Poland 2020 available at: https://www.parp.gov.pl/storage/publications/pdf/2021.06.04-Raport-oglny-EN-dostpny_13082021.pdf

Both industrial as well as service/trade companies participated in the study. The tool gives the cluster manager a better picture of the directions/scope of support provided to cluster members. The mood of entrepreneurs and the financial situation of enterprises is analyzed on a monthly basis. This serves to provide both a diagnosis and a forecast of demand across domestic and foreign markets, any planned reductions or downtime in production, and barriers to development.

There are several other good B2R/R2B practices, including:

- joint projects,
- thematic platforms/groups of advanced cooperation,
- training/teaching programs,
- internships.

Some examples are presented below:

- joint projects:

White Hill synergy of cooperation in the area of R&D The objective of the project was to pave the way for the development of a new product: an automatic system for collecting data and supporting decisions with regard to greenhouse crops. Its objective was to help transition from the manual analysis of plants by experts in greenhouses to the observation and measurement being performed by robots.

MeCodia ç Modern composites with a metallic matrix reinforced with natural diatoms A research project focusing on the development and production of modern composite materials with a metallic matrix naturally reinforced by diatom shells to improve the durability of metalworking tools. The innovative composite material may be of interest to lightweight construction, automotive, aerospace or electronics industries.

RAMP (Robotics Automation Marketplace) a free and open IoT platform (FIWARE) running on state-of-the-art servers with access to cloud storage and computing, enabling connection

with robots, sensors, cameras, AR/VR devices, and other equipment. RAMP provides a 3D simulation tool to create a Digital Twin for virtual testing, a co-creation space for teams to collaborate online, and other digital services. Better Factories also provides an Open and Standardized Advance Production Planning and Scheduling (APPS) system for manufacturers to test commercial tools to optimize waste, energy, resources management, as well as general logistic.

Better Factory an initiative run by the Bydgoszcz Industrial Cluster. The aim of the project is to provide small and medium-sized enterprises with a methodology for increasing production automation, as well as developing new and personalized products. The task of executing the project will be assigned to high-skilled Technical, Business and Arts experts, who will analyze the current requirements of enterprises using core knowledge from manufacturers to redesign customizable products and service portfolios via new digital technologies. This may give rise to new product designs, business models or brands, digitally transform factories to match the demand for new or personalized products and to pave the way to new markets with customizable, personalized product or service portfolio.

- groups of advanced collaboration:

Thematic platforms are one of the solutions that help facilitate B2R/R2B. As an example, the Green Chemistry Cluster launched the Platform for Energy and Material Recovery, which promotes partnerships between the research organizations and enterprises. In addition to establishing collaboration entities in environmental industries, the aims of the Energy and Material Recovery Platform extend to: environmental protection; environmental education; promoting modern technological solutions as well as exchange of experience.

- training/teaching programs:

Due to the lack of a sufficient number of qualified employees in the industry, the Cluster has been involved in the promotion of technical education in the long-term. We work at all levels of education – from nursery schools to higher education. One of the greatest achievements was the creation of the only Polish faculty dedicated to this industry ("Plastic processing", a dual study program) at the University of Technology and Life Sciences in Bydgoszcz. In addition, the Cluster organizes trips to industry companies for pupils from the upper-grade primary school students, the purpose of which is to showcase modern production plants and what work at the different postings is like. The Cluster also organizes internships, apprenticeships, practical vocational training (in cooperation with an technical high school), and has also established awards in a technical knowledge competition and a scholarship for the best graduates of technical schools.

- Internships:

The Sustainable Infrastructure Cluster has set up internships for research workers at different companies. The internship was intended to produce at least one innovative solution with an implementation strategy. The project aimed at strengthening collaboration and increasing the transfer of knowledge between the scientific and business communities, as well as improving the qualifications of employees of SMEs and researchers, lecturers and researchers-lecturers from Małopolska.

4-month paid internships were addressed to both scientific employees and SME employees. Scientists were offered a four-month stint SMEs, whereas business sector employees were given the opportunity to work in a research organization. During the internship they could work on an innovative solution and its deployment strategy in one of the members of the Sustainable Infrastructure Cluster.

Conclusions and recommendations

Clusters have been rapidly developing since Poland's accession to the EU. There is currently a lot of interest from different environments in shaping cluster policy. On the one hand, the coordinators and members of cluster initiatives themselves express significant expectations and hopes for having more instruments available to support their activities aimed at expanding collaboration and executing joint projects. Similarly, active cluster policy development is supported by public authorities, which recognize the various benefits for the economy brought on by the expansion of clusters.

The evolution of cluster policy in Poland shows increasing emphasis on supporting established cluster organizations, while marginalizing clusters in their early stages of development. Since 2015, clusters considered to be internationally competitive and strategically important to the Polish economy have been designated as National Key Clusters (NKCs). At the moment, cluster policy in Poland is closely linked with the EU policy, mostly in terms of financing its tools, with structural funds as the primary source of funding. This is because cluster policy is especially important for transition economies that are undergoing institutional change. This is also true for Poland's with its emerging national innovation system. One of the system's main flaws is a lack of collaboration among businesses, as well as between the science and business sectors. Hence, the rationale for supporting clusters stems from their recognition as an important component of national and regional innovation systems, since they bring together both business and scientific units to facilitate knowledge flows, technology transfer, learning processes, and diffusion of innovation. As a result, the development of cluster initiatives in countries such as Poland may be an efficient way to overcome one of the main barriers to the economy's innovativeness, which is a low level of collaboration.

The study conducted under our project focused on analyzing the role of clusters in stimulating science-business collaboration, which is often perceived as one of the key factors for driving innovation in the economy. This assumption is confirmed by the statistical analysis presented in this report, which demonstrated that innovation active enterprises partner up with universities or other higher education institution more often than with government or public research institutes. Collaboration is also more frequent among innovation active enterprises then non-innovative entities. At the same time, collaboration in clusters was greater among large companies, which exhibit higher levels of innovativeness when compared with small and medium enterprises.

The findings of the project indicate that all cluster organizations in Poland which took part in the study had established relationships with both universities and other research organizations. The relationships were supported by formal agreements under which these organizations

became members of the cluster organization, as well as other types of agreements. The number of research organizations engaged in collaboration with cluster organizations ranged between 6 and 21, according to respondents. Universities were not the only type of institution that engaged in such collaboration – others included technology transfer centers, science/technology parks, regional innovation forums, etc. Developing science-business collaboration was part of the strategic approach adopted by clusters, as almost all of them had prepared a strategic document which emphasized the importance of working with with research organizations. According to the in-depth interviews, in the majority of cases the research-business collaboration was initiated by companies, not researchers or cluster managers. This finding speaks to the fact that the clusters are fairly mature, meaning that cluster coordinators are no longer highly involved in initiating collaboration among cluster members.

The results of the study demonstrate that one of the upshots of collaboration in Polish clusters was the launch and engagement in different international R&D&I projects, which resulted in various benefits, such as: finding solutions to technological problems, deploying technologies, and networking, as well as gaining competences, experience, knowledge and skills. This proves that internationalization is becoming an important direction in the development of Polish clusters, which go beyond their local frameworks for cooperation and are entering into international collaboration networks. This means that clusters have entered a new stage of evolution in which, after the engaging with partners chiefly at the local level, the time has come to build trans-regional and cross-border collaboration networks.

One of the key problems of innovation system in Poland is low level of collaboration between academia and industry. This state of affairs can be changed through the intervention of intermediary entities whose purpose is to facilitate collaboration. This role is often taken up by clusters organizations, which bridge the gap between enterprises and research institutions. In practice, there are different motives for science-business collaboration. In general, it may be described as the need to transfer knowledge and technologies that are developed throughout the process of commercializing goods and services. This study serves to demonstrate that the most important factor motivating scientists to work with businesses in Polish clusters is the ability to extend their network, followed by seeking new avenues of commercializing their research findings. Other reasons for pursuing collaboration are: procuring non-financial research assistance (such as gaining access to data, exchanging knowledge with professionals, or developing technology), as well as receiving research funding or personal financial gains. Additionally, respondents identified numerous additional criteria that drove them to pursue collaboration with a cluster organization and its members, including: maintaining close ties to business practice, exchanging experience, participating projects, building relationships with other entities, gaining prestige, study visits, the utility of conducted research to the business world, knowledge of the environment and willingness to incorporate it, the need to perform

tasks for organizations in the region, the desire to engage in region-specific issues, and the exchange of experience in the sphere of research and development.

The study also identified most important benefits from B2R/R2B in cluster organizations, such as: identifying and resolving technological issues raised by businesses, increasing mutual trust between scientists and entrepreneurs and the level of academia-industry collaboration, transferring knowledge from academia to industry with mutual benefit, expanding opportunities for various types of activities (such as postgraduate studies, sectoral conferences, internships, Industrial Doctoral Programs, strategic alliances/joint research projects, opportunities to influence university curricula, use of laboratories and other university facilities in order to solve real technological problems encountered by businesses, development of technological processes, access to expertise and increased opportunities for knowledge sharing and skill development, gaining information and knowledge about new technological trends, and increased opportunities for internationalization and participation in international projects as a result of cluster collaboration initiatives.

In practice, B2R/R2B in cluster organization can take different forms. Domestic and international cooperative projects are the primary mode of collaboration, but there are also, information exchange fora, participation in seminars and the use of facilities available at research organizations or universities. However, implementation doctorates, and liaison offices are still less popular among cluster managers. The most often reported modes of collaboration through which representatives of the research industry worked with a cluster organization were: consulting, training, conducting research, preparation of project applications or offers, membership in the management board of a cluster organization, and supervision of commissioned bachelor's/master's/doctoral theses. In terms of the type of academia-business collaboration pursued within cluster organizations, the most business-related activities were the most common, followed by research-related activities and education-related activities.

The study allows sheds light on drivers of B2R/R2B in cluster organizations in Poland, in particular: communication between cluster members, mutual trust (and personal relationships) between cluster members, financial resources, human resources, facilities, geographic proximity, cross-sector similarities, compatibility of the capacity and fields of research of the RO/UNIV with to needs of cluster firms, and reputation/prestige gains.

The study also identifies and presents the best practices of B2R/R2B in Polish cluster organizations. These practices demonstrate the systemic nature of collaboration between businesses and research organizations, the cluster manager's active engagement at the start of the partnership, and the potential for replication by other cluster organizations. They also produce a variety of benefits for cluster members. Some of the best practices are implemented in Sano Center, which is well-established Centre of Excellence in the area of computational medicine, which greatly facilitates the commercialization of research findings. Another best

practice is the Center of Advanced Technology AERONET Aviation Valley, which functions as a multi-purpose platform for cooperation, enabling specialized education in the aviation sector, as well as solving current problems related to the modernization and optimization of aviation industry technologies. Another best practice described in a report is the business cycle barometer, which presents a set of basic information to support decision-making processes at member companies, as well as the cluster manager. The key characteristic of presented best practices is the fact that they support collaboration between science and business, thus promoting knowledge sharing and transfer of technology.

The results of the study can be used to formulate some recommendations for cluster policy, especially in the area of stimulating business-to-research (B2R)/research-to-business (R2B) relations. Government support should focus on strengthening the scientific/research capacity and its use in actual business by promoting knowledge and technology transfer from universities to enterprises in clusters. Example instruments concern co-financing R&D work undertaken in collaboration between scientific and industrial entities, investments in common research infrastructure, use of intellectual property rights (including assistance in obtaining patents), purchase of new technology, and development of human capital, e.g. by organizing traineeships for scientists in companies. In the face of globalization of innovative activity (techno-globalism) it is also important to support the internationalization of knowledge-based clusters, e.g. participation in international consortia and scientific networks. In this respect, domestic and the EU structural funds may be complemented by national and EU funding for research, development and innovation activities, e.g. under the European Union Framework Programs.

In addition to direct instruments for supporting cluster initiatives, an important function of cluster policy is to popularize the cluster model as an effective way of organizing innovation activity and creating an environment conducive to collaboration between different types of entities. This can be done through various promotional activities, conferences, training, and publications aimed at increasing the awareness of the benefits that collaboration between research institutions and businesses can bring. It is also important to create favorable conditions for conducting business activity, which will stimulate entrepreneurship and help further tap into the production capacity in the economy.

Cluster policy should focus particularly on clusters in high and medium-high technology industries. A characteristic feature of this type of policies is that they operate in relatively young industries with an unstable level of density and short-term relationships between entities (such as joint R&D projects). Research and development entities play a key role in such clusters, being less focused around enterprises than other types of clusters. Compared to industrial clusters, research clusters are usually significantly smaller in terms of the number of entities involved, employment, or scope of specialization. However, they are characterized by a huge growth

potential, stemming from their capacity to influence technical progress and create innovations that may disrupt the functioning of a given industry. There is no doubt that such cluster initiatives should be supported by economic policy, as they play a significant role in increasing innovation in the economy. However, they require a different approach from government institutions than industrial clusters, both in terms of the selection of cluster initiatives eligible for support and the instruments used.

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