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

Edited by Marta Mackiewicz

Visegrad Fund

The report was written as a result of 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**.

Reviewers:

Professor Romana Ewa Śliwa

Dr hab. Katarzyna Cheba

Authors:

Pavel Bednář

Zoltán Bendó

Lukáš Danko

Mariola Grzybowska-Brzezińska

Katarína Havierniková

Małgorzata Kędzior-Laskowska

Marcel Kordoš

Arkadiusz Michał Kowalski

Karol Krajčo

Dominika Kuberska

Wiesława Lizińska

Marta Mackiewicz

Drahomíra Pavelková

Cooperation: Adriana Knapkova

Project manager: Marta Mackiewicz

Warsaw/Olsztyn/Budapest/Trencin/Zlin 2022

Table of content

List of Abbreviations

ALE	The Association of Legal Entities
API	Agency for Entrepreneurship and Innovation (Agentura pro podporu podnikání a inovace)
B2R	Business to research
B2R/R2B	Business-Research/Research-Business
BA	Bratislava region
BB	Banská Bystrica region
CI	cluster initiative
CMO	cluster management organisation
CO	cluster organization
ECEI	The European Cluster Excellence Initiative
EDIOP	Economic Development and Innovation Operational Programme
EDIOP+	Economic Development and Innovation Operational Programme Plus
EDOP	Economic Development Operational Programme
EIS	European Innovation Scoreboard
ERDF	European Regional Development Fund
ESCA	The European Secretariat for Cluster Analysis
ESF	European Social Fund
EU	European Union
GDP	Gross Domestic Product
HEI	higher education institutions
ICT	Information and Communication Technology
IDI	in-depth interview
IPR	Intellectual property rights
IT	Information technology
KE	Košice region
KNC	Key National Cluster
MIT	Ministry of Industry and Trade
NCA	National Cluster Association
NPO	Non-profit organization
NR	Nitra region

OECD	Organization for Economic Co-operation and Development
OP	Operational programme
OPEI	Operational Programme Industry and Enterprise
OPEIC	Operation Programme Enterprise & Innovation for Competitiveness
PCT	Patent Cooperation Treaty
PI	Public institutions
R&D	Research & Development
R&D&I	Research & Development & Innovation
R2B	Research to business
RI	Research institution
RIS	Regional Innovation Strategies
RO	Research organization
RO/UNIV	Research organisations/Universities
ROP	Regional Operational Programmes
S3	Smart Specialisation Strategy
SARIO	The Slovak Investment and Trade Development Agency
SAS	Slovak Academy of Sciences
SIEA	The Slovak Innovation and Energy Agency
SME	Small- and medium-sized enterprise
SPK	Slovak Plastic Cluster
UKS	Union of Slovak Clusters
UNI	University
V4	Visegrad countries: Czech Republic, Hungary, Poland, Slovakia

Summary

This report presents the results of 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 Visegrad Group countries. The research methods used included literature review, in-depth interviews with cluster organizations' managers, a survey of research organizations engaged in collaboration under clusters, and interviews with representatives of the research organizations to expand on the information collected in the survey.

The report begins with a presentation of the theoretical background and comparison of the cluster landscape in V4 countries. The emergence of cluster organizations in V4 countries occurred between 2000 (Hungary) and 2004 (Slovakia).

The study conducted in 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 institutions more often than with government or public research institutes. Collaboration is also more frequent among innovation-active enterprises than 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-sized enterprises.

The motives for collaboration are similar in all the countries, and include access to research funding, access to knowledge and new technologies, and access to research networks, as well as development of staff. Collaboration inhibitors are similar in the Czech Republic and Slovakia – the top three in the Czech Republic include: (1) Capacity constraints of R&D&I in SMEs, (2) Organization structure (RO/UNIV administrative structure and firm structure), and (3) Capacity and fields of research of RO/UNIV in relation to needs of firms in the cluster, while in Slovakia only the last one is different - Insufficient financial resources. There are also similarities between Poland and Hungary. The top three are: (1) Cost of collaboration due to administrative overheads, (2) Organization structure (RO/UNIV administrative structure and firm structure), and (3) Organization interests and culture (differences between the world of RO/UNIV and industry).

The study also identified the 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 Poland, clusters are recognized as a way to increase the level of collaboration between companies, as well as between the science and business sectors. In Hungary, there is an ambivalent attitude towards clusters – on the one hand they are perceived as bridges between the science sector and business, while on the other hand public authorities are still hesitant in entrusting some assignments to clusters that would emphasize their role in this process. In the Czech Republic there are a number of strong clusters, but their role in the innovation policy must be strengthened through them being recognized as important actors by public authorities. In the Slovak Republic, clusters help in establishing mutual cooperation, in solving companies' scientific and research problems, and in participation in new projects in the field of applied research. They play a significant role in connecting study programs with practice.

The study also identifies and presents the best practices of B2R/R2B cluster organizations from all the V4 countries. 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.

Introduction

This final report was written as part of 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 the 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 the 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 and present good practices of such collaboration.

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.

Some evidence suggests that clusters provide a structure of linkages which can foster research-business cooperation (Agrawal, Cockburn, 2002; Edgington, 2008). This fact was one of the reasons behind introducing a cluster policy in the European Union. Its aims are to be achieved, inter alia, by supporting cluster organizations which undertake various initiatives to build a cluster strategy/brand/identity and promote networking between cluster participants, which may result in innovation. Cluster organizations serve as platforms which bring together various cluster actors and therefore can provide an environment which facilitates conducting collective activities resulting in more innovations. Therefore, learning about B2R/R2B collaboration in cluster organizations of V4 countries will provide a better understanding of how Czechia, Hungary, Poland and Slovakia can become more innovative.

After years of developing and fostering relationships between cluster organizations' participants, they have gone through a trial-and-error phase which should have allowed them

to amass experience and come up with the B2R/R2B practice that best fits the industries that form their core.

Weak linkages between research institutions and firms in V4 countries seem to be one of the key reasons for the relatively low level of their innovativeness. It is crucial to understand that at the current level of their development their further growth can be achieved by focusing on opportunities which can boost their innovativeness. However, business-research collaboration is perceived as a challenge in the European landscape, too (see the Summary Report on lessons learnt from fostering modern Cluster Policy in regions in industrial transition from 2019 by the European Observatory for Clusters and industrial Change) and discussions are going on regarding how to improve it.

Despite various studies on cluster organizations in V4 countries, until now, no comprehensive research has been conducted on how companies within cluster organizations build links with universities and scientific institutions (B2R) and vice versa (R2B). Therefore, the project was designed based on the premise that understanding communication and cooperation between participants of cluster organizations (business and research) could serve as a way to improve the levels of innovativeness of V4 countries.

In accordance with the project methodology, the research presented in this final report was conducted in four steps:

1. Literature review to gather the necessary data for analyses and to extend knowledge on the state of the art in current business-research relations.
2. Carrying out in-depth interviews with cluster organizations' managers to define the role of research organizations in clusters organizations.
3. Conducting a survey among research organizations to collect data on the different forms of collaboration and their main benefits.
4. Conducting interviews with 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 the lessons learned so far and 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.

The report is structured as follows. The first chapter provides a theoretical background on clustering and science-business collaboration. The second chapter gives an overview of the methodology of the research project and the methods applied to accomplish its objectives. The third chapter provides an analysis of the current status of collaboration between business and research institutions. The following chapter gives an overview of the cluster landscape in the V4 countries, and also includes a profile of cluster organizations that took part in the study. The fourth 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. It also gives an overview of the forms of B2R/R2B functioning in practice among cluster organizations. In the same chapter, the challenges, barriers and detrimental factors were analyzed to determine what can hinder B2R/R2B. The fifth chapter describes good practices of collaboration in cluster organizations that can be transplanted and implemented in all V4 countries. The sixth chapter presents a model of cooperation. Finally, the last chapter contains 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.

1. Clusters as platforms for cooperation – theoretical background

The emergence and development of clusters in European countries is seen as an instrument how to increase regional competitiveness, making the "cluster" principle a key element of regional, innovation and industrial policies. Cluster is an element of local economy that is the result of development and natural benefits in a region resulting from proximity to localization and intensive cooperation. Businesses centered within the cluster can compete on one hand, on the other hand, they can work together. The success of cluster depends on interconnecting with the region, resources, investment activities, stimulating through various projects and legislation. Collaboration and competition are potential tools for increasing regional value because it exploits the combination of knowledge, skills, knowledge, and know-how of several individual subjects, hence achieving the desired synergistic effect. The chapter on theoretical basis analyzes and defines the terms clustering and cluster within its typology, policy, tools along with its positive and negative aspects. Furthermore, in more detail the issue of the University Industry Cooperation model elements are described such as the organizational forms, cooperation motives, the barriers and facilitators of cooperation as well as the effects of clustering and results of mutual university and industry cooperation

1.1. Clusters and Clustering – the exposition agenda

The cluster issue was elaborated in more detail by American economist Michael Porter, who in 1990, in his work entitled "Competitive Advantage of Nations," described the importance of businesses association within the area and its link with the diamond model of competitive advantage. Porter has defined clusters as “geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities , standards agencies, and trade associations) in particular fields that compete but also cooperate” (Porter, 1990).

The clutches of competitive industries, usually scattered around physically, tend to focus geographically. One sector of competitive industry helps to create other mutually reinforcing processes. According to Krugman, et al. (2014), clusters are not considered to be fixed flows of goods and services, but rather to dynamic agreements based on knowledge creation, rising revenues and innovation in broader sense. Lukasík, Janovčík, Kavecký, (2007) dealt with cluster

concepts in terms of urban agglomeration that include companies from different areas located in the same urban area because companies perform similar or interconnected activities. Economist like Nadabán (2009) has supplemented Marshal's definition of cluster model in the area of social relations among cluster participants highlighting that social capital of a cluster has a major impact on the development of cluster. According to Brakman, et al. (2006), clusters consist of co-located and interconnected industries, governmental authorities, local, academic and financial institutions, and co-operation institutions. Dynamic clusters are typical for a successful microeconomic business environment. Karlsson (2007) states that typical characteristics of dynamic cluster environment include:

- intense local rivalry, a struggle for prestige that is a stimulus for continual improvement, change and the creation of prerequisites for a more progressive and diversified supply base,
- dynamic competition resulting from the arrival of new companies, including spin-offs of larger companies already operating in region,
- intensive cooperation through different cooperation institutions, such as professional organizations, chambers of commerce, cluster organizations, etc. In addition, clusters are characterized by intense informal interaction based on personal relationships,
- access to increasingly specialized and modern factors of production (human capital, financial capital, infrastructure) and, in some clusters, relationships with universities and public / private research institutes,
- links with related industries, sharing common talents and new technological advances.

To define and explain the concept of cluster is not an easy task. The concept of cluster is used in several areas. Within the macroeconomic and microeconomic structure, it is the issue of national, regional and cross-border clusters, competence of clusters, clusters in industry, or production and innovation systems. In most cases, the cluster concept is associated with management system and performance enhancement. Clusters include a number of related industries and other stakeholders being important to competition. These include, for example, specialized inputs suppliers such as components, machines and services, and specialized infrastructure providers. Clusters also often expand downstream into channels and customers and cross-border to complementary product manufacturers and companies in industries related to skills, technologies, or common inputs. Finally, many clusters include governmental and local authorities and other institutions - such as universities, standardization agencies, think-tanks, business associations that provide specialized training, education, information, research and technical support (Prno, 2005). Many clusters also include governmental or other institutions - universities, law agencies, research teams, or business associations - providing specialized training, education, information, research and technical support. Michael E. Porter (1990) has portrayed four interconnected areas to describe the business environment, so-called

diamond model illustrated in Figure 1. Porter refers to cluster as a geographically close group of interconnected enterprises, specialized suppliers, service providers and related institutions in a particular field, as well as companies in related fields that compete one another but also complementing and cooperating with common features. Porter model contains the following components:

1. Company strategy, structure and rivalry - represents a corporate strategy as a different way to competitiveness, takes into account customer´s choice and promotes innovation; and rivalry that strengthens competitiveness amongst the leader in a sector through innovation.
2. Input conditions - include a variety of natural, human and capital resources, information system, legal system and administrative system, scientific and technological infrastructure.
3. Demand side conditions - must include a sophisticated and demanding local customer who predicts demand for specialized segments or needs somewhere else.
4. Related and supported industries - include the existence of capable local subcontractors and competitive local companies in related industries in terms of technology, workforce, or customer´s knowledge.

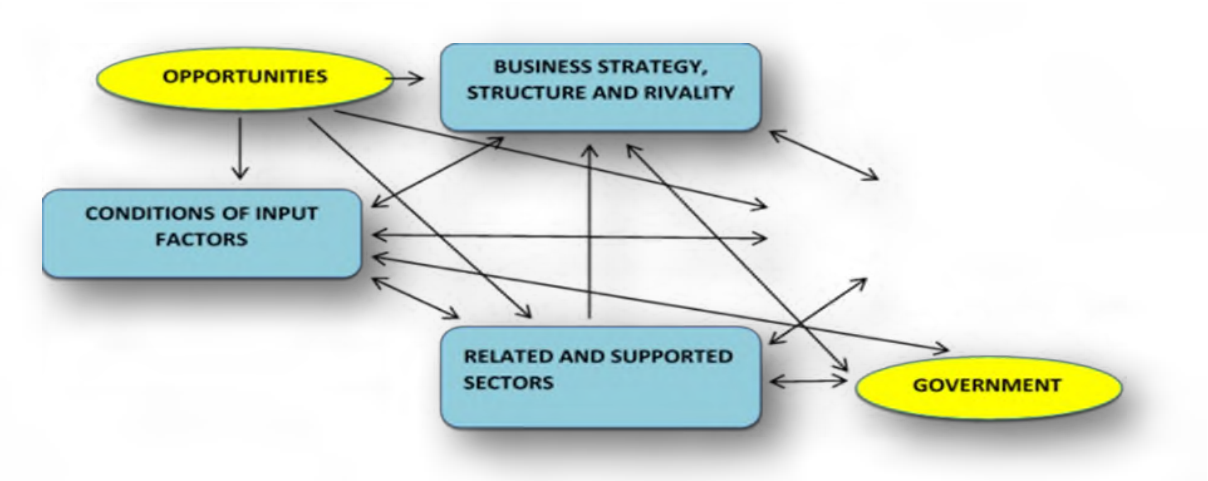


Figure 1. Porter´s diamond model

Source: own processing by Porter, 1990

According to Pavelková et al. (2013) clusters are production networks of interdependent companies, including suppliers linked to each other within the production value chain. In some cases, they include strategic alliances with universities, research institutes, knowledge intensive services, intermediaries, consultants and customers. From the stated above it can be implied

that clusters represent a grouping of business entities, educational and research institutions to improve their business position and succeed in a competitive market. It is believed that the effects resulting from this association will be reflected mainly in lowering the costs, attracting new customers, and joining new markets entry. According to OECD (2001), clusters are local associations of horizontally or vertically interconnected companies that specialize in similar business areas, along with support organizations.

To better understand a cluster policy and its orientation, three key components such as document (policy), program, and implementation agency need to be described. Policy should be understood as government-defined strategic goals. It is basically a document that does not contain any tools, measures, nor does it allocate funding, it only describes vision, goals and their significance. Policy is implemented through programs. According to Breslin (2002) program allocates funding and sets out the conditions under which money from programs can be drawn. Implementing agencies such as governmental agencies or governmental bodies - departments are in charge of program implementation. The positive effects of clusters on the economic development of companies, sectors, regions, but also countries have resulted in targeted cluster support through the implementation of so-called cluster policies. Cluster policy is defined as a specific government effort how to support clusters (Karlsson, 2007). As stated by Sölvell, et al. (2003) cluster policies can be categorized into three categories, reflecting their motivation as well as political goals. The first category is support policies aimed at improving the business environment that indirectly stimulate the emergence and dynamism of clusters. The second category includes traditional framework policies, such as industrial policy, SME development policy, research and innovation policies or regional policy. The third category is presented by policies being aimed at creating, mobilizing and improving clusters in specific sectors. This category is considered to be a strict cluster policy. According to Pavelkova (2009) cluster policy depends on the type of clusters, the current level of cluster development, but also on the knowledge of suitable support tools possibility. Ideally, cluster policies address specific cluster problems. In addition, for the functionality of clusters it is significant to create appropriate framework of conditions that stimulate the development of companies, but also the emergence of companies. Cluster support also helps to improve relations among key economic actors in the region, to activate regional authorities, businesses, and academic sphere, and to find ways how to actively collaborate with these stakeholders (Burger, 2013). From a practical point of view, cluster policies can be divided into three categories (European Commission, 20017):

- development policies focused on creating, mobilizing or improving the functioning of clusters (e.g. the best cluster strategy national contest),
- policies aimed at improving the efficiency of specific instruments (e.g. R&D subsidies provided only to firms in regional clusters where spill-over effects are expected),

- policies that help the microeconomic environment to increase the presumable emergence of clusters (e.g. policies removing the regional competitiveness barriers).

In addition, cluster policies may have different objectives from local to meta-clusters and can be characterized by both top-down and bottom-up approaches. Cluster policies may include other policies such as industrial, innovation, science, technology, education, regional and export promotion policies. Cluster development can, however, be enhanced through standards implementation. However, because of sectoral, regional or national specificities, it is not possible to create a universal cluster policy. In general, to support the emergence of new clusters is more complicated than to support already operating clusters (Haviernikova, 2016). Cluster policy, unlike sectoral or industrial policy, should be neutral in terms of industry or the type of economic activity. In cluster theory, all clusters are useful. Cluster externalities and spillover effects enhancement will increase the productivity and prosperity of any cluster. Thus, the government should not be picking up among clusters, but should create conditions that support the modernization of all clusters. Cluster policy is thus fundamentally different from sectoral or industrial policy, often being mistaken, for example, by focusing on certain types of activities preference (Balog, Duman, 2010). If a region wants to stimulate the creation and growth of innovative clusters, investing into university education, science and research is also necessary. However, it is important that the orientation of research institutes is relevant to particular clusters (Balog, 2015). According to OECD (2001), separate cluster policies are defined on the basis of one of the three main policy groups, namely: regional policy, science, research and technology policy and industry and entrepreneurship policy. Depending on particular policy, its scope is defined, such as:

- a cluster policy based on regional policy focuses on building social capital (building and maintaining common relationships leading to mutually beneficial results and building mutual trust);
- cluster policy based on science, research and technology policy puts emphasis on innovation and commercial exploitation of research results;
- cluster policy based on industry and entrepreneurship policy focuses on factors supporting national or regional growth, key sectors and their competitiveness, or support for SMEs;
- a cluster policy based on two, respectively of all three policies.

Clustering is a contradictory process, on one hand, the involvement of subjects in cluster activities brings many benefits such as access to innovation, cost reduction, production diversification, easier and more cost-effective availability for different types of services, a wider portfolio of products or services, and much more. On the other hand, the clustering process also encounters a number of negative impacts such as sovereignty restrictions, being dependent on dominant cluster subjects, inappropriate choice of affiliates, geographic location

of a cluster, and further negatives, such as unavailability of qualified workforce and infrastructure and so on. As main symptoms of a clusters can be considered than companies within the cluster are involved into more than one sector and several entities (e.g. suppliers), state and other institutions (universities, research institutes, development institutions, standardization institutes, trade and other associations). In particular, the development of clusters is essential for the innovative growth of companies provided by R&D institutions (Lukasík et al. 2007; Prno, 2005; Dicken, 2007).

Cluster Initiatives (CIs) appear to be another significant term regarding the cluster agenda. According to the Green Paper on Cluster Initiatives (European Commission, 2017), Cluster Initiatives are organized efforts aimed at increasing the growth and competitiveness of clusters in region with the participation of cluster companies, government and / or the research community. This means that cluster initiatives are a rather formalized and institutionalized form of cooperation between a group of local entities seeking to launch a new cluster or solve some major problems experienced by an already existing cluster. A key objective of cluster policy is to develop clusters, understood as viable business structures consisting of geographically proximate enterprises cooperating and competing with one another within a specific industry and related industries. Public policy instruments are targeted at cluster initiatives with a varying degree of institutionalization; the direct beneficiary of support are cluster organizations, which are responsible for coming up with, carrying out and financially settling specific projects. While clusters exist independently of companies or any programs, a cluster initiative is based on undertaking a specific project or developing various types of cluster-like organizations, which may be the target of support as part of economic policy.

CIs have become a central element how to improve the growth and competitiveness of clusters. Cluster initiatives have their own life cycle being independent of the cluster's life cycle. CIs may arise in the early stages of the cluster's life cycle, but more often it is a complement that acts as a certain "accelerator" in later stages. According to Prno 2005; Balog, 2015), the cluster's life cycle consists of the following phases:

- Initiative - Finding development options and priorities for cluster creation, its geographic location and mapping;
- Establishment - Common agreement on cooperation among enterprises, institutions and regional government, clustering, start-up activities, cluster organizational structure, identification of problem areas in industry and potential cluster members, occasional joint projects;
- Development - Creating new links among cluster members, shared mission, vision, strategy, cluster goals and activities, realization, building and expansion of cluster network, co-operation in project management, joint research, development, creation and commercialization of innovation, purchase of input material and exploitation new

production technologies with higher production quality, joint educational activities, training and overall development of human resources, active and effective marketing-based cooperation, joint image formation, joint negotiation in business and legislative relations;
- Maturity - Establishment of cooperation with other clusters, expansion of cluster members' activities, projects at interregional and international level;
- Decline - Cluster cooperation is disrupted, efficiency and innovative performance of the cluster is declining, effects of joint activities are falling down;
- Transformation - change of external environment (markets, technologies, processes and entities) influence the cluster's activities, leading to adaptation to new situation and subsequent transformation of a cluster.

As it can be seen from various economic studies (Havierniková, 2018; Pavelková, 2009; Nadabán, 2009; Karlsson, 2007; Burger, 2013), clustering is not only an advantage but also a number of potential disadvantages can be seen in here. While analyzing the positives and negatives of clustering the benefits of clustering process can include:

- Innovation potential - wide range of knowledge of associated actors. The bigger the number of participants in cluster, the greater the innovative capacity and flexibility on competitive market, which can ultimately lead to the emergence of new firms, innovations, or cost reduction or diversification of production.
- Opportunities for small and medium-sized enterprises to develop and enter the market.
- Better availability of other services in banking, accounting, consulting, marketing, etc.
- Distribution of costs and reduction of unit costs.
- Responding faster to market requirements.
- Easier access to information, new technologies, better workforce.
- Positive impact on regional development.
- A wider range of products and services.

Among the drawbacks following factors can be included:

- A partial loss of sovereignty,
- Being subordinated to the dominant elements of the cluster.
- Low awareness of the possibilities for business association.
- Geographic location of a cluster, e.g. areas where there is insufficient transport infrastructure.
- Inappropriate selection of subjects involved in the cluster.
- Lack of skilled labor force.

1.2. The elements of the University Industry Cooperation model

When it comes to the organizational forms of university industry collaboration (UIC), for example, Chen (1994) classified the forms of UIC for technology exchange according to the duration of the relationship and the technology flow. Santoro and Gopalakrishnan (2000), on the other hand suggest four classifications for UICs, including: (1) research support (i.e. Endowment/Trust Fund); (2) cooperative research (i.e. institutional agreements, group arrangements, institutional facilities, informal intentions); (3) knowledge transfer (i.e. hiring of recent graduates, personal interactions, institutional programs, cooperative education); and (4) technology transfer (i.e. product development and commercialization activities through university research centers).

Either way, to take into account as much as the possible links that could occur between universities and industry, the framework proposed by Bonarccorsi and Piccaluga (1994) and modified by Ankrah, and AL-Tabbaa (2015) consisting of six main categories was found to be relatively broad in scope and can be described in more detail.

Firstly, the category of Personal Informal Relationships can be characterized by academic spin-offs, individual consultancy (paid for or free), information exchange forums, collegial interchange, conference, and publications, joint or individual lectures, personal contact with university academic staff or industrial staff and co-locational arrangement.

Secondly, there are the Personal Formal Relationships offering the options such as student internships and sandwich courses; students' involvement in industrial projects; scholarships, studentships, fellowships and postgraduate linkages; joint supervision of PhDs and Masters theses; exchange programs (e.g. Erasmus+); sabbaticals periods for professors; hiring of graduate students; employment of relevant scientists by industry; the usage of university or industrial facilities (e.g., lab, database, etc.).

The Third-Party category indicates institutional consultancy (university companies including Faculty Consulting); liaison offices (in universities or industry); general Assistance Units (including technology transfer organizations); government agencies (including regional technology transfer networks); industrial associations (functioning as brokers) and technological Brokerage Companies.

Regarding the fourth category Formal Targeted Agreements, here can be mentioned important issues such as contract research (including technical services contract); patenting and licensing agreements (licensing of intellectual property rights); cooperative research projects; equity holding in companies by universities or faculty members; joint research programs (including

joint venture research project with a university as a research partner or joint venture research project with a university as a subcontractor), and training programs for employees.

The fifth category Formal Non-Targeted Agreements implies broad agreements for UICs; endowed Chairs and Advisory Boards; funding of university posts; industrially sponsored R&D in university departments, and research grant, gifts, endowment, trusts donations (financial or equipment), general or directed to specific departments or academics.

Finally, the last category Focused Structures is demonstrated by association contracts; innovation/incubation centers; research, science and technology parks; university-industry consortia; university-industry research cooperative research centers; subsidiary ownerships and mergers.

Another crucial example of university industry cooperation has been managed in Japan where within the improving university relations with industry was identified as a critical feature in encouraging national competitiveness based on science and technology, authorized universities and other publicly supported research agencies to establish technology licensing organizations (TLOs). As stated by Edgington (2008) this was designed to assist researchers to obtain patents on their inventions and to license those inventions to private industry. Other legislation in the year 2000 legitimized external research by national university professors if the intent of that research was to assist them in commercializing their own inventions. Following this new law, 45 TLOs were established (as of 2004) both at national and private universities, and the number of filed patent applications, patent grants and licensing and option contracts increased as a result of these government efforts. Nonetheless, many problems have been revealed, including the poor financial sustainability of TLO activities and the lack of professionals skilled in university–industry collaboration. In 2004, Japan's 87 national universities became National University Corporations rather than branches of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and their faculty were no longer civil servants. This resulted in universities being able to claim ownership over all discoveries made by their faculty members, so long as the inventors were given reasonable remuneration. As a result of these changes there was a sharp increase in the number of start-up firms based on university basic research and technology breakthroughs. This was bolstered by the year 2000 by the Law to Strengthen Industrial Technology, which legalized compensated consulting and also holding of line management positions in private companies by university faculty, provided permission was obtained in advance in case of management positions. In 2001, the 'Hiranuma Plan' of the Ministry of Economy, Trade and Industry (METI) set a goal of creating 1,000 new firms within three years. In effect, about 1,500 new enterprises were created by year 2005; however, there have been questions about the long-term sustainability of many of these start-ups. In addition, the Small and Medium Enterprise Basic Law was radically revised with a new focus on promoting business innovation and new business start-ups more generally. Subsequently, the government

established a Small Business Innovation Research Program (modeled after a similar scheme in the USA) to allow subsidies and other fiscal incentives for SME research that hitherto had been made principally only to large firms. An important development in the evolution of policies for small firms has been the emphasis on regional technology clusters. In the past, regional growth pole policy (including Technopolis) was mainly perceived in terms of creating a concentration of firms but not necessarily emphasizing their complementarities or potential to work together to build producer chains or other types of networks. The new emphasis is on nurturing horizontal links between key agencies—such as local universities, local companies, technology licensing organizations, specialized services such as patent attorneys, former executives of companies that can act as mentors for new entrepreneurs, and a range of infrastructure (business incubators, industry support organizations) often provided by local governments.

Despite industrial and academic systems at varying stages of development, governments are focusing on the potential of the university as a resource to enhance innovation environments and create a regime of science-based economic development. As argued by Etzkowitz, et al. (2000) one model through which these changes can be interpreted is a triple helix of university–industry–government relations model where there are four processes related to major changes in the production, exchange and use of knowledge that the triple helix model has identified. The first is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of an economic development mission by universities. The second is the influence of one institutional sphere upon another in bringing about transformation, for example government, in Sweden and the US, respectively, revising rules of intellectual property ownership to transfer rights from individuals or government to the universities. The third is the creation of a new overlay of trilateral linkages, networks, and organizations among the three helices, serving to institutionalize and reproduce interface as well as stimulate organizational creativity and regional cohesiveness. Groups such as the Knowledge Circle in Amsterdam, the New York Academy of Sciences and Joint Venture Silicon Valley encourage interaction among members of the three spheres, leading to new ideas and joint projects that might not otherwise have emerged from interaction within single spheres or from bilateral relations. A fourth process is the recursive effect of these inter-institutional networks representing academia, industry and government both on their originating spheres and the larger society. The common objective is to realize an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge based economic development, and strategic alliances among firms large and small, operating in different areas, and with different levels of technology., government laboratories, and academic research groups. These arrangements are often encouraged, but not controlled, by government, whether through new rules of the game, direct or indirect financial assistance, or through the Bayh–Dole Act in the USA or new actors such as the abovementioned foundations to promote innovation in Sweden (Etzkowitz, Leydesdorff, 2000).

In terms of cooperation motives why companies along with universities and research institutions join clusters, according to Olivier (1990) there are six determinants of inter-organizational relationships (IOR) such as necessity, reciprocity, efficiency, stability, legitimacy and asymmetry with two assumptions when organizations are assumed to make deliberate decisions to establish an IOR for explicitly formulated purposes and an organizational perspective (top-management) approach is assumed, even though the determinants may also explain lower and sub-unit reasons. The motivations for universities to enter into relationships with industry suggest that universities are not influenced to enter into relationships with industry to exercise power or control over industry or its resources and based on six determinants could be compared to the motivations to enter into relationships with universities as being proposed by Ankrah, and AL-Tabbaa (2015).

1) The first determinant - necessary issues for universities are responsiveness to government policy and strategic institutional policy however; for industry it is responsiveness to government initiatives/policy and strategic institutional policy.
2) Regarding the reciprocity for universities are important: access complementary expertise, state-of-the-art equipment and facilities along with the employment opportunities for university graduates; nevertheless for industry it is access to students for summer internship or hiring and hiring of faculty members.
3) For universities efficient is access funding for research (government grant for research & industrial funding for research assistance, lab equipment, etc.); business opportunity, e.g. exploitation of research capabilities and results or deployment of IPR to obtain patents; personal financial gain for academics. On the other hand, efficiency for industry means: commercialize university-based technologies for financial gain; benefit financially from serendipitous research results; cost savings (easier and cheaper than to obtain a license to exploit foreign technology); national incentives for developing such relations such as tax exemptions and grants; enhance the technological capacity and economic competitiveness of firms; shortening product life cycle; human capital development.
4) The stability for university means a shift in knowledge-based economy (growth in new knowledge); discover new knowledge/test application of theory; obtain better insights into curricula development; expose students and faculty to practical problems/applied technologies; publication of papers. However, for industry it means a shift in knowledge based economy (growth in new knowledge); business growth; access new knowledge, cutting-edge technology, state-of-the art expertise/research facilities and complementary know-how; multidisciplinary character of leading edge technologies; access to research networks or pre-cursor to other collaborations; solutions to specific problems; subcontract R&D (for example due to lack of inhouse R&D); risk reduction or sharing.

5) From the side of legitimacy, the necessary aspect to be taken into account within the university are societal pressure; service to the industrial community/society; promote innovation (through technology exchange); contribute to regional or national economy; academics' quest for recognition or achieve eminence, and within the industry it is enhancement of corporate image.
6) At last, there is an asymmetry when for the industry it is crucial to maintain control over proprietary technology.

David, and Metcalfe (2008) argue that at most major U.S. research universities the important recruiting contacts with graduate scientists and engineers are typically arranged at the level of the individual departments, and often are linked with a variety of "industrial affiliates" programs. The formation of enduring ties for the transfer of knowledge through the movement of personnel gives business organizations access to the craft aspects of applying new techniques, contacts with new recruits' personal network of other young researchers, and an advantage in spotting exceptional capabilities to conduct high caliber research. Such ties are sustained by personal relationships with the student's professors and strengthened by repeat play which tend to inhibit the latter's inclination to "over-sell" members of their current crop of Ph.D.'s and postdocs. The point here is that the direct participation of the parties, rather than institutionally provided third-party intermediation services, will generally be a requirement for successful "relationship management" in the market for young research talent.

According to Paytas, Gradeck and Andrews (2004) universities are an excellent resource for transforming the economy through the creation of new industries; however, the ability of these industries to grow the region is related not to the character of the university, but to the character of the region, the state and of the industry itself. The three factors related to the university are:

1. Breadth of involvement: in this sense three institutional spheres (public, private, and academic) are increasingly interwoven with a spiral pattern of linkages emerging at various stages on the innovation and industrial policymaking processes. To become more active players in the innovation process is to make research a part of the academic mission as well as take on a role in regional economic development, both through research and teaching. Universities are becoming increasingly entrepreneurial and engaged with business and industry. At this point, most research universities have created some kind of technology transfer program or industrial-liaison program to interact with the business sector. Economic development has become a more common focus in the mission statements of many universities.
2. Strong base of R&D. Regional development interests often encourage universities to do more to create new commercial enterprises, but research about the influence of universities on the formation of new companies has been mixed.

3. Regional alignment. The alignment of university assets, skills and expertise with regional industry clusters maximizes the regional benefit. Some regions may have a substantial research presence, but companies in the surrounding region are not able to absorb the resulting technology. In these cases, innovation is more likely to flow out of the region and if the boundaries of the industry cluster overflow the regional boundaries, the impact of the university will be dispersed.

Davey et al. (2018) mentioned the relevant motivation areas for a university cooperation with business. In promotion area, the motivators are to obtain funding and financial resources, increase chances of promotion and improve the reputation within the university. Research area consists of the following motivators such as research usage in practice and gaining new insights for research. Education area inherits motivators like improving the teaching and graduate employability. In a social area, the crucial motivators are the contribution to the mission of the university and to address societal changes and issues.

While discussing the barriers of cooperation as well as facilitators of cooperation several factors were found, if correctly managed, to have a positive effect on the perceived success of knowledge and technology exchange. On the other hand, where the same factors were neglected or mismanaged, they tended to have a corresponding negative impact on the perceived success of knowledge and technology exchange. According to Ankrah, and AL-Tabbaa (2015) these factors could be summarized in the following way.

a) Regarding the category Capacity and Resources the factors that facilitate or impede the UICs are adequate resources (funding, human and facilities); incentive structures for university researchers; recruitment and training of technology transfer staff; capacity constraints of SMEs.
b) The Legal Issues, Institutional Polices and Contractual Mechanisms are affected by inflexible university policies including intellectual property rights (IPR), patents, and licenses and contractual mechanisms; treatment of confidential and proprietary information; moral responsibility versus legal restrictions (research on humans);
c) When it comes to Management and Organizational Issues we can find many barriers and facilitators of UIC such as leadership/top management commitment and support; collaboration champion; teamwork and flexibility to adapt; communication; mutual trust and commitment (and personal relationships); corporate stability; project management; organization culture (cultural differences between the world of academia and of industry); organization structure (university administrative structure and firm structure); firm size (size of organization); absorptive capacity; skill and role of both university and industry boundary spanners; human capital mobility/personnel exchange.

d) While highlighting the Issues relating to the Technology category there is the factor of nature of the technology/knowledge to be transferred (tacit or explicit; generic or specialized; academic rigor or industrial relevance);
e) Considering the Political issues category, the significant factor is the policy/legislation/regulation to guide/support/encourage UIC (support such as tax credits, information networks and direct advisory assistance to industry).
f) Within the Social issue, the factor of enhancement in reputation/prestige would facilitate or impede the UICs.
g) Finally, also other issues are implied by factors such as low level of awareness of university research capabilities; use of intermediary (third party); risk of research; cross-sector differences/similarities; geographic proximity.

David and Metcalfe (2008) point out that the organizational structure of most research universities, in which the upper levels of administration typically at best only, have a derived interest in pursuing the particular substantive research programs that animate members of their research faculty and are likely to eschew any attempt to evaluate and prioritize among them on the basis of their comparative scientific interest or societal worth. Accordingly, university administrators rarely if ever approach firms with proposals to engage in particular research projects that would involve collaborations between specified groups or individual faculty scientists and engineers and counterparts who are employed in the business R&D labs. Instead, the research director of a company that has decided that sponsoring a collaborative project with certain university-based research scientists would be beneficial to organization's "bottom line," usually will have authority to take the initiative of approaching the prospective academic partners to discuss such an arrangement. However, as the latter, in their capacities of research faculty members rather than officers of the university usually do not have corresponding authority to negotiate formal inter-organizational agreements, and the business firm's representatives find themselves told they must deal with the university administration, and more precisely with one or a number of "service units" within the institution (variously described as the office of external relations," "sponsored research office," "university research services," "technology transfer office," all of whom will in one way or another be equipped with legal counsel and contract negotiators. Reasonable as this may appear as a procedure reflecting the different specializations of the people whose expertise the university calls upon, problems with its operation in practice often arise precisely because the primary concerns of these specialized services typically have little to do with the specifics of the professors' interests in the research collaboration. The difficulties occasioned by this internal organizational structure of universities, which contributes to separating the interest of the institution as a "research host" from that of its faculty researchers, thereby placing these research "service units" in a regulatory role vis-à-vis the latter, are considerable. But they are far from arbitrary or

capricious, in view of the potential legal complexities that contractual agreements for collaborative research performance may entail.

According to Davey et al. (2018) the most important facilitators emerged as those related to the relationship component of UIC activities, highlighting the importance of relationships in cooperation.

In terms of relational area, the most crucial UIC facilitators appears to be the following issues such as short geographical distance between the two organizations; existence of mutual trust and commitment; existence of shared goal; prior relation with the business partner.

Regarding the orientation area, the distinctive UIC facilitators are commercial orientation of the university; scientific orientation of the business; existence of funding to undertake the cooperation; interest of business in accessing scientific knowledge; interest of the university in accessing business sector - R&D facilities.

On the other hand, the most important barriers related to the UIC relationship can be illustrated in the following breakdown.

The awareness barrier are the issues as follows: business lack awareness of university research activities / offerings; universities lack awareness of opportunities arising from UIC; difficulty in finding the appropriate collaboration partner; no appropriate initial contact person with either the university or business.

- Funding and resources barriers are represented by the lack of business / university / government funding for UIC and limited resources of SMEs.
- Internal (university) barriers are bureaucracy related to UIC; insufficient work time allocated by the university for academics´ UIC activities; UIC conflict with teaching and research responsibilities of university staff; frequent staff turnovers within university or the business.
- Results barriers consist of items such as the focus on producing practical results by business; business need for confidentiality; limited absorption capacity of business.
- Cultural barriers can be characterized by lack of people with scientific knowledge within business; differing motivation / values between university and business; differing mode of communication and language between university and business; differing time horizons between university and business.

As argued by European Commission (2011) there are a number of ways in which universities can contribute to the development of their regional strategies for innovation, growth and sustainable development within the cluster and industry however, the more transformational the project, the greater are the barriers to its effective deployment. These barriers can be either

internal to the institution and its capacity to 'reach out' to the wider region (i.e. supply side) or the capacity and willingness of the public and private sector actors in the region to 'reach in' to the university to seek expertise and knowledge that can contribute to regional growth and development (i.e. demand side). Barriers and enablers can be grouped into the following themes, and each can be assessed from an internal perspective (i.e. supply side) or as it pertains to the external environment (i.e. demand side). Below the brief overlook summarizes the conditions under which these barriers tend to manifest themselves, and whether the effects are caused by issues with the demand side or the supply side.

- Perceived institutional purpose. As internal barrier research and knowledge development activities are disconnected from regional development objectives and are driven by the pursuit of peer reviewed academic outputs. Nevertheless, it can be an external barrier when the region does not see universities as relevant or central to its regional development strategies; senior managers in the public and private sectors do not see the universities as a regional asset.

- Channels of engagement can be an internal barrier when universities lack the mechanisms to effectively engage with the 'outside world' or activities are hived off into special purpose vehicles and not seen as 'core' activity; and an external barrier when there is a lack of effective 'bridging' institutions between academia and the private sector to 'reach in' to the university.

- Funding sources can be an internal barrier when universities focus research in areas where research grants are easier to win rather than regional priorities; structural funding programs are seen as high risk due to regulations and intervention rates; and an external barrier when there is lack of capital for firms to invest in R&D activities; short term funding cycles limit the ability to invest in 'translational' organizations to help convert research into a foundation for industrial specialism.

- Operating principles are an internal barrier when academics see themselves as 'critical observers' rather than actors in the process of regional development; focus is on achieving peer accolades rather than solutions to 'real world' problems; and also an external barrier when public and private sectors are alienated by academic language and work patterns; there is suspicion of the motivations of universities and whether they are 'in' the region but not 'of' the region.

- Industrial composition acts as an internal barrier when academic teaching and research profile of the universities in the region does not mirror the industrial ambitions of the region as well as an external barrier when the local economy is built around declining industries and populated by small companies with little sectoral critical mass.

- Link between systems represent an internal barrier when universities are part of national higher education system so have little incentive or scope to respond to regional need and an external barrier when there is a conflict between national innovation and competitiveness and territorial development policies; lack of regional voice or autonomy in decision making; lack of regional leadership and/or consensus on the challenges.

- Collaborative capacity and skills signifies an internal barrier when university staff have no time or encouragement to engage with regional programs; lack of 'boundary spanning' skills in the university; lack of leadership to drive change; and an external barrier when there is limited absorptive capacity within local businesses; there is a lack of mechanisms to aggregate demand; private sector senior managers don't give consideration to their role within the region; lack of boundary spanners in the public and private sectors; lack of consensus on what the issues are and how to overcome them.

When it comes to the effects of clustering and results of university and industry cooperation or the outcomes of UIC there can be find own benefits and drawback for both parties. Regarding benefits, several studies (e.g. Geisler, 1995; Lee, 2000) have linked motivations to benefits subsequently realized in UIC. However, not all benefits could be signalled by the motivations listed previously. Therefore, the specific benefits identified from the studies are dealt with separately in this section. All realized benefits by universities and industry have been coded under three headings (Ankrah, AL-Tabbaa, 2015):

1) Economic benefits (i.e. benefits that feed into the overall economy). Here the universities can feel positive effects such as source of revenue (both public and private); patents/IPRs/licensing income; additional income or financial benefit to researchers; create business opportunities; contribution to local/regional economic development. Industry can benefit in new products and/or processes; improved products and/or processes; patents, prototypes, generate IPRs, etc.; more cost-effective than similar research in-house; improved competitiveness; access public grants; promote economic growth/enhancement of wealth creation.

2) Institutional benefits (i.e. benefits derived by Universities and Industry). The advantage for universities are exposure of students and faculty to practical problems/new ideas and/or to state-of-the-art technology, with positive effects on the curriculum; provide a ''test bed'' for feedback on research ideas, results/interpretations for the refinement of academic ideas/theories; stimulate technological advancement and/or research activities in certain key areas; acquisition of or access to up-to-date equipment; training and employment opportunities for students; build credibility and trust for the academic researcher among practitioners; stimulate the development of spin-offs (or spin-off companies); provide opportunity for companies to influence and encourage the development of particular lines of university

research; joint publications with industry; publication of papers by academics. The industry can profit in aspects such as improved innovative ability and capacity/keep up to date with major technological developments; advance new technologies; accelerates commercialization of technologies/increases speed of innovation to market; no inter-firm conflicts of interest; provide much needed legitimacy for industry products (e.g. software program); access to new knowledge and leading edge technologies and/or a wide variety of multidisciplinary research expertise and research infrastructure; influence university research directions and new programs for industry good; access to specialized consultancy/identify relevant problems/solve specific technical problems; product testing with independent credibility in testing; training/continued professional development; opportunity to access a wider international network of expertise; act as a catalyst that leads to other collaborative ventures; joint publications; hiring of talent graduates.

3) Social benefits (i.e. benefits that relate to communal activity or promote sociability). Universities can gain service to the community and enhancement of university's reputation. Industry can enhance reputation by becoming more socially responsible business.

It is important for both the universities and industry, particularly the universities, to recognize the possible drawbacks, so that protective action can be taken to put in place well-developed policies and administrative procedures to mitigate against failure and ensure the success of the relationship (Harman & Sherwell, 2002). Importantly, the drawbacks have been classified into four categories considered to be apposite – university versus industry (Ankrah, AL-Tabbaa, 2015):

1) Deviation from mission or objective. Disadvantages for universities are threats to research autonomy or integrity for commercial advantage that may have a negative impact on culture of open science and affect university mission; confidentiality agreements may block the dissemination of knowledge; could result in the abandonment of long-term basic research in favor of results-oriented, short-term, applied research and technology transfer; concern that the end result of collaboration could be short-term contracts in which industry would require 'quick and dirty' solutions to problems, with university departments acting as extensions to the research activities of firms. For industry they are issues such as slow academic bureaucracies may stifle technology commercialization, depress the firm's performance and delay the fulfillment of the firm's objectives; diversion away from the 'bottom-line' issues of industry like return on capital investment; collaboration may be costly due to increase in administrative overheads, as industry may have to develop specific managerial and administrative competencies, which may be a time-consuming process.

2) Regarding the quality issues category, the hindrance for universities are potential diversion of energy and commitment of individual staff who are involved in interaction with

industry, away from core educational activities; could affect types of research questions addressed and reduce the quantity and quality of basic research. For industry it is about low intellectual level of some contract work; results in theoretical and impracticable solutions since university staff are too theoretical and not very practical whereas industry's focus is much more problem centered on critical situations requiring immediate attention.

3) In terms of conflicts, universities can find a handicap in areas such as conflicts between researchers and company over the release of adverse results/damage in professional relationships among the researchers; biased reporting by researchers sponsored by companies in favor of positive experimental results relating to company products. Industry can be jeopardized by disharmony and discord during R&D development; intellectual property disputes and patenting disagreement.

4) Finally, the risks category inherits obstacles for universities such as dilemma of either publishing results for short-term revenue and academic recognition or withholding until they are patented, with the risk of the technology becoming obsolete; risks that academic-industry relationships pose to human subjects of research and to the integrity of academic investigation. The risks for industry are diminished control or leakage of proprietary information; high failure rate of collaborations; financial risk to industry; risk of incomplete transfer or non-performance of technology; market risk where there is uncertainty of the success of the product launched in the market.

While discussing the obstacles and profits of university and industry cooperation regarding the role of the university in cluster development it assesses both the factors of the university and the factors of the cluster that are vital to successful university-industry cluster development. According to Paytas, Gradeck and Andrews (2004) universities that are highly engaged with regional industry clusters have diverse and complementary units that broadly address the needs of the cluster. Rather than a compartmentalized approach, engaged universities are sources of research and technology, but also address other aspects that affect cluster growth such as business, marketing, legal, and workforce issues. In order to have an impact on a regional industry cluster, the university must have a significant base of research aligned with the needs of that cluster. In the case of research and technology assets, size does matter. The university must have a large base of research and development to significantly impact a cluster, rather narrowly benefiting only a few firms. The university must also have expertise and resources in appropriate areas that align with the needs of the clusters in the region. Less important is the structure or processes of the technology transfer function. Universities cannot defy the forces of the market. Established clusters with mature products and processes are less receptive to innovation, especially from universities and other external sources. Even if they are receptive, a cluster may lack the ability to absorb people and technology produced by the university. Clusters that are externally, rather than regionally, organized and oriented may even

facilitate the diffusion of university-derived benefits outside the region. The university can produce the seeds of new firms and industries, but the region must offer a fertile climate for them to flourish. The key factors related to the industry cluster are its pattern of organization, market trends, and the life cycle stage of the industry or technology. University-based cluster development is a difficult path that requires commitment, time and patience. The success of a university-based cluster initiative requires more than an active, engaged, high quality university. It is also necessary to have appropriate conditions within the regional industry clusters. Within a region, universities are best able to affect the growth of young, emerging clusters, but it takes a broad commitment of significant university resources across a variety of departments aligned with the needs of the cluster.

If highlighting the university perspective from the industry-cluster collaboration Etzkowitz, and Leydesdorff (2000) argue the university can be expected to remain the core institution of the knowledge sector as long as it retains its original educational mission. Teaching is the university's comparative advantage, especially when linked to research and economic development. Students are also potential inventors. They represent a dynamic flow-through of ''human capital'' in academic research groups, as opposed to more static industrial laboratories and research institutes. Although they are sometimes considered a necessary distraction, the turnover of students insures the primacy of the university as a source of innovation. The university may be compared to other recently proposed contenders for knowledge leadership, such as the consulting firm. A consulting company draws together widely dispersed personnel for individual projects and then disperses them again after a project, solving a client's particular problem, is completed. Such firms lack the organizational ability to pursue a cumulative research program as a matter of course. The university's unique comparative advantage is that it combines continuity with change, organizational and research memory with new persons and new ideas, through the passage of student generations. When there is a break in the generations, typically caused by a loss of research funding, one academic research group disappears and can be replaced by another.

As to be concluded, by and large, universities can play a powerful role in the development of industry clusters. There are many examples of how new industries form from university research. Similarly, new industry clusters have re-ordered the ranking of major economic regions. Unfortunately, the path from university research to cluster development and finally to regional economic benefit is not simple or direct. The assets of the university must be properly aligned with clusters that are appropriate targets for the regional economy. This report concludes that the characteristics of the cluster are as important, if not more important than the characteristics of the university. The task for the university (and for regional stakeholders) is to identify and support areas of university expertise that align with clusters of opportunity for the region. For the university these clusters of opportunity are defined by an area of significant university expertise. A large base of research and development is required but not sufficient.

The university must also address the business, workforce, and community issues. The university must be aligned with regional interests and industry clusters across a broad spectrum, not just in terms of technical knowledge. For the region, clusters of opportunity are defined by sectors with expanding markets and where the ability of the university to spark innovation can impact the competitive advantage of the region.

2. Research methodology

The project focuses on cluster organizations and possibilities of cooperation between business and research according to the quadruple helix within the territorial ecosystems in Czechia, Hungary, Poland and Slovakia. The main research aim is to identify models of cooperation between business and research facilitated by cluster organizations based on mapping of best practice in V4 countries. This will allow them to be transferred among V4 countries in the future. The research aim was achieved by addressing the following questions:

1. What forms (procedures, activities, and models) of cooperation between business and research institutions on the basis of cluster organizations (but not necessarily initiated by the cluster) are used in the individual V4 countries?
2. What are the principal motives for cooperation between companies and research institutions on the basis of cluster organizations in the individual V4 countries?
3. What factors influence cooperation between business and research institutions in cluster organizations in the individual V4 countries?
4. What are the obstacles and challenges related to cooperation between business and research institutions in the V4 cluster organizations?
5. What types of research organizations such as universities and research institutions are members of cluster organizations in the V4 countries?
6. What models of cooperation between business and research institutions constitute best practices in cluster organizations in the V4 countries?
7. What policy instruments on cluster organization development and R2B/B2R cooperation have been established in the V4 countries? What policy instruments focusing on cluster development and R2B/B2R cooperation are considered helpful? How can they be further improved or reconsidered?

To answer the above research questions, the following methods were applied.

Literature review (desk study)

The literature review was used to prepare a theoretical background for the study, to gather the necessary data for analyses, and to extend knowledge of the state of the art in current business-research relations. It covered a number of sources, including:

- research papers and monographs;
- evaluation reports on clusters and cluster support measures implemented, especially those fostering business-research cooperation;

- information published by clusters (cluster development strategies, information brochures, websites).

The literature review was a starting point for designing questionnaires and more in-depth analyses.

In-depth interviews (IDI)

In-depth interviews made it possible to gather qualitative information on the role of research institutions in clusters, the added value of cooperation, and forms of cooperation. They also enabled identification of the main motives for cooperation, results of cooperation, and factors that determine its forms and scope. They also helped diagnose the most important challenges to be taken into account when designing the prospective support instruments. During the interviews with cluster managers, information about the research institutions that are members of the cluster was collected. This information was used for the survey among the research institutions and interviews with the selected representatives of these institutions.

The in-depth interviews were conducted based on a structured questionnaire (interview guide), comprising several main themes accompanied by more specific questions, through which detailed information could be gathered. The questionnaire allowed the respondent to raise any additional themes and problems they considered relevant to the discussion.

The selection of respondents differed among the V4 countries, as there are different models of cluster policy and the overall number of clusters.

In Poland, the researchers focused on the National Key Clusters. These are the most developed clusters selected in a competitive way in a 3-step procedure. The status of National Key Clusters is determined in a competition by clusters that meet certain formal conditions and are awarded a minimum of 100 points (out of 140) as part of the substantive evaluation carried out by a group of experts. The first step is the formal evaluation, the second step is the parametric evaluation (in this evaluation, a minimum of 65 points have to be gained to qualify for the final stage of presenting the development of the cluster and activities for the benefit of cluster members). The assessment of the cluster potential is based on a number of indicators in six areas, which include human and organizational resources, infrastructure and financial resources, the economic potential of the cluster, knowledge creation and transfer, actions for public policies, and customer orientation. All the National Key Clusters have research institutions as their members as this is a formal requirement.

In the Czech Republic, researchers focused on COs fulfilled according to the criteria: i) at a minimum of three research organizations/universities as members of the CO, ii) experience with managing research projects supported by operational programs (as the CO should fulfil

eligibility criteria almost as strict as in the "accreditation scheme" to be able to apply and be awarded a project), and iii) being a member of the National Cluster Association.

In Hungary, researchers focused on the Accredited Clusters. Accreditation of clusters began in Hungary in 2008. As of March 2021, there are 26 accredited clusters. Accreditation of clusters is done through a dedicated scheme (open call for proposals). Proposals for accreditation are submitted by cluster management organizations. The decision is made in three main steps: 1) review of eligibility criteria; 2) review of selection criteria; 3) decision on the accreditation by the Accreditation Committee. The scheme is managed by the responsible unit of the Ministry of Finance. The Accreditation Committee comprises representatives of the public and private sector. The following factors are considered during assessment: co-operation inside the cluster; cluster management and the composition of the cluster; international focus of the cluster; innovation potential and performance; cluster strategy.

In Slovakia, researchers focused on the COs, which received the ECEI Gold Label (Košice IT Valley) and ECEI Bronze Label provided by the ESCA. This method was selected as in Slovakia there is no specific system of cluster accreditation.

Table 1. Research sample

Country	Number of IDI	Justification
Poland	15	All the National Key Clusters – clusters selected in a competitive procedure
Czech Republic	10	A sample of ten clusters fulfilled criteria (see above)
Hungary	10	A sample of ten clusters from the "Accredited Clusters"
Slovakia	9	A sample of clusters labelled by the ESCA

Source: own work

Survey

A survey with the research institutions operating within clusters was conducted to gather up-to-date, comparable data on the forms of cooperation with enterprises and the benefits for research institutes and universities. The survey enabled detailed information to be compiled on the number of joint projects, their results, etc.

The information collected via a structured tool comprising mainly closed questions made possible comparisons and quantitative analyses. The technique used for the survey was an on-line questionnaire. The respondents were specified by cluster managers (the research team asked for contact persons from cooperating research institutes and universities). There were 46 complete answers to the survey.

Interviews

Additionally, interviews with the representatives of research institutes were carried out to increase knowledge on cooperation. The respondents were the employees of the research institutes that were responsible for direct contacts with companies being cluster members.

Workshops and roadmaps

Four workshops were organized (one in each country) aimed at presenting and discussing identified business-research cooperation models in clusters and developing roadmaps for possible actions targeted at expanding cooperation between science and business undertaken by different actors, especially public authorities, cluster coordinators, and scientific units.

Data analysis

The data collected in a survey and during the in-depth interviews was a subject of qualitative and quantitative analysis. A set of indicators was created which was used for comparative analysis between V4 countries.

3. General information on clusters in V4 countries

Visegrad countries represent four independent yet to some extent similar innovation ecosystems. With reference to their research and innovation performance and according to the 2021 European Innovation Scoreboard three countries – Hungary, Slovakia, and Poland are considered as emerging innovators (i.e. countries whose performance is below 70% of the EU average) whereas Czechia is a moderate innovator (i.e. its performance is between 70% and 100% of the EU average) (Table 2).

Table 2. The Visegrad countries in the European Innovation Scoreboard in 2021 (in % relative to the EU average)

Component	Czechia	Hungary	Poland	Slovakia
Summary Innovation Index	83.9	67.9	58.5	63.1
Human resources	81.9	42.0	63.9	74.9
Attractive research systems	74.2	68.0	39.4	56.5
Digitalization	79.4	86.4	83.1	81.2
Finance and support	69.5	83.4	56.0	25.5
Firm investments	73.2	64.2	60.1	48.2
Use of information technologies	117.3	78.1	78.5	83.8
Innovators	89.7	35.7	15.1	27.2
Linkages	79.5	83.5	68.8	49.1
Intellectual assets	59.7	48.1	84.4	48.3
Employment impacts	88.7	46.0	31.3	46.2
Sales impacts	97.8	94.6	63.6	90.5
Environmental sustainability	95.9	72.2	62.2	110.4

Source: own elaboration based on European Union (2021)

Convergence with the European Union has been taking place across the Visegrad. Nevertheless, when compared to 2020 Slovakia was one of seven EU countries in which the Summary Innovation Index declined. For Czechia its top three strengths include: Use of information technologies, Sales impacts, and Environmental sustainability. In the case of Hungary they are: Sales impacts, Digitalization, and Linkages. Poland's top three strengths are: Digitalization, Intellectual Assets, and Use of information technologies, whereas Slovakia's top three strengths are: Environmental sustainability, Sales impacts, and Use of information technologies.

Innovativeness of companies depends on a plethora of factors. Establishing relationships within the innovation ecosystem is one of them. The openness of companies across the Visegrad to collaborate with other entities differs. In 2018 22.7% of Hungarian enterprises reported cooperating on business activities with other enterprises or organizations. At the same time in Slovakia, Czechia, and Poland this percentage stood at 15.0%, 13.2%, and 9.0% respectively. In innovative enterprises these percentages were different but the order of countries remained the same: Hungary – 51.5%, Slovakia – 37.0%, Czechia – 28.3%, and Poland – 27.5%[1]. When analyzing a particular form of cooperation which is cooperation on research and development and other innovation activities the share of companies which engage in them is the highest in Czechia (13.2% for all enterprises and 28.3% for innovative enterprises), followed by Hungary (10.9%; 35.6%), Slovakia (9.5%; 31.3%), and Poland (5.2%; 20.5%)[2]. This type of cooperation can be developed with universities or research organizations which constitute a particularly important element of the innovation ecosystem. Overall, companies in the Visegrad are more open to R&D&I cooperation with universities and other types of higher education institutions than with government and public/private research institutes (Figure 2).

[1] https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis11_co&lang=en accessed on February 20th 2022.
[2] https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis11_coop&lang=en accessed on February 20th 2022.

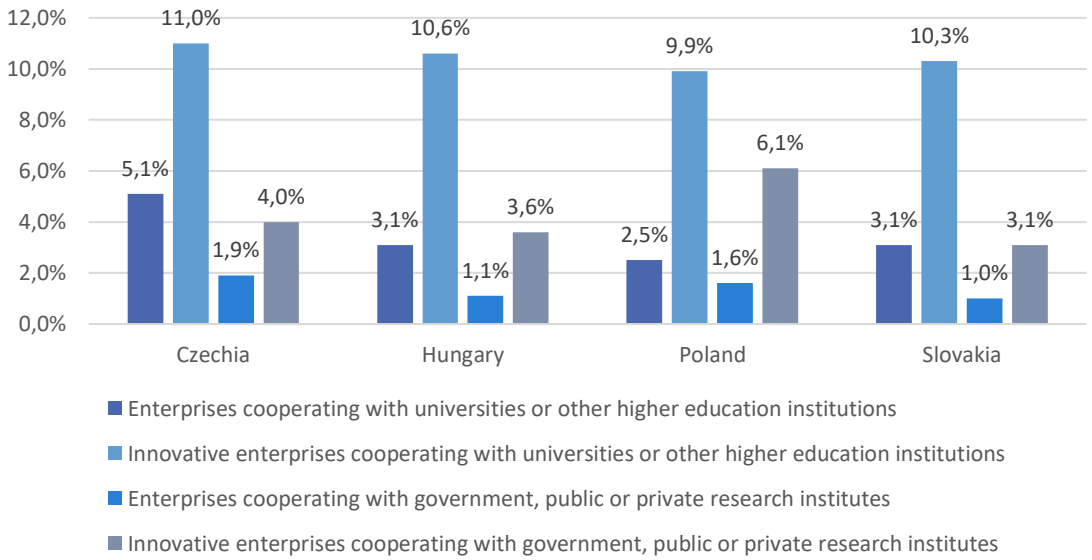


Figure 2. Cooperation with universities and research institutes in the Visegrad countries in 2018

Source: own elaboration based on https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis11_coop&lang=en accessed on February 20th 2022

All Visegrad countries have employed measures to boost competitiveness, innovativeness as well as to speed up convergence with the EU. Since their accession they have been designing and executing various policies to achieve these goals. One of their common features was their focus on different forms of cooperation which include clusters, cluster initiatives, and cluster organizations. Nowadays, their collective experience can be considered as a well of knowledge on cluster policy design and its results. All four countries introduced clusters and cluster-led development into their policy agenda around the same time. Their underlying motivation included strengthening their efforts aimed at building more competitive and innovative economies. The idea was also supported throughout the process of their EU accession which coincided in time when many Member States were already pursuing actions to support clusters. As sovereign states they have taken their own paths to design and implement cluster policies. This section summarizes selected aspects of cluster and cluster policy development in respective Visegrad states.

Czechia[3]

During the initial stage after the EU accession in 2004 one of key actions by the Czech government towards developing cluster-inspired economic development were undertaken under the Operational Program Industry and Enterprise 2004–2006 and under the National

[3] Country Report Czech Republic, https://v4clusters.sgh.waw.pl/en/publications

Cluster Strategy 2005–2008. During this time support was focused on clusters and cluster initiatives. Introduction of the National Innovation Policy 2005–2010 led to further growth of the number of cluster organizations. Simultaneously, Operational Program Enterprise and Innovation 2007–2013 (OPEI) included measures to support development of cooperation groups (cluster organizations included) and was aimed at boosting innovative potential, employment of new technologies, and internationalization. At the same time, much effort was put in building cooperation between firms and research organizations. Cluster development was also supported through other Operational Programs (Operational Program Human Resources, Operational Program Research and Development for Innovations, Operational Program Education for Competitiveness).

Later on, the second innovation policy since the EU accession – "National Innovation Strategy for the programming period 2012–2020" – was developed. Clusters were included in the Strategy which supported actions leading to innovations through networking and cooperation between firms (including cluster involvement in this process). At the beginning if this programming period (in late 2013) two cluster policy development methodologies were certified – National cluster policy[4] and Regional cluster policy[5]. Operational Program Enterprise and Innovation for Competitiveness 2014–2020 was another effort to boost innovativeness which was to be reached through developing relationships between firms and research organizations and clusters were to support it.

According to a document "Theses of the Economic Strategy of the Czech Republic 2020–2030" state of cluster development in Czechia is the country's weakness. At the same time, "Innovation Strategy of the Czech Republic 2019–2030" recognizes clusters' role in the research ecosystem. In the new programming perspective 2021–2027 the Operational Program Technologies and Applications for Competitiveness focuses on strengthening firms' R&D&I activities.

From an institutional perspective two actors have played a key role in cluster policy development in Czechia – the Ministry of Industry and Trade (MIT) and CzechInvest (responsible for practical and operational application of concepts and policies developed at MIT). In 2016, the Agency for Entrepreneurship and Innovation adopted the tasks previously attributed to CzechInvest (particularly with relation to Operational Program Enterprise and Innovation for Competitiveness 2014–2020).

[4] Pavelková, D. et al. National Cluster Policy (Certificate methodology). Zlín: Tomas Bata University, 2013.
[5] Pavelková, D. et al. Regional Cluster Policy (Certificate methodology). Zlín: Tomas Bata University, 2013.

From a historical perspective, the first cluster organization in Czechia was established in 2003. Early in 2022, according to the National Cluster Association (NCA) database, 57 cluster organizations are active in the country and they are unevenly dispersed throughout Czechia (the Moravian-Silesian and South Moravian regions are home to the largest number of cluster organizations).

Hungary[6]

Historiography of cluster organizations in Hungary dates back to 2000 when the Ministry of National Economy was involved in the creation of first COs. This top-down approach was eventually unsuccessful because soon these initiatives dispersed.

During the programming period 2007–2013, and within the New Hungary Development Plan, cluster development became a key issue and various cluster-related actions were undertaken (under the Pole Program). They included, but were not limited to, creation of a network of brokers, introduction of a cluster development model and cluster accreditation scheme, funding opportunities as well as boosting internationalization. These favorable circumstances resulted in creation of numerous cluster organizations. In 2011 the Pole Program was replaced by Cluster Development Program of the New Szechenyi Plan. The focus was repositioned and instead of aiming at creation of new cluster organizations a new approach was introduced whose goal was to increase the number of accredited cluster organizations and the value of projects undertaken by their members. Given previous experience, both the cluster development model and the accreditation scheme were rethought and redesigned.

As the new programming period was approaching, a new framework program for 2014–2020 was launched – Szechenyi 2020. The cluster theme, although included, was visibly less significant. Cluster development was present in selected strategies (e.g. Smart Specialization Strategies – national and regional, R&D&I Strategy – national) and Operational Programs. Some of previous Programs solutions were still in place, however stricter criteria were introduced. The most recent remodel of the accreditation scheme took place in 2016, followed by the last round of accreditation which was carried out under its rules.

With the advent of stricter criteria for accreditation and less favorable circumstances for cluster development, the number of new cluster organizations in Hungary is quite low. Currently, 26 cluster organizations are accredited (comprised of an average of 38 members) and another 19 are recognized in a registry of the Ministry of Finance.

[6] Country Report Hungary, https://v4clusters.sgh.waw.pl/en/publications

The ground building works on new cluster strategy were undertaken in 2021. It is supposed to be accompanied by a renewal of the cluster accreditation scheme. The first call in one of the Operational Programs (aimed at technology and infrastructure development of small and medium sized enterprises) included a form of preferential treatment to CO members. Similar solution is expected in future calls. However, a proposal of the Economic Development and Innovation Operational Program Plus for the 2021–2027 programming period, which includes a priority axis "Stimulating knowledge transfer through the support of cooperation", does not distinguish clusters as knowledge transfer institutions. This could serve as an argument that they are not recognized by the Hungarian government as key platforms which bring business and research together. At the same time, while the National Smart Specialization Strategy for 2021–2027 was being designed, accredited clusters were engaged in its creation through territorial innovation platforms.

Poland[7]

The last two decades have been filled with various policy efforts employing the cluster theme. Throughout the years the design of national and regional cluster policies has evolved while the introduced changes were triggered by consecutive programming periods (Kuberska, Mackiewicz 2022).

The cluster concept was introduced in Poland when the country was in the EU pre-accession stage. Initially, during that time as well as in 2004–2006 most efforts were aimed at promotion of the clustering theme among various stakeholders. The cluster concept was supposed to be seeded in the minds of all groups within the triple helix – university, industry, and government. Simultaneously, and with the aim to create and support first cluster initiatives and cluster organizations, trainings of cluster managers were organized (Clustering Training Program). Soon, the very first cluster initiatives were established followed by first cluster organizations.

The next programming period – 2007–2013 – brought significant opportunities to receive financial support from the EU funds. As a result, new cluster organizations were formed and their number was growing. During this time of extensive development of both national as well as regional cluster policies was taking place. 2011 saw the establishment of a Working Group on Cluster Policy which provided recommendations on future directions of cluster policy. A time of "cluster prosperity" extended slightly into the next programming period as some programs from the previous programming period were yet to be finalized.

Between 2015 and 2020 Poland experienced a shift in its approach to clusters and cluster policy. First and foremost, public support to clusters became limited (one measure to support cluster internationalization was available under Operational Program Smart Growth). This caused

[7] Country Report Poland, https://v4clusters.sgh.waw.pl/en/publications

various cluster organizations to cease their operations therefore proving their evanescence in the economic ecosystem. At the same time, at the national level, an accreditation program came into force – Key National Cluster (KNC) program. KNC status is awarded through an open competition provided that a cluster organization proves having a significant importance to the economy as well as being internationally competitive. So far five rounds of the KNC competitions took place. Cluster organizations 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 et al. 2020).

Before the advent of the 2021–2027 programming period extensive analyses were carried out to redesign cluster policy in Poland. Its new principles include: support for clusters based on their level of development, public support at national and regional level, double-track policy (subjective and functional approach), a flexible demarcation line of the support level and sources of financing, supra-regional and cross-border nature, long-term approach, building social capital around cooperation and clustering (Choińska-Jackiewicz et al. 2020).

The direction of the evolution of cluster policy in Poland has allowed for professionalization of several cluster organizations which established themselves not only among their members but also in the regional, national, and – in some instances – international environment.

Slovakia[8]

Currently, Slovakia neither possess a coherent cluster policy nor legislation directly designed to regulate the existence of and support to clusters. However, clusters are mentioned in various strategic documents as well as program documents. These include e.g. Research and Innovation Strategy for Smart Specialization of the Slovak Republic (RIS3), Rural Development Program of the Slovak Republic, Operational Program Integrated Infrastructure (supporting cluster organizations in the 2014–2020 programming period), Operational Program Research and Innovation (supporting cluster organizations in the 2014–2020 programming period), Integrated Regional Operational Program. Cluster policy is not as much established in Slovakia as in other Visegrad countries and therefore, from an institutional perspective, none of the ministries or agencies is directly involved and explicitly responsible for its implementation. However, different ministries influence cluster development in the areas of their expertise (e.g. Ministry of Economy, Ministry of Education, Science, Research and Sports, Ministry of Transport and Construction, Ministry of Culture, Ministry of Investment, Regional Development, and Informatization and Ministry of Agriculture and Rural Development. Apart from that, Union of Slovak Clusters (established in 2010 and currently comprised of 16 members) as well as Slovak

[8] Country Report Slovakia, https://v4clusters.sgh.waw.pl/en/publications

Business Agency (SBA), Slovak Investment and Trade Development Agency (SARIO) and Slovak Innovation and Energy Agency (SIEA) have also been actively involved in the Slovak cluster ecosystem.

The country is home to various cluster initiatives which have converted into cluster organizations of two types (based on typology created by the Slovak Innovation and Energy Agency) – technological clusters and tourism clusters. The latter form of cluster organizations are provided with a separate support system and located in Trnava, Nitra, Banská Bystrica, and Žilina regions whereas technological clusters are located in every region apart from Trencin. Industry profile of technological clusters is most diverse in the Bratislava region (they represent creative industries, energy and environment, ICT, food industry, and mobility: vehicles, rail, traffic systems. Nitra region is home to energy and environment, biotechnology, new materials and chemistry as well as production and engineering clusters. Cluster organizations in Banská Bystrica region represent creative industries, energy and environment, and production and engineering while Kosice region is home to ICT and production and engineering clusters. Cluster organizations in two remaining regions – Presov and Zilina – represent respectively energy and environment and ICT industries.

Cluster policies in respective Visegrad countries have been designed with the intention to achieve various goals which in some cases included explicit actions supporting business and research collaboration. Given that their achieved results vary across locations the carried-out research aims to disentangle specific aspects of B2R/R2B collaboration within established cluster organizations in Czechia, Hungary, Poland, and Slovakia. Two main stages of the field research consisted of (1) in-depth interviews with cluster organization managers (10 in Czechia, 10 in Hungary, 15 in Poland, and 8 in Slovakia) (Table 3) and (2) a survey among representatives of universities or research organizations which are members of cluster organizations (11 surveys carried out in Czechia, 11 in Hungary, 20 in Poland, and 4 in Slovakia).

Table 3. Cluster organizations participating in in-depth interviews

Country	Cluster	Predominant field(s) of activity	Year of foundation	Legal form
Czechia	Czech Optic Cluster	Production and engineering	2017	Registered association
Czechia	Plastic Cluster	Production and engineering	2006	Registered association

Country	Cluster	Predominant field(s) of activity	Year of foundation	Legal form
Czechia	Furniture Cluster	Production and engineering	2006	Registered association
Czechia	Czech Implant Cluster	Health and medical science	2017	Registered association
Czechia	CREA Hydro&Energy Cluster	Energy and environment	2014	Registered association
Czechia	Clutex Cluster	Textile industries	2006	Registered association
Czechia	Autoklastr	Mobility: Vehicles, rail, traffic systems	2006	Registered association
Czechia	IT Cluster	ICT	2006	Registered association
Czechia	AERO Cluster	Aviation and space	2010	Registered association
Czechia	Nanoprogress	New materials and chemistry	2010	Registered association
Hungary	INNOSKART Digital Cluster (*INNOSKART Digitális Klaszter*)	ICT	2006	No legal form (deed of foundation, rules of organisation and operation)
Hungary	System Science Innovation Cluster(*Rendszertudományi Innovációs Klaszter*)	ICT	2006	No legal form (deed of foundation)
Hungary	ArchEnerg International Renewable Energy and Building Trade Cluste (*ArchEnerg Nemzetközi Megújuló Energetikai és Építőipari Innovációs Klaszter*)	Energy and environment	2007	No legal form (deed of foundation)

Country	Cluster	Predominant field(s) of activity	Year of foundation	Legal form
Hungary	Hírös Supplier Cluster (*Hírös Beszállítói Klaszter*)	Production and logistics	2008	No legal form (deed of foundation, rules of organisation and operation)
Hungary	Information management Innovation Cluster (*Információmenedzsment Innovációs Klaszter*)	ICT	2008	No legal form (deed of foundation)
Hungary	Omnipack First Hungarian Packaging Technology Cluster (*Omnipack Első Magyar Csomagolástechnikai Klaszter*)	Logistics: Packaging	2003	No legal form (deed of foundation)
Hungary	Pharmapolis Debrecen Innovative Pharmaceautical Cluster (*Pharmapolis Debrecen Innovatív Gyógyszeripari Klaszter*)	Health and medical science	2008	No legal form (cooperation contract)
Hungary	North Hungarian IT Cluster (*Észak-Magyarországi Informatikai Klaszter*)	ICT	2007	No legal form (deed of foundation)
Hungary	Pannon Wood- and Furniture Industry Cluster (*Pannon Fa- és Bútoripari Akkreditált Innovációs Klaszter*)	Production and engineering	2001	No legal form (deed of foundation, rules of organisation and operation)
Hungary	Software Innovation Pole Cluster (*Szoftveripari Innovációs Pólus Klaszter*)	ICT	2007	No legal form (deed of foundation)
Poland	Aviation Valley (*Klaster Dolina Lotnicza*)	Aviation and space	2003	Association

Country	Cluster	Predominant field(s) of activity	Year of foundation	Legal form
Poland	Bydgoszcz Industrial Cluster (*Bydgoski Klaster Przemysłowy*)	Production and engineering	2006	Association
Poland	ICT Pomeranian Cluster – Interizon (*Pomorski Klaster ICT Interizon*)	ICT	2009	Partnership
Poland	LifeScience Krakow Cluster (*Klaster LifeScience Kraków*)	Health and medical science	2006	Foundation
Poland	Mazovia Cluster ICT (*Mazowiecki Klaster ICT*)	ICT	2007	Cooperation agreement
Poland	MedSilesia – Silesian Medical Cluster (*MedSilesia – Śląska Sieć Wyrobów Medycznych*)	Health and medical science	2007	Does not have
Poland	Metal Processing Cluster (*Klaster Obróbki Metali*)	Production and engineering	2007	Cooperation agreement
Poland	North-South Logistic Transportation Cluster (*Klaster Logistyczno Transportowy Północ-Południe*)	Transportation and mobility	2012	Limited liability company
Poland	Polish Construction Cluster (*Polski Klaster Budowlany*)	Construction	2011	Association
Poland	Polish Automotive Group (*Polska Grupa Motoryzacyjna*)	Mobility: Vehicles, rail, traffic systems	2016	Association
Poland	Silesia Automotive & Advanced Manufacturing	Mobility: Vehicles, rail, traffic systems	2011	Joint-stock company
Poland	Silesian Aviation Cluster (*Śląski Klaster Lotniczy*)	Aviation and space	2006	Association
Poland	Sustainable Infrastructure Cluster (*Klaster Zrównoważona Infrastruktura*)	Construction	2011	Limited liability company

Country	Cluster	Predominant field(s) of activity	Year of foundation	Legal form
Poland	Waste Management and Recycling Cluster (*Klaster Gospodarki Odpadowej i Recyklingu*)	Energy and environment	2007	Limited liability company
Poland	West Pomeranian Chemical Cluster "Green Chemistry" (*Zachodniopomorski Klaster Chemiczny "Zielona Chemia"*)	New materials and chemistry	2007	Association
Slovakia	Bioeconomy Cluster	Biotechnology	2015	ALE
Slovakia	HEMP Cluster	Production and engineering	2018	ALE
Slovakia	House of Events Innovation	Creative industries	2019	ALE
Slovakia	IPEEK – Energy Environmental Cluster from Ipel Region	Energy and environment	2020	ALE
Slovakia	KOŠICE IT Valley	ICT	2007	ALE
Slovakia	SBaA – Slovenská Batériová Aliancia / Slovak Battery Alliance	Energy and environment	2019	ALE
Slovakia	Slovak Plastic Cluster	New materials and chemistry	2009	ALE
Slovakia	SME Booster and Innovations Cluster	Creative industries	2020	ALE

Source: own elaboration

Cluster organizations participating in the study were founded in all programming periods with 30% cluster organizations established before 2007, 47% established in 2007–2013 and remaining 23% stablished after 2013. With regard to their field of activity they represent:

- Aviation and space – 3 COs,
- Biotechnology – 1 CO,
- Construction – 2 COs,
- Creative industries – 2 COs,
- Energy and environment – 5 COs,
- Health and medical science – 4 COs,

- ICT – 9 COs,
- Logistics: Packaging, Delivery, Logistical Systems and Services – 1 CO,
- Mobility: Vehicles, rail, traffic systems – 3 COs,
- New materials and chemistry – 3 COs,
- Production and engineering – 7 COs,
- Production and engineering as well as Logistics: Packaging, Delivery, Logistical Systems and Services – 1 CO,
- Textile industries – 1 CO,
- Transportation and mobility – 1 CO.

Almost all cluster organizations participating in the study (with exception of only two cluster organizations) operate guided by a strategic document on cluster development which includes collaboration with universities and/or research organizations (only two COs with a strategy document do not include it).

Cluster organizations across the Visegrad engage in different types of activities (Figure 3,Table 4) which include: networking, human resources, R&D&I, internationalization, marketing and administration. In general, their portfolio includes all or, in some cases, most of them. Across cluster organizations participating in the study networking and internationalization engaged cluster organizations' management the most in the last three years (in 75% of cluster organizations this type of engagement stood at 28.75% and 30% respectively). At the same time 20% of engagement was focused on HR-related activities as well as R&D&I.

When analyzing differences between particular countries the following conclusions can be drawn:

- Czechia: largest engagement in R&D&I (largest across V4) with substantial engagement in networking, internationalization, and human resources;
- Hungary: largest engagement in networking with substantial engagement in internationalization and administration (largest across V4);
- Poland: largest engagement in internationalization (largest across V4) with substantial engagement in networking, R&D&I, and human resources;
- Slovakia: largest engagement in networking with substantial engagement in internationalization.

Figure 3. Activities undertaken by cluster organizations in the Visegrad countries in the last three years: CO manager perspective

CZ: N=10; HU: N=8; PL: N=12; SK: N=8

Source: own elaboration based on data from in-depth interviews

Table 4. Activities undertaken by cluster organizations in the Visegrad countries in the last three years: CO manager perspective (by quartile, in %)

Country	Level	Network-ing	Human resources	R&D&I	Internatio-nalization	Marketing	Admini-stration
Visegrad	min	0	0	0	0	0	0
	1Q	20	5	2.75	10	5	5
	2Q	20	10	12.5	20	10	10
	3Q	28.75	20	20	30	16	15
	max	80	60	60	60	30	40
Czechia	min	10	5	10	0	5	0
	1Q	10	5	18.75	10	5	5
	2Q	17.5	10	32.5	15	7.5	6.5
	3Q	20	17.5	48.75	20	11.5	10
	max	30	30	60	40	20	40
Hungary	min	0	0	0	10	0	5
	1Q	20	0	0	17.5	8.75	8.75
	2Q	25	2.5	0	22.5	15	12.5
	3Q	40	12.5	0	26.25	20	30
	max	80	60	5	40	20	40
Poland	min	10	0	0	10	0	0
	1Q	18.75	8.75	13.75	20	5	5
	2Q	20	15	20	30	10	10
	3Q	25	20	20	37.5	15	10
	max	50	20	25	60	30	20
Slovakia	min	20	8	0	0	5	5
	1Q	20	12.5	4.25	3.75	10	10
	2Q	22.5	16	10	12.5	15	12.5
	3Q	32.5	20	11.25	30	19.5	16.25
	max	60	30	30	40	25	25

CZ: N=10; HU: N=8; PL: N=12; SK: N=8

min – minimal % recorded in the sample; max – maximum % recorded in the sample; 1Q – 25% of the sample recorded a % lower than this; 2Q – 50% of the sample recorded a % lower than this; 3Q – 75% of the sample recorded a % lower than this

Source: own elaboration based on data from in-depth interviews

Cooperation within COs can be initiated by different actors. With regard to collaboration between business and research 38% of representatives of universities and research organizations indicated that it was the cluster manager who was responsible for initiation of this form of cooperation (Figure 4). However, in 48% of cases initiation came from people working in universities and research institutions (it was either executed by respondents, their

supervisors/managers, or other people from their organization). Companies as actors initiating cooperation were indicated by only 6% of respondents.

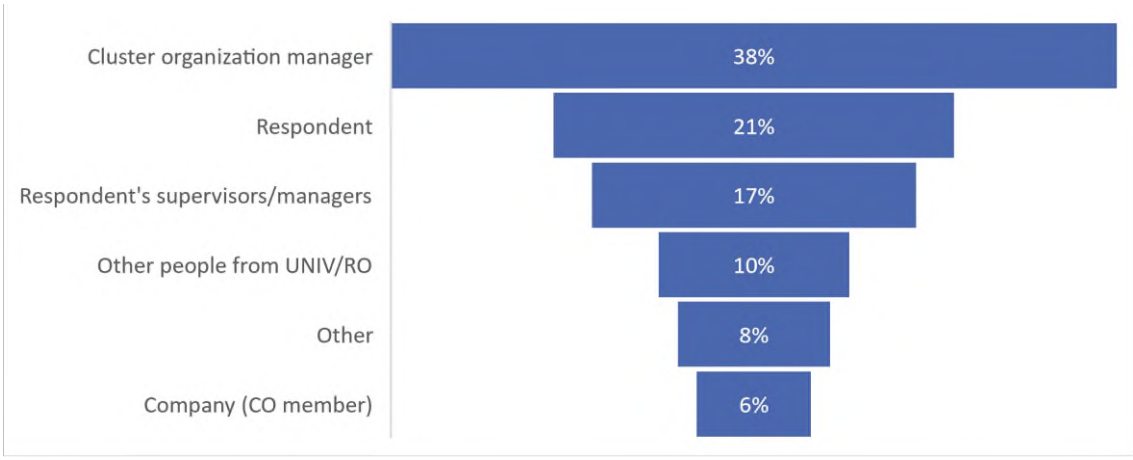


Figure 4. Collaboration initiation between business and research in cluster organizations in the Visegrad countries: UNIV/RO perspective

N=46 however four respondents indicated multiple answers
Source: own elaboration based on survey data

The statistics for respective Visegrad countries is presented in Table 5. Cluster managers seem to be the most active with regard to initiating cooperation between business and research in Slovakia (75%) and Poland (52%). Whereas in Hungary 18% of respondents indicated that collaboration initiation came from companies.

Table 5. Collaboration initiation between business and research in cluster organizations in the Visegrad countries: UNIV/RO perspective (by country, in %)

Country	Respondent	Respondent's supervisors/ managers	Other people from UNIV/RO	Cluster organization manager	Company (CO member)	Other
Czechia	38	25	6	25	0	6
Hungary	9	27	18	18	18	9
Poland	19	10	10	52	5	5
Slovakia	0	0	0	75	0	25

CZ: N=11 (three respondents indicated multiple answers); HU: N=11; PL: N=20 (one respondent indicated multiple answers); SK: N=4

Source: own elaboration based on survey data

The perspective of CO managers sheds a partially different light on the issue of R&D&I collaboration initiation (Figure 5). Among them, universities and research organizations are perceived as the most active in R&D&I collaboration initiation in Hungary whereas firms are perceived as the most active in Poland. At the same time, cluster organizations in Slovakia are perceived as most frequent R&D&I collaboration initiators relative to other V4 countries.

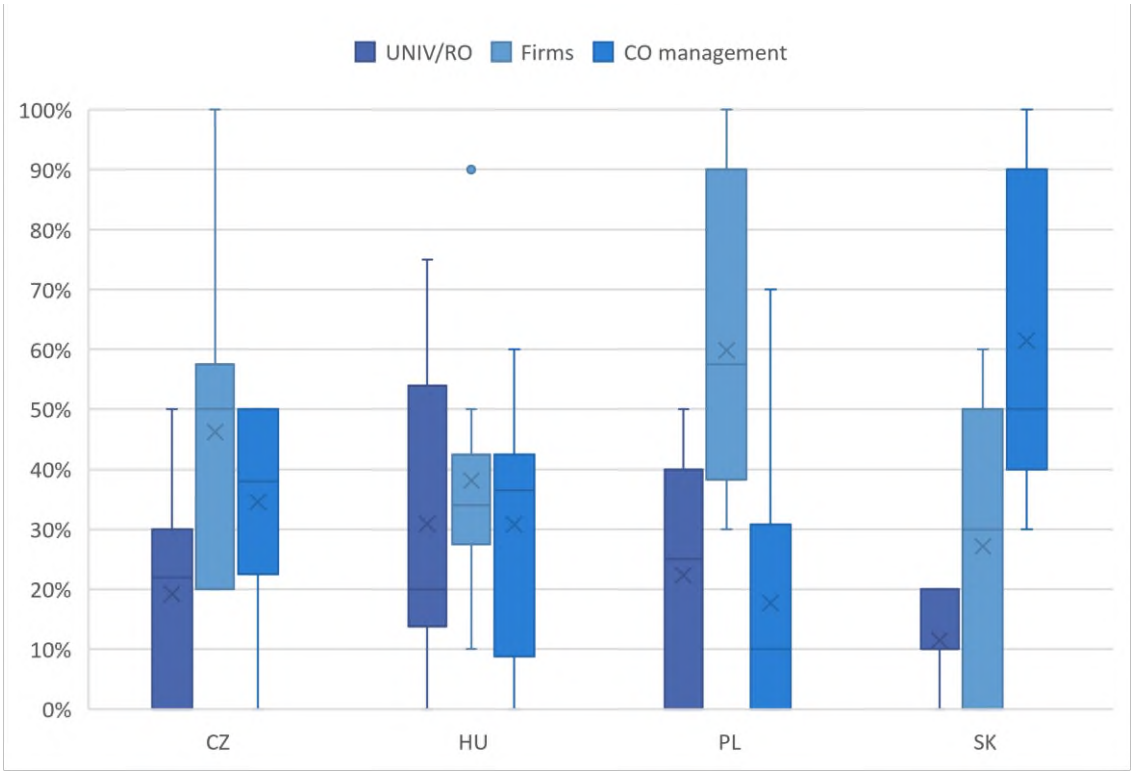


Figure 5. R&D&I collaboration initiation between business and research in cluster organizations in the Visegrad countries: CO manager perspective (by country)

CZ: N=8; HU: N=10; PL: N=14; SK: N=7
Source: own elaboration based on data from in-depth interviews

Firms participating in cluster organizations across the Visegrad countries differ in their technological advancement (Figure 6). In most cases CO managers indicated that the share of technology recipients exceeded the share of strategic innovators. With regard to firms' engagement in R&D&I collaboration with universities and/or research organizations CO managers reported that a relatively large number of companies engage in this kind of relationships within their CO structure (Figure 7). These results show that companies in cluster organizations are more open to collaboration with UNIV/RO than general country statistics suggest.

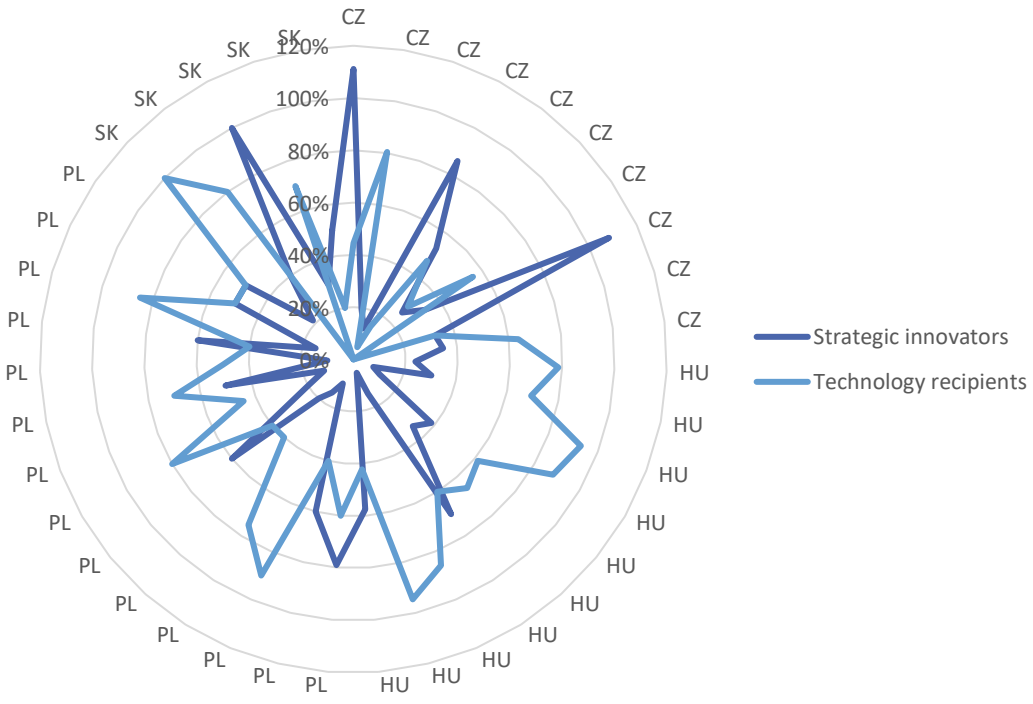


Figure 6. Technological advancement of companies in cluster organizations in the Visegrad countries: CO manager perspective

CZ: N=10; HU: N=10; PL: N=14; SK: N=5

Source: own elaboration based on data from in-depth interviews

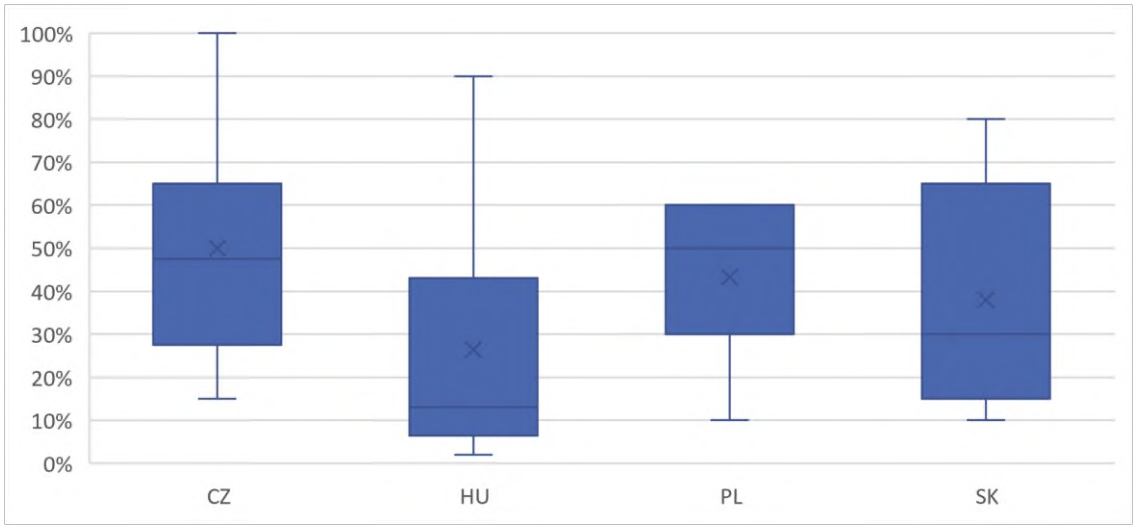


Figure 7. Share of companies engaged in R&D&I collaboration with UNIV/RO within cluster organizations in the Visegrad countries: CO manager perspective (by country)

CZ: N=10; HU: N=10; PL: N=15; SK: N=5

Source: own elaboration based on data from in-depth interviews

Intensity of collaboration between cluster members can be influenced by various factors. Most recently, the COVID-19 pandemic has been shaping cluster ecosystems around the globe. When inquired about the influence of the pandemic on collaboration with cluster organizations and their members (Figure 8) 50% of respondents (representatives of universities and research organizations) indicated that it decreased or strongly decreased the collaboration. 45% of respondents saw no difference between the pre-pandemic and pandemic times whereas 5% indicated an increase (this answer was only indicated in Poland). The largest decrease in intensity was observed in Slovakia (Table 6).

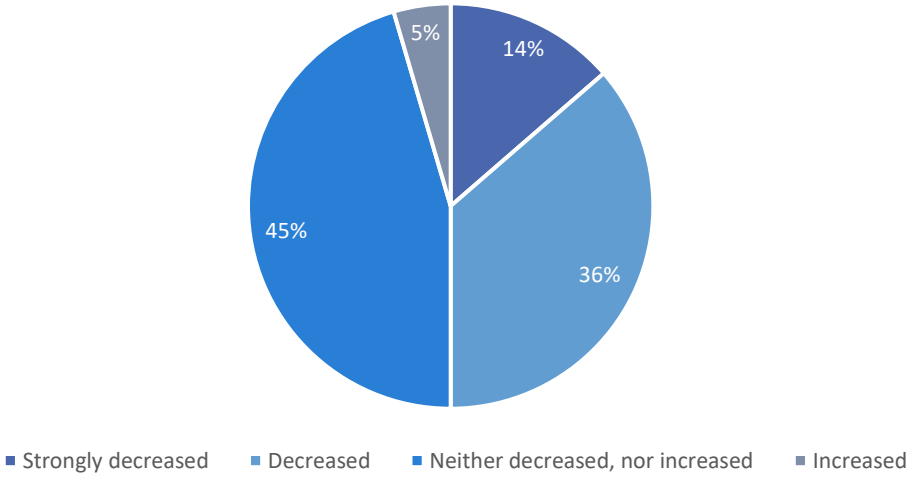


Figure 8. Influence of COVID-19 pandemic on intensity of UNIV/RO collaboration within cluster organizations in the Visegrad countries: UNIV/RO perspective

N=44
Source: own elaboration based on survey data

Table 6. Influence of COVID-19 pandemic on intensity of UNIV/RO collaboration within cluster organizations in the Visegrad countries: UNIV/RO perspective (by country, in %)

Country	Strongly decreased	Decreased	Neither decreased, nor increased	Increased
Czechia	10	40	50	0
Hungary	10	30	60	0
Poland	15	40	35	10
Slovakia	25	25	50	0

CZ: N=10; HU: N=10; PL: N=20; SK: N=4
Source: own elaboration based on survey data

4. Clusters as platforms for B2R/R2B cooperation: Evidence from V4 countries

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

The majority of clusters have succeeded in building a conducive atmosphere for fostering collaboration between businesses, researchers, and government organizations. This usually results in increased corporate competitiveness, increased adoption of new solutions and industry best practices, and increased R&D efforts. Clusters are often recognised as important elements of innovation systems, as they stimulate cooperation between institutions forming that systems, in particular representing business and science sector. Hence, one of the major principles of the cluster based economic development policy is to provide the groundwork for economic development by fostering collaboration between research and industry. This is why cluster public funding is typically channelled through cluster organizations to encourage various types of collaborative actions, such as common R&D projects, or to benefit the entire cluster, such as the collection and processing of knowledge and information in cluster-relevant areas or the creation of specialized research (Kowalski 2020). In reality, B2R/R2B collaboration is one of the variables that kickstarts the generation of innovations and launching them into the market. The superior general motivate for cluster collaboration between industry and academics is the necessity to transmit knowledge and technologies that emerge during the process of commercialization of products and services. Both the company and the higher education institution gain from the formation of a partnership. The goal of this part of the research is to identify the motivations for B2R/R2B collaboration in cluster organizations, as well as the advantages to stakeholders in Visegrad countries. Table 7 shows the findings of the survey conducted in four Visegrad countries: Czech Republic (n=11), Hungary (n=11), Poland (n=20) and Slovakia (n=4) linked to this topic area.

Table 7. Factors that have motivated researchers to pursue cooperation with the cluster organization and its members in Visegrad countries

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Ability to extend my network (networking)	3	0	3	21	19
Receiving non-financial research assistance (e.g.	5	3	7	21	10

access to data, exchange of knowledge with practitioners, developing technology)					
Commercializing research findings	8	5	11	18	4
Receiving research funding	12	5	9	12	8
Gaining access to infrastructure (e.g. lab equipment)	21	5	10	5	5
Necessity to undergo employee assessment at the university/research institution/other institution	20	13	11	2	0
Personal financial benefits	27	7	6	5	1

Source: own elaboration based on survey data [N=46].

The most compelling reason for exploring a collaboration with a cluster organization and its members is that it allows a researcher to expand their network. This is consistent with the economic network theory, which highlights the necessity of external resource mobilization, such as in research and development (Oerlemans, Meeus, Boekema 1998). We can understand the influence of social interactions on economic results using the network method (Goyal 2007). Networks aid companies in developing their inventive capacities by exposing them to new sources of ideas, providing speedy access to resources, and promoting knowledge transfer in the context of research and innovation. Furthermore, networking may provide a division of inventive labor that allows for the achievement of objectives that a single actor could not achieve on their own. One of the most difficult challenges for innovation networks is building the ability to improve information flow among existing members while staying accessible to newcomers (Powell, Grodal 2005). It's worth mentioning that the success of innovation networking depends on the partners' knowledge-based capabilities, particularly their absorptive capacity, or the ability to perceive the value of external information, absorb it, and commercialize it (Cohen & Levinthal, 1989). Superior R&D capability allows for the discovery of new prospects and, eventually, more effective assessment of joint R&D initiatives, in addition to valuing and integrating external information.

The second most important motivation behind pursuing cooperation with a cluster organization and its members is the opportunity of receiving non-financial research assistance, e.g. access to data, exchange of knowledge with practitioners, developing technology. Additionally, clusters may allow regional and worldwide relationships between cluster members and other clusters, for example, to test new goods and services. They may also serve as a neutral broker and platform for members to share risks in their user engagement activities (including research), as well as supply infrastructure and services (e.g. living labs, demonstration platforms or test beds). Clusters may encourage user innovation by holding contests and providing vouchers for

users to test new goods and services on behalf of their cluster enterprises, as well as identifying prospective R&D resources for early engagement in creating initial ideas.

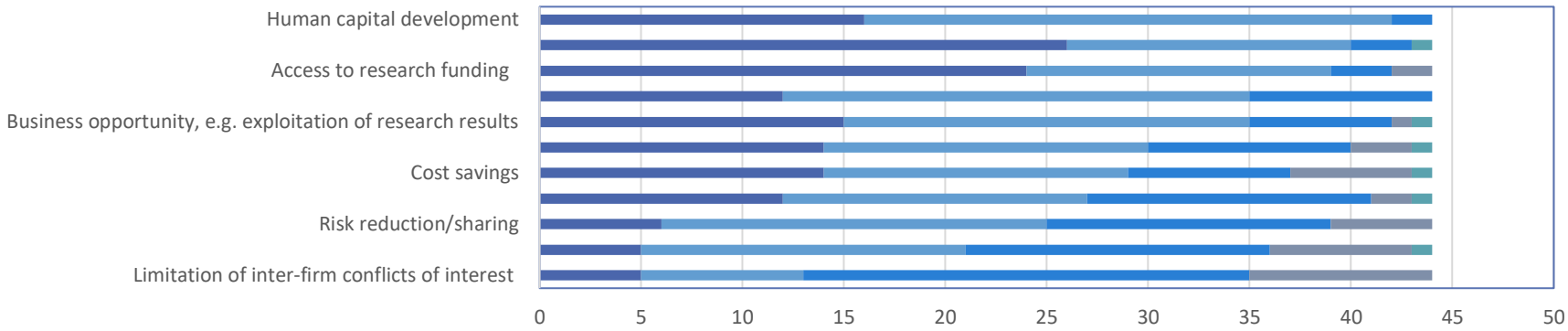
The possibility to commercialize research discoveries is the next most significant reason for exploring collaboration with a cluster organization and its members. The value of commercializing research discoveries has evolved as a consequence of a change in the conventional approach to innovation, which has been molded by the emergence of innovation process models (Rothwell, Rothwell, & Zegveld, 1985). According to the first generation of these models, which were based on J. Schumpeter's linear model of innovation, innovation progressed through a simple linear and sequential process that began with science and laboratory work and progressed through successive stages until new knowledge could be commercially applied in practical industrial activity. When it comes to innovation processes, this paradigm emphasizes research and development while ignoring the commercialization of R&D results in business. It also implies that innovation is automatically adopted as a consequence of individual inventors' or organizations' efforts. It is now well acknowledged that the most challenging step of creating breakthrough technology is commercialization (Kowalski 2022). According to this viewpoint, the most important driver of innovation is not R&D, which is a source of so-called technical push, but the market, which dictates research, development, and innovation trends and is a source of innovation pull, or demand-driven innovation. This concept is part of an open innovation approach, which involves looking for new product and service ideas outside of a company's boundaries. These strategies include finding and merging concepts that are complimentary to current R&D initiatives, as well as developing collaborations with other market participants. Because of the present dispersion of information and capital, combining the intellectual resources and activities of multiple companies, such as under the framework of clusters, is the most significant part of innovation.

Further motivators behind pursuing collaboration with a cluster organization and its members are receiving research funding. Additionally, the respondents mentioned a number of additional criteria that influenced their decision to collaborate with a cluster organization and its members, including:

- solving issues of economic practice,
- providing research to Slovak firms (indicated by Slovakian respondent),
- maintaining close relations with business practice,
- exchanging experience and participating in different projects,
- building relationships with other entities,
- building prestige,
- conducting study visits,
- proving the usefulness of conducted research to the business world,

- gaining knowledge of the business environment and having more opportunities to integrate/engage with it,
- broadening the opportunities to carry out tasks for organizations in the local region and to engage in issues relevant to the region,
- exchanging R&D experience.

For Visegrad respondents, the least important motives for B2R/R2B collaboration were: gaining access to infrastructure (e.g. lab equipment), necessity to undergo employee assessment at the university/research institution/other institution and personal financial benefits.



	Limitation of inter-firm conflicts of interest	Influence research directions and new programs for industry	Risk reduction/sharing	Multidisciplinary character of products and technologies	Cost savings	Opportunity to access a wider international network of expertise	Business opportunity, e.g. exploitation of research results	Access to research networks or pre-cursor to other collaborations	Access to research funding	Access to new knowledge, cutting-edge technology	Human capital development
Strongly agree	5	5	6	12	14	14	15	12	24	26	16
Agree	8	16	19	15	15	16	20	23	15	14	26
Undecided	22	15	14	14	8	10	7	9	3	3	2
Disagree	9	7	5	2	6	3	1	0	2	0	0
Strongly disagree	0	1	0	1	1	1	1	0	0	1	0

Source: own elaboration based on survey data [N=44].

Figure 9. Factors that have motivated cluster managers to pursue cooperation with the research organisations

Comparison of motives for B2R/R2B cooperation in cluster organizations and benefits for the stakeholders reflects following findings. Stakeholders in Poland highlighted motives concerning extending networks (networking) to pursue R&D projects and matchmaking of stakeholders in networks. This motive is also linked to the commercialization of research, which is extremely important in enhancing competitiveness of Polish clusters. On contrary, stakeholders in Czech Republic emphasized access to research funding as one of the most critical motive of B2R/R2B cooperation. This motive is based on linking stakeholders from both public and private sectors to implement joint research projects funded by national/regional schemes. Additionally, the access to new knowledge, cutting-edge technology, and state-of-the-art expertise was identified as dominant factor among stakeholders in this respective environment. Even though, the access to research funding was a motive among stakeholders in Hungary, we highlight the role of human capital development. This motive was emphasized among stakeholders in relation to developing skills and expertise in R&D. Furthermore, the access to knowledge/technology/research facilities was identified as a dominant motive, which relates to human capital development. Both these motives lead to efficient B2R/R2B cooperation between stakeholders and provide benefits for long-term partnerships in joint research activities. Stakeholders in Slovakia emphasized business opportunities, multidisciplinary character of products/technologies, and access to research networks as main motives for B2R/R2B cooperation. Among mentioned, business opportunities and access to networks aid stakeholders to exploit research capabilities and results of multidisciplinary character to markets. Additionally, stakeholders emphasized both business opportunities and wider networks help to develop other collaborations that go beyond traditional models of public/private partnerships in Slovakia.

4.2. Forms of B2R/R2B cooperation in cluster organizations

A number of questions dealt with the various aspects of forms of B2R/R2B cooperation in cluster organisations in our research. Cluster managers have been asked in all four countries on how cooperation materializes between firms and RO/UNIV within clusters. Six forms of cooperation have been predefined and cluster managers also had the option to list further cooperation forms (multiple choices were possible). **Results confirm that clusters provide platform to various kinds of cooperation in each country. Importantly, the overwhelming majority of the interviewed clusters give floor to different modes of cooperation.** On average, 3-5 cooperation forms are present and used in the interviewed clusters (see Figure 10. Average number of forms of cooperation between firms and RO/UNIV – replies from cluster managers) with Polish clusters having the highest average.

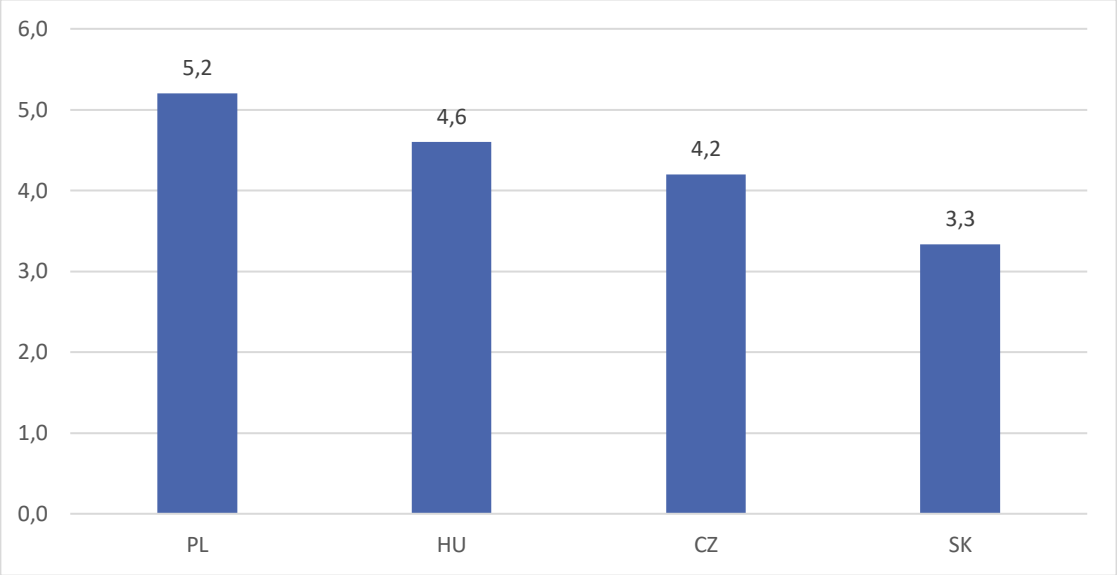


Figure 10. Average number of forms of cooperation between firms and RO/UNIV – replies from cluster managers

Source: own elaboration based on the interviews with cluster managers

The above outcome is reconfirmed from the replies of representatives of RO/UNIVs in the online survey. One of the questions of the online survey asked which activities RO/UNIV representatives carried out when cooperating with cluster members. There have been seven pre-defined replies to this question and the possibility to name further activities. Respondents could make multiple choices. Respondents selected 2.5 – 3.0 activities on average in the four countries. Even tough average values are lower for all four countries compared to replies from cluster managers and the ranking of countries differs (highest averages in SK and lowest averages in HU), still it can be concluded that it is not only the cluster managers that refer to multiple cooperation forms in clusters but also RO/UNIV representatives.

With regard to forms of cooperation, **research organisations and universities are almost always members of clusters** based on the conducted interviews (Figure 11**Błąd! Nie można odnaleźć źródła odwołania.**). All interviewed clusters report about RO/UNIV members in CZ, HU and PL and two-third of the interviewed clusters have at least one RO/UNIV member in SK. Having an RO/UNIV member is a pre-condition to qualify as a National Key Cluster (PL) or Accredited Cluster (HU), therefore the result does not come as a surprise. What is more important is that number of RO/UNIV in the clusters is above the minimum requirement in HU and PL, which may be a sign that clusters do not involve knowledge partners just to comply with administrative requirements but because they trust in their beneficial impact. **Occasional cooperation is widely used form** of how firms and RO/UNIV partners work together in a cluster in each V4 country (CZ: 80%, HU: 90%, PL: 93%, SK: 78%). **With the exception of PL, occasional**

cooperation seems more widespread than long term agreements that probably require more commitments from each of the cooperating parties. In fact, it is the long-term agreement mode of cooperation in which the clusters of the 4 countries provided the most divergent experience (CZ: 50%, HU: 60%, PL:93%, SK: 33%): the underlying reason may need further analysis. Interviews confirmed that technology platforms, alliances and endowed chairs and advisory boards are frequently used forms of cooperation, too and only few cluster managers quoted further modes of cooperation.

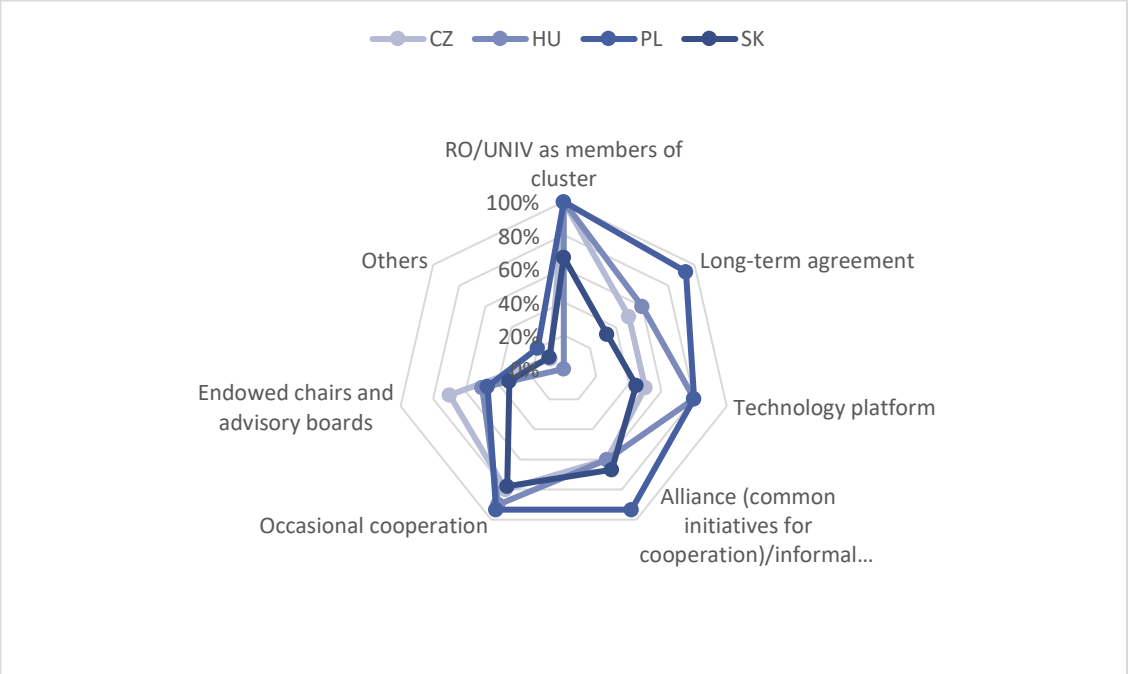


Figure 11. Forms of cooperation between firms and RO/UNIV – replies from cluster managers

Source: own elaboration based on the online survey with research organisations and universities

Our interviews confirm that various types of cooperation activities are undertaken by cluster members in the V4 clusters. **Information exchange fora and participation in seminars, conferences, exhibitions, fairs are the types of activities that are carried out by most clusters in the V4 countries** with low dispersion of country values (CZ: 100%, HU: 100%, PL: 93%, SK: 78% for both types of activities). With regard to use of RO/UNIV/industry facility two country groups are formed by the results: CZ and PL clusters report this activity almost unanimously, whereas roughly half of the HU (40%) and SK (56%) clusters chose this option. Reliance on liaison offices creates two country pairs, too: in this case it is CZ (80%) and HU (70%) that report their frequent occurrence, whereas PL (40%) and SK (44%) have a more moderate intensity of this type of activity. Whereas domestic/international cooperative RDI projects are widely used in V4 countries (minimum value is 70%), in Poland all clusters report about this type of activity.

Students' internship and students' involvement in firms' projects is markedly lower in SK than in the other three countries**. In CZ, HU and SK staff mobility was mentioned by only few cluster managers (22%-30%) but not in Poland where this type of activity was chosen by 80% of the respondents**. As for further type of activities not pre-listed for cluster managers, there was generally a low number of replies: in this case, the highest value (33%) was from SK cluster managers mentioning other type of activities.

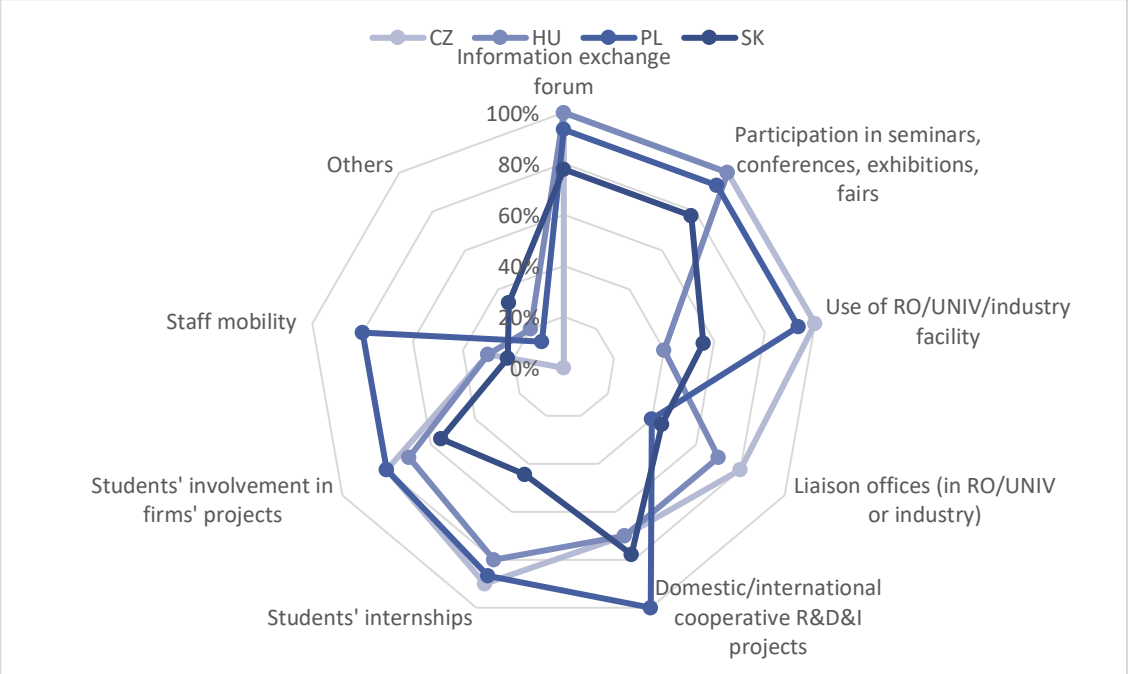
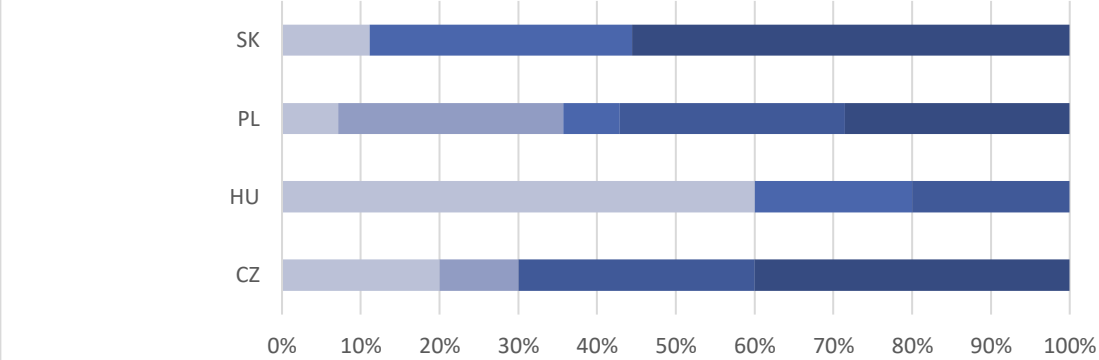


Figure 12. Types of cooperation activities between firms and RO/UNIV – replies from cluster managers

Source: own elaboration based on the interviews with cluster managers

Cluster managers were asked to rank the importance of three different models of cooperation between firms and RO/UNIV. One of the models was **collaborative projects organised and managed by the cluster manager**. From the results we can see (Figure 13**Błąd! Nie można odnaleźć źródła odwołania.**) that **this model has high importance in CZ, PL and SK but not in HU**. The reason for the difference may lie in how how clusters are structured and what roles cluster managers take on. The HU outcome is not surprising at all: in Hungary, the cluster management organisation is typically active in strategic, networking/matchmaking and administrative fields that concern all or most of the cluster members but are not actively involved in single projects, definitely not as managers or organisers of such projects. However, the cluster management usually has a very active role in facilitating the birth of projects through direct and indirect means but leaves the management of articulated projects to the ones that

implement them. Monitoring and assistance may nevertheless be provided frequently by cluster managers to running projects.



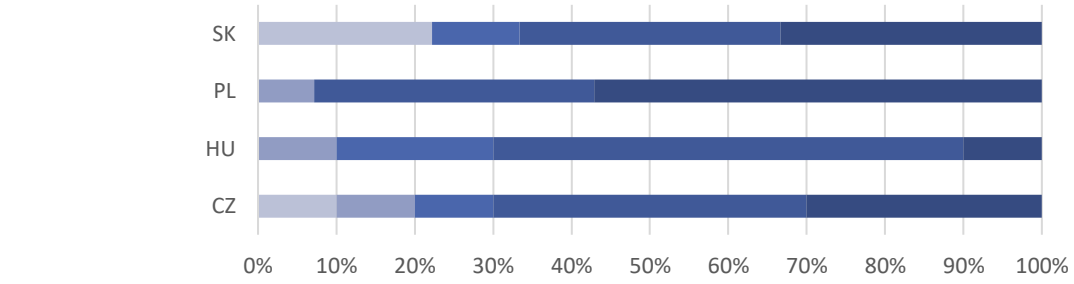
	CZ	HU	PL	SK
Unimportant	20%	60%	7%	11%
Slightly important	10%	0%	29%	0%
Moderately important	0%	20%	7%	33%
Important	30%	20%	29%	0%
Very important	40%	0%	29%	56%

Unimportant Slightly important Moderately important Important Very important

Figure 13. Models of cooperation between firms and RO/UNIV – collaborative R&D&I projects organised and managed by the cluster manager – replies from cluster managers

Source: own elaboration based on the interviews with cluster managers

A different model of cooperation is when **collaborative R&D&I projects are organised and managed by individual members not by the cluster manager. This model was considered highly important in the clusters across the V4 countries** (Figure 14).

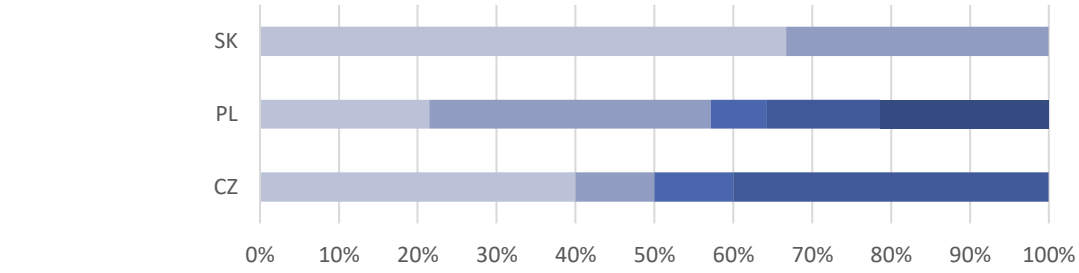


	CZ	HU	PL	SK
Unimportant	10%	0%	0%	22%
Slightly important	10%	10%	7%	0%
Moderately important	10%	20%	0%	11%
Important	40%	60%	36%	33%
Very important	30%	10%	57%	33%

Figure 14. Models of cooperation between firms and RO/UNIV – collaborative R&D&I projects organised and managed by individual members – replies from cluster managers

Source: own elaboration based on the interviews with cluster managers

A third cooperation model offered to cluster managers was the **open cluster centre for industrial R&D&I,** in which individual facilities are owned by the cluster. CZ, PL and SK collected replies using the same scale as for the previous two models. Results show that **this model is considered relatively the least important compared the other two models** in the three countries but still a relevant model in CZ and PL (Figure 15). In Hungary, replies were collected in a Yes/No form and 90% of the cluster managers said that this model is not important. In fact, this model is basically non-existing in Hungary, replies from cluster managers provide a reconfirmation in this respect. Results may be explained by what capacities clusters can build legally and financially. In Hungary, clusters do not have a legal form and cluster management organisations are typically very small enterprises or departments in chambers of commerce that are not typical hosts of research infrastructure.



	CZ	PL	SK
Unimportant	40%	21%	67%
Slightly important	10%	36%	33%
Moderately important	10%	7%	0%
Important	40%	14%	0%
Very important	0%	21%	0%

Figure 15. Models of cooperation between firms and RO/UNIV – open cluster centre for industrial R&D&I – replies from cluster managers

Source: own elaboration based on the interviews with cluster managers

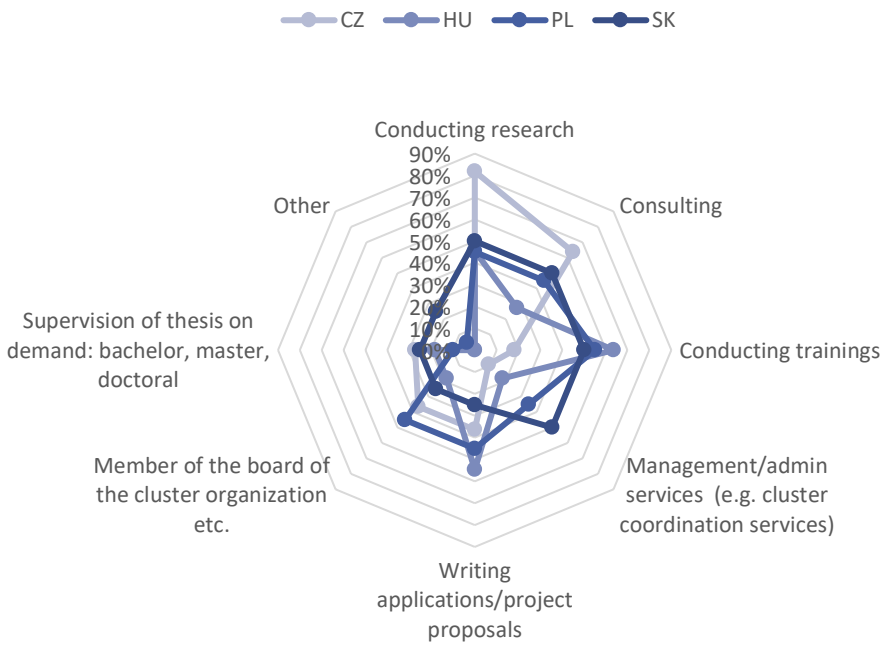


Figure 16. Type of tasks/activities that RO/UNIV carry out when cooperating with the cluster organization and its members – replies from RO/UNIV

Source: own elaboration based on the interviews with cluster managers

Like cluster managers, RO/UNIV representatives also gave account about various types of activities that RO/UNIVs carry out when cooperating with the cluster organisation and its members (Figure 16). **Conducting research, consulting, conducting trainings and writing applications/project proposals are the most frequently mentioned activities but country patterns differ**. About half of the respondents chose conducting research activities in HU, PL and SK but in CZ the ratio reached 82%. Interestingly, roughly half of the respondents chose conducting trainings in HU, PL and SK but in CZ the ratio is reached only 18%. Management and admin services and member of board of the cluster organisation were among the less frequently mentioned activities on average but single country ratios differ. Supervision of thesis on demand was picked by relatively few in all four countries.

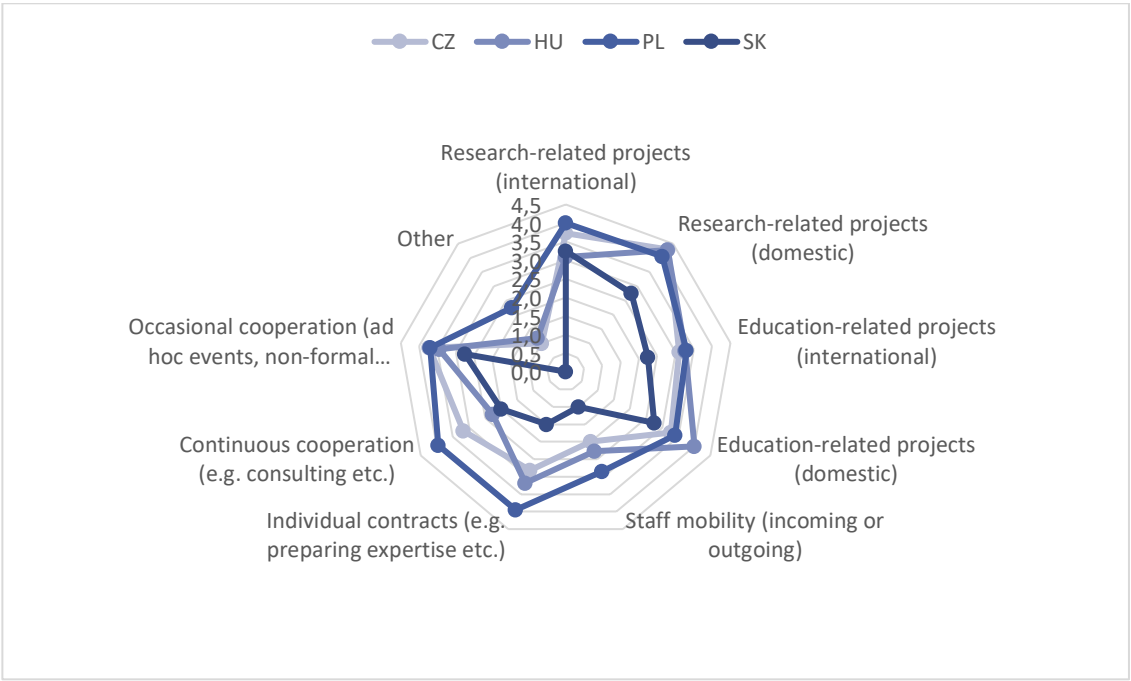


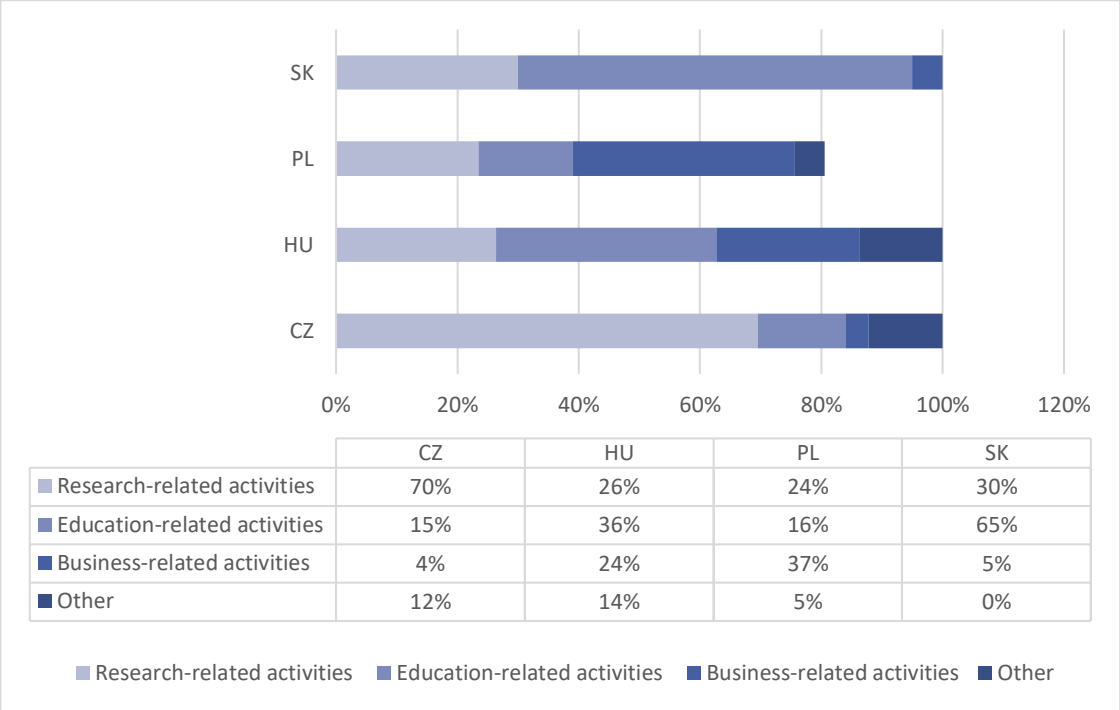
Figure 17. Relevance of listed forms in the cooperation with the cluster organization – replies from RO/UNIV

1 – not relevant at all, 2 – slightly relevant, 3 – moderately relevant, 4 – very relevant, 5- extremely relevant

Source: own elaboration based on the online survey with research organisations and universities

RO/UNIV representatives ranked the relevance of listed forms of cooperation with the cluster organisation on a 1-5 scale. Results show (Figure 17) **that research and education related projects are the most relevant forms of cooperation in all four countries**. **Domestic projects**

seem to rank just slightly higher for research-related projects with the exception of Slovakia. The bias towards domestic projects over international projects is more evident in the case of education related projects. Occasional cooperation is relatively high in importance in CZ, HU and PL but not in SK. **Staff mobility was assigned relatively low relevance in the 4 countries on average.** Individual contracts and continuous cooperation were ranked substantially differently by UNIV/RO representatives of the V4 countries.



	CZ	HU	PL	SK
Research-related activities	70%	26%	24%	30%
Education-related activities	15%	36%	16%	65%
Business-related activities	4%	24%	37%	5%
Other	12%	14%	5%	0%

Figure 18. Share of profiles of activities indicating the time each of them occupies with regard to RO/UNIV cooperation with the cluster organization and its members

Source: own elaboration based on the online survey with research organisations and universities

Patterns are different in the four countries in terms of how RO/UNIV respondents split their time in cooperating with the cluster organisation and its members (Figure 18). In CZ, research related activities take 70% of the time RO/UNIV representatives. In HU, the distribution among research-related activities, education-related activities and business related activities is quite equal. In PL, business related activities take relatively the most time of RO/UNIV representatives, whereas in SK the education related-activities take the lead by far.

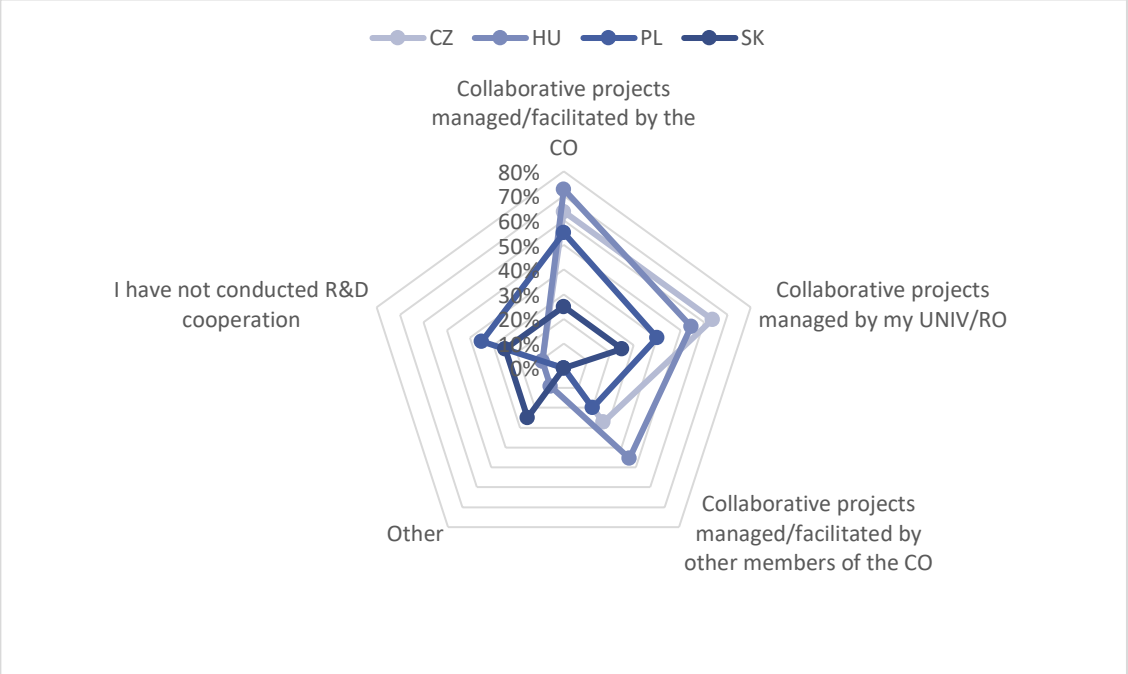


Figure 19. Applied models of R&D cooperation with the cluster organization and its members by RO/UNIV

Source: own elaboration based on the online survey with research organisations and universities

Based on the online survey, RO/UNIV representatives participate in such R&D cooperation models most frequently in the V4 countries that apply collaborative projects managed/facilitated by the cluster organisation (Figure 19). **Collaborative projects managed by UNIV/RO have almost the same share among replies.** In both of these models CZ, HU and PL values are similar and significantly higher than for SK. Collaborative projects managed/facilitated by other members of the cluster organisation were still relevant for CZ, HU and PL but quoted less frequently than the previous two models.

4.3. 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 1). The extra factors were indicated, which, according to the managers, were an important determinants of emergent collaboration – formal procedures at universities and research institutes, which lead to prolonged decision-making, but also open communication and information/knowledge sharing, monitoring current needs/demand of members, sustainable cooperation in research - co-financing of projects, internships of students mainly phd students and doctoral projects.

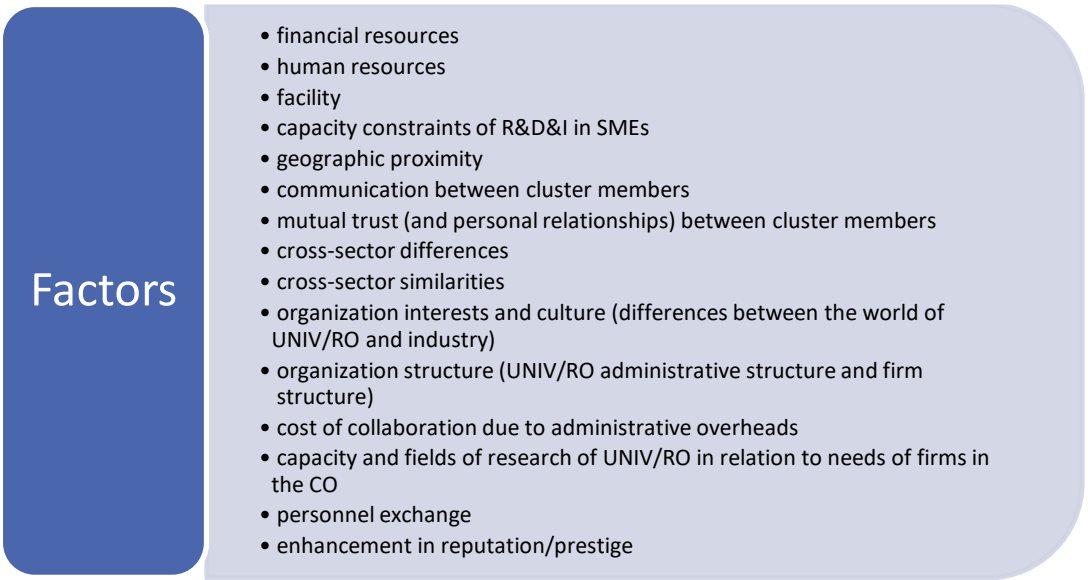


Figure 20. Factors conditioning cooperation between business and research organizations

Source: own elaboration based on the interviews with cluster managers (N=44)

The answers provided by managers indicate that the vast majority of the above-mentioned factors were viewed as favorable for collaboration in their eyes (Figure 21).

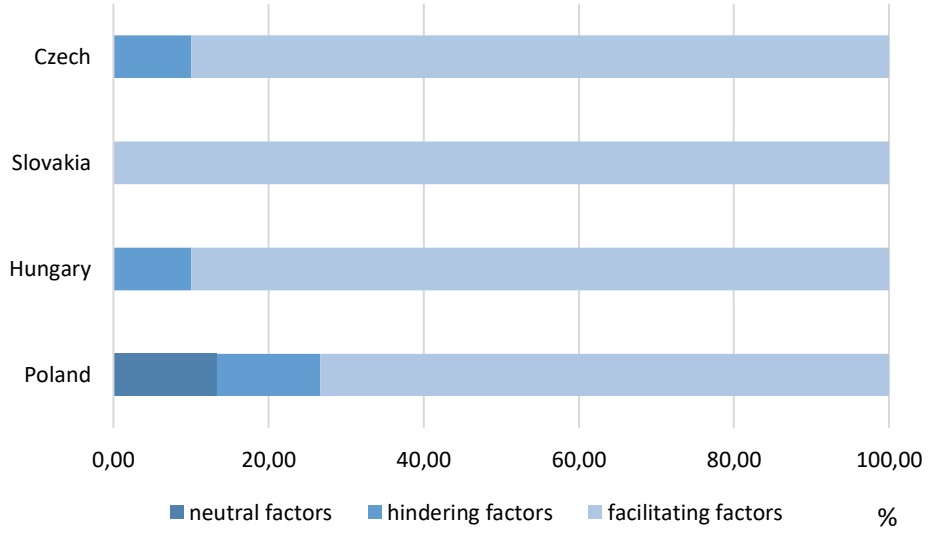


Figure 21. The average assessment of the factors conditioning cooperation between business and research

Source: own elaboration based on the interviews with cluster managers (N=44)

In Poland two clusters did the managers report that factors are neutral and in 3 countries detrimental to the development of collaboration between business and research organization. Thus, as the research shows, Poland was characterized by the lowest share of factors assessed as facilitating collaboration. Only in Slovakia all factors were viewed as favorable for collaboration.

A more detailed analysis of the scores shows a fairly varied range of reported values (Figure 3). In all countries, only two factors were not indicated as hindering collaboration between business and research organization. They were: geographic proximity and enhancement in reputation/prestige. The remaining factors were characterized by a differentiated assessment by managers in all countries in terms of their importance for the development of collaboration.

Some factors were never identified as facilitating collaboration between business and research organization: organizational interests and culture (differences between the world of UNIV/RO and industry) – but only in Poland and Czech, organizational structure (administrative structure of ROs/universities and corporate structure) – only in Poland, and cost of collaboration due to administrative overheads – also only in Poland.

Only three factors were identified as those of a purely collaborative nature, they were: mutual trust (and personal relationships) between cluster members (in Czech and Hungary), communication between cluster members (in Hungary) and financial resources (in Hungary).

The factor that was indicated to the greatest extent as hindering collaboration between business and research organization was cost of collaboration due to administrative overheads in Poland. In Slovakia and the Czech Republic, it was also capacity constraints of R&D&I in SMEs, in Hungary, however it was organization interests and culture (differences between the world of UNIV/RO and industry).

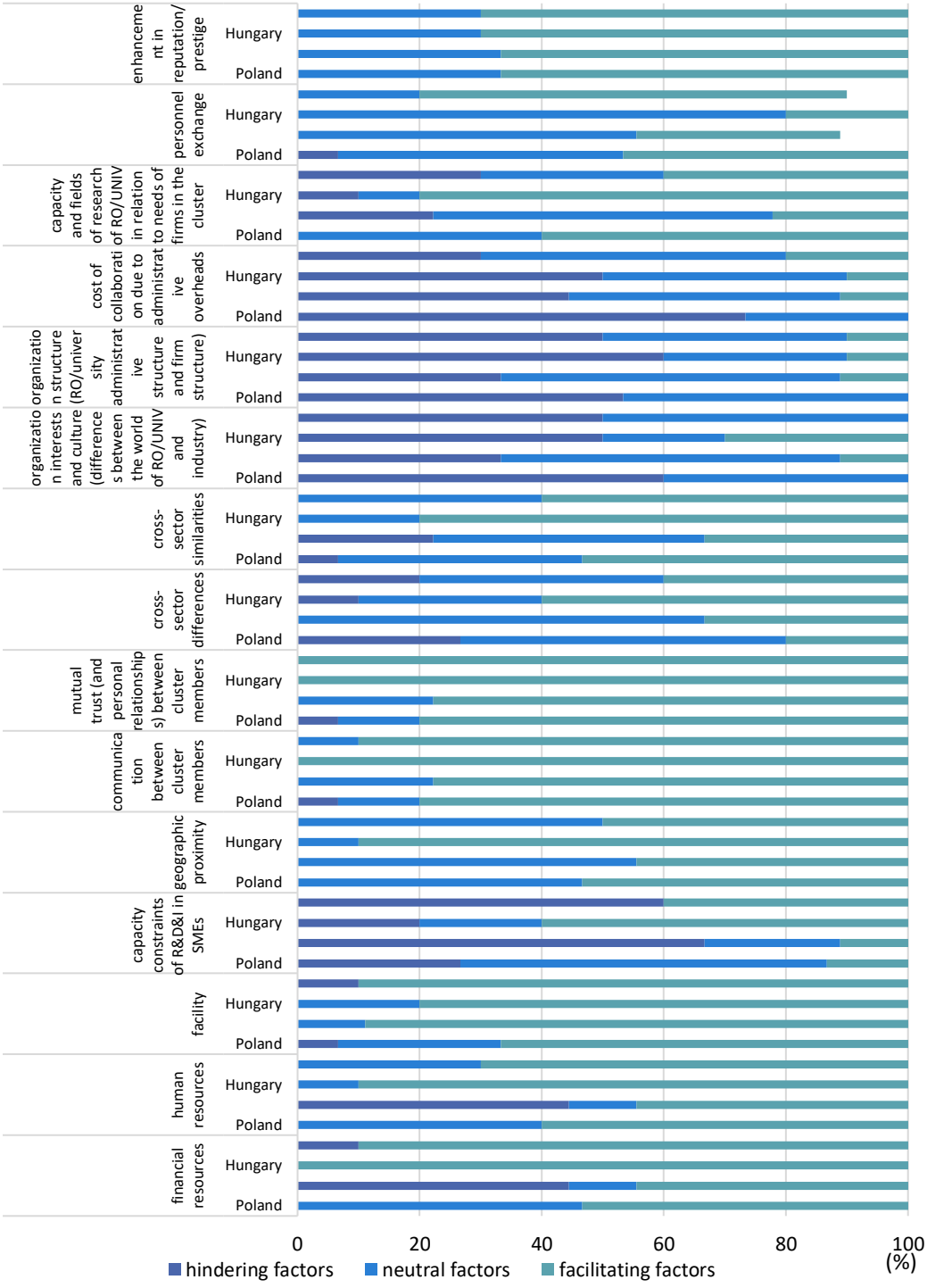


Figure 22. The assessment' structure of the factors determining cooperation between business and research organization in the opinion of the respondents from all countries

Source: own elaboration based on the interviews with cluster managers (N=44)

Among all factors assessed by managers, 12 of them (80%) were identified as facilitating collaboration in clusters (8 factors in all countries). The two highest ranked in all countries were: communication between cluster members, mutual trust (and personal relationships) between cluster members and facilities (Figure 4). Only in Hungary the factor - capacity constraints of R&D&I in SMEs has been assessed as a facilitating collaboration between business and research organization. Only in Slovakia financial resources haven't been assessed as a facilitating factor. The average value of the rating index for all factors facilitating collaboration in all countries was 0.85 (the maximum value 2.0). The countries where the value of this indicator was lower than in the entire group were: Slovakia (0.64) and Poland (0.77). The remaining countries had a higher value of indicator – Czech (0.94) and Hungary (1.01).

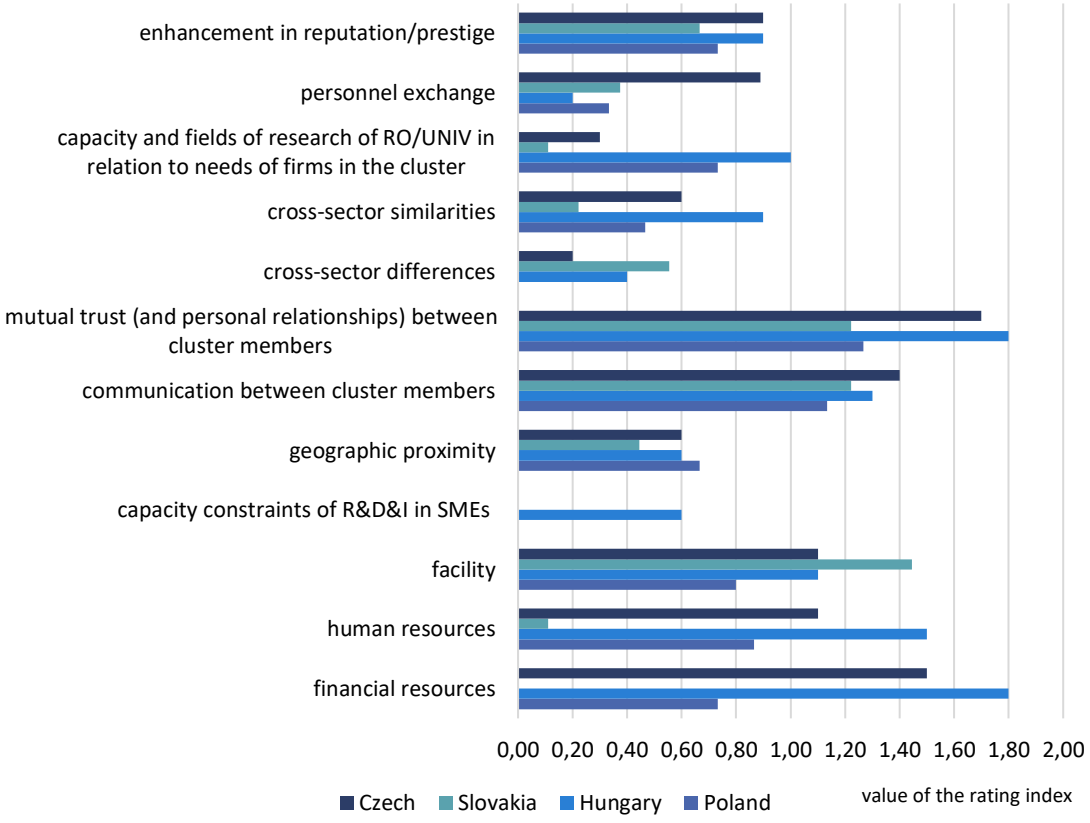


Figure 23. The average assessment of the factors facilitating cooperation between business and research organization

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

Source: own elaboration based on the interviews with cluster managers (N=44)

The financial resources allow to create development strategy and invest in order to develop companies assets. The nature of cluster organizations offers the possibility of cooperation between entities from private and public sector. That joint efforts generate tangible benefits for cluster organization. There are three major forms of funding cooperation between those entities: public sources, private sources, membership fees.

The survey results indicate a predominant role of public sources in financing collaborative R&D&I projects in the last three years (on average). In all V4 countries, the share of public sources were above 50%. The highest influence was in Poland (67%) and the lowest in Hungary (53%). In Slovakia and Czech Republic public sources accounted for about 58% and 55% of funding sources, respectively. The results shows that cooperation between B2R/R2B strongly depended mainly on public sources. It may lead to a discussion about higher involvement of private funds in R&D financing. As a second important funding opportunity respondents identified private sources. Membership fees were the least important considered by respondents. The survey results confirmed diversification of financial resources. In half of V4 surveyed cluster organizations two different funding sources were used and another 42% of the respondents declared employing three financial sources.

In Hungary there were two main sources of financing: public and private source (Figure 5). 75% of the respondents indicated those two forms of funding. ¼ of cluster managers indicated three financial sources with relatively high percentage of answer “other”. One of that options was a loan. In only one case membership fees were indicated as a way of funding. However, membership fees are not spent on collaborative projects but on basic operations of cluster management, events, networking and training.

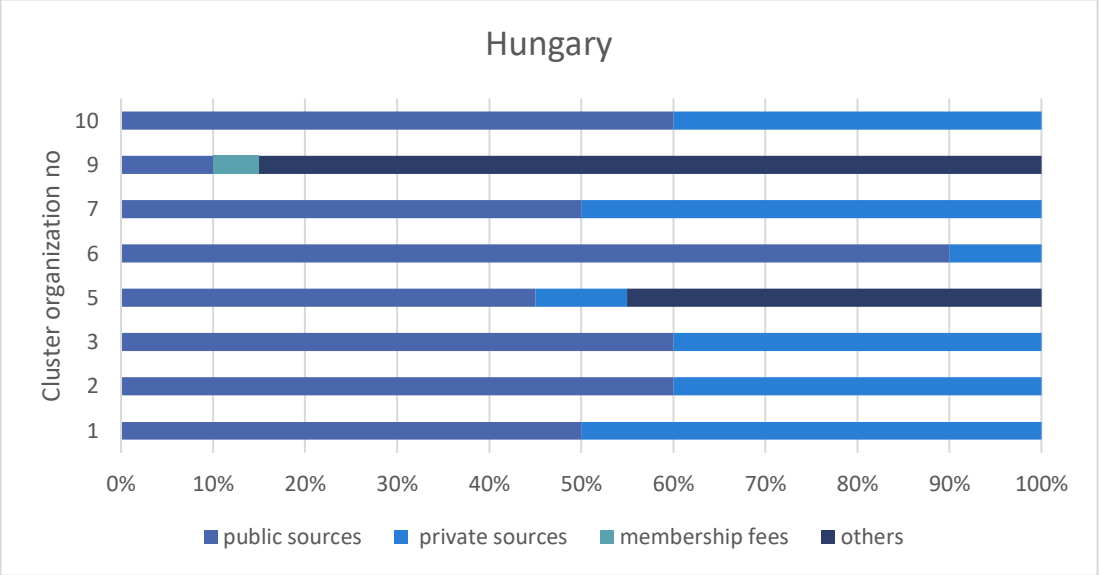


Figure 24. The structure of financial sources for collaborative R&D&I projects in Hungary

Source: own elaboration based on the interviews with cluster managers (N=8)

The structure of financial sources for collaborative R&D&I projects in Slovakia is quite different from other V4 countries. A half of respondents indicated that private funds were a basic financing sources (Figure 24). Another 50% of cluster organization managers stated private sources as important in funding R&D projects but also including membership fees. In one cluster organisation collaborative projects were financed in 100% from private source. It was the isolated case of all interviews in V4 Group.

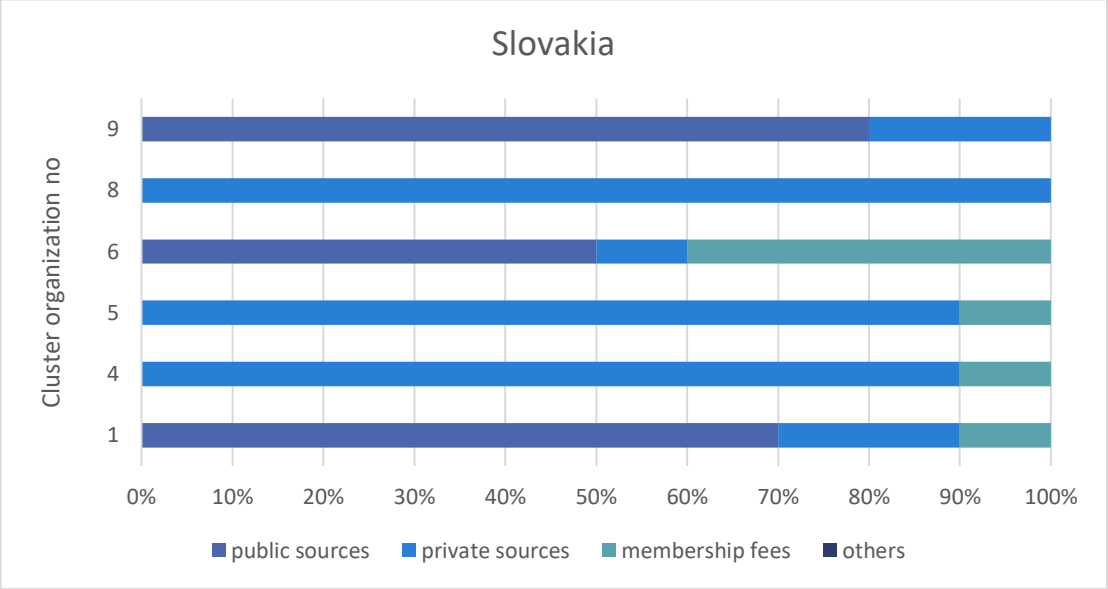


Figure 25. The structure of financial sources for collaborative R&D&I projects in Slovakia

Source: own elaboration based on the interviews with cluster managers (N=6)

In Czech Republic the structure of financial sources for collaborative projects is different from those in Hungary and Slovakia (Figure 26). The results show that in most of cluster organizations (67%) three various sources of financing were applied. Only one cluster manager indicated 4 different forms. The involvement of public funds was not lower than 40%.

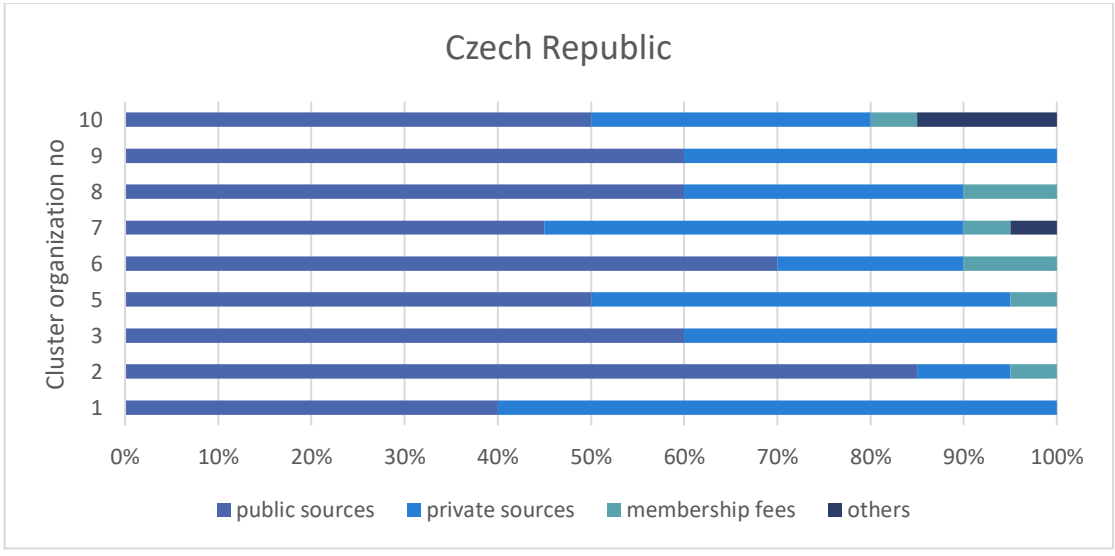


Figure 26. The structure of financial sources for collaborative R&D&I projects in Czech Republic

Source: own elaboration based on the interviews with cluster managers (N=9)

Funding structure in Poland is rather more similar to Czech Republic than to Hungary and Slovakia. The survey results show that public sources had a predominant influence on financing R&D&I projects (Figure 8). Membership fees were the most often used as funding sources (30%) compared to other V4 countries. Cluster managers declared two different funding sources used in their collaborative projects.

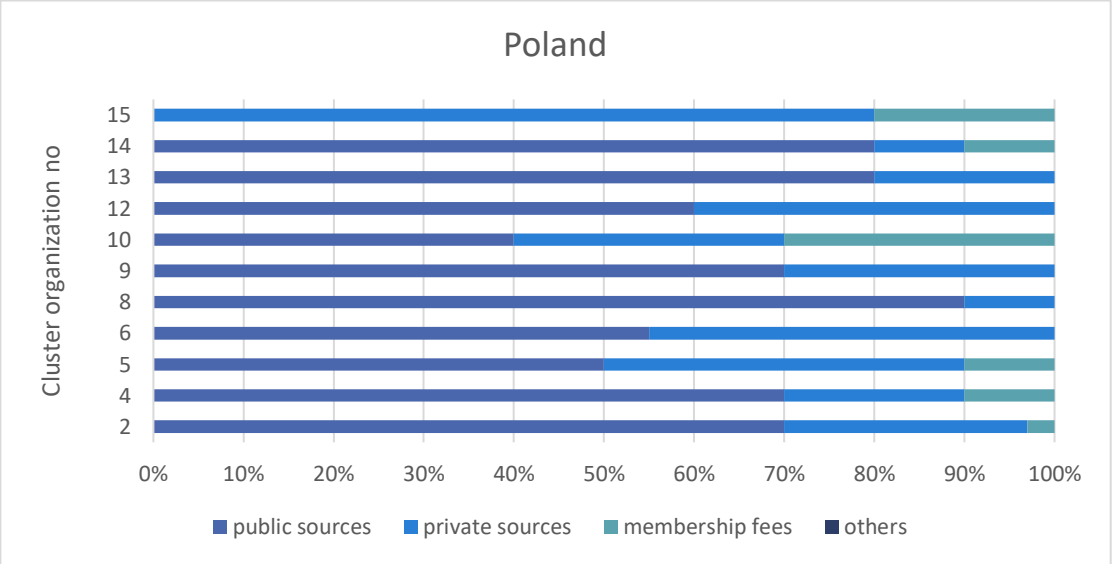


Figure 27. The structure of financial sources for collaborative R&D&I projects in Poland

Source: own elaboration based on the interviews with cluster managers (N=11)

In order to obtain more detailed information about financing of science-business partnership, the representatives of research organizations were asked about financial aspects of collaboration with cluster organization and its members within the last 3 years. They referred to sources of funding presented in Figure 27 and were asked to indicate three most important. The total number of responses totalled 96. In 2 cases respondents did not collaborate with cluster organization within the last 3 years. Another two respondents indicated "other" forms of financing (with one answer that cooperation was run "without funding/financing"). According to survey results, in V4 countries the most important funding sources were: university/research organization internal budget (30%), external research grants – domestic (18%) and cluster organization's budget (16%). According to collaborative R&D&I projects, it seems that there is a bigger problem with involving international forms of funding such as research (8%) or education (10%) grants. Figure 10 reveals also rather low level of internationalisation of financing sources. Collaborative cooperation in V4 cluster organisations does not have an international dimension. Although international companies are involved in

cooperation with cluster organizations, the financial resources come from domestic entities budgets.

Figure 28. Most important funding sources for RO/UNIV cooperation with the cluster organization and its members in the last 3 years in V4 countries

Source: own elaboration based on survey results

At a national level, there are some differences in sources of financing cooperation on the platform of cluster organizations. Figure 11 reveals that university/research organization internal budget was the most important funding source in Poland (37%). This form of financing was engaged twice as often as companies – members of the cluster organization budgets (17%). On the contrary, in Slovakia there were three equally important sources. As important as university/research organization internal budget (29%) were also cluster organization's budget and external international grants. It has to be emphasised that only in Slovakia a high interest in that source of financing. However, the use of external international research grants (14%) were also relatively high when comparing the structure to other countries – Poland and Czech Republic. On the other hand, the highest share of this form of financing can be observed in Hungary. In the opinions of Hungarian respondents, university/research organization internal budget was the primary source of financing the collaborative R&D&I cooperation. Among all V4 countries, domestic research grants were the most common form of funding in Czech Republic what needs to be highlighted. At the second place, researchers indicated university/research organization and cluster organization's budget.

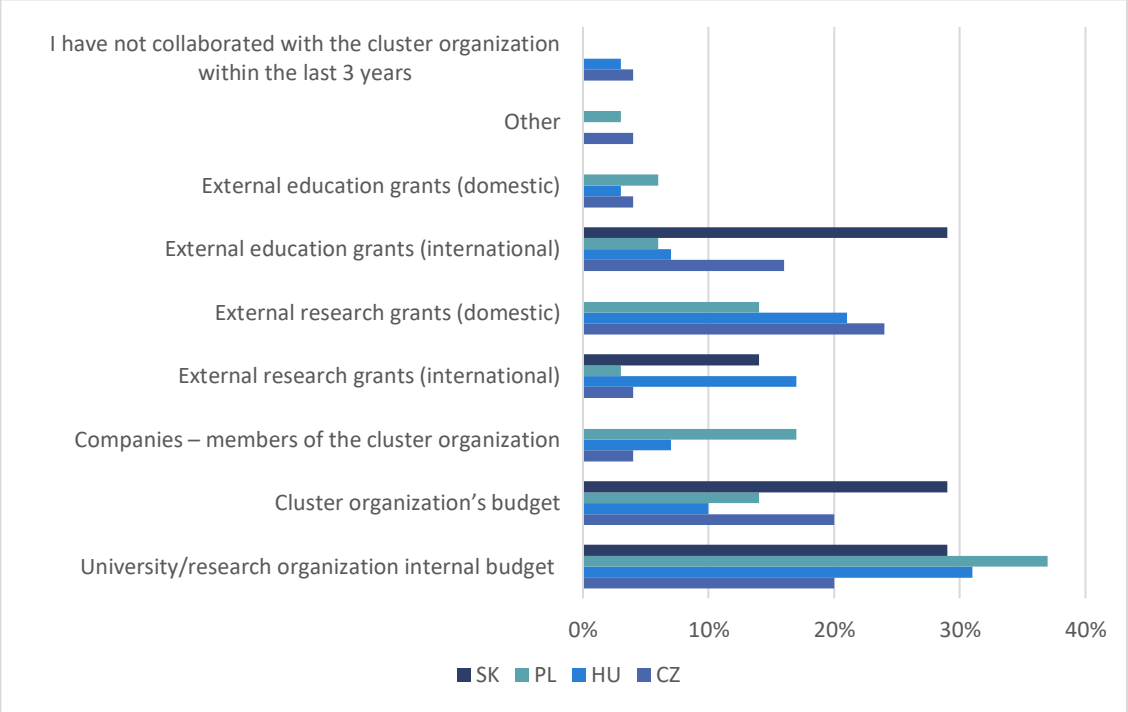


Figure 29. Most important funding sources for RO/UNIV cooperation with the cluster organization and its members in the last 3 years – the structure of indications

Source: own elaboration based on survey results

Research institutions and universities are focusing on research but the business and industry are the main knowledge users. The benefits of collaboration between them extended to multilateral links and activities. Figure 29 presents a set of outcomes reviewed by researchers in V4 countries. In general, these effects of cooperation are divided into two groups: outcomes for business and UNIV/RO institutions and different types of innovations. The most often indicated results of RO/UNIV cooperation with cluster organizations and its members were extending researchers' network, and preparing applications/project proposal. It is observed that in V4 countries more results are rather scientific in its nature. A lower factor of indications was achieved in results closer to business activities like trademarks, patents, prototypes, business and product innovations, etc.

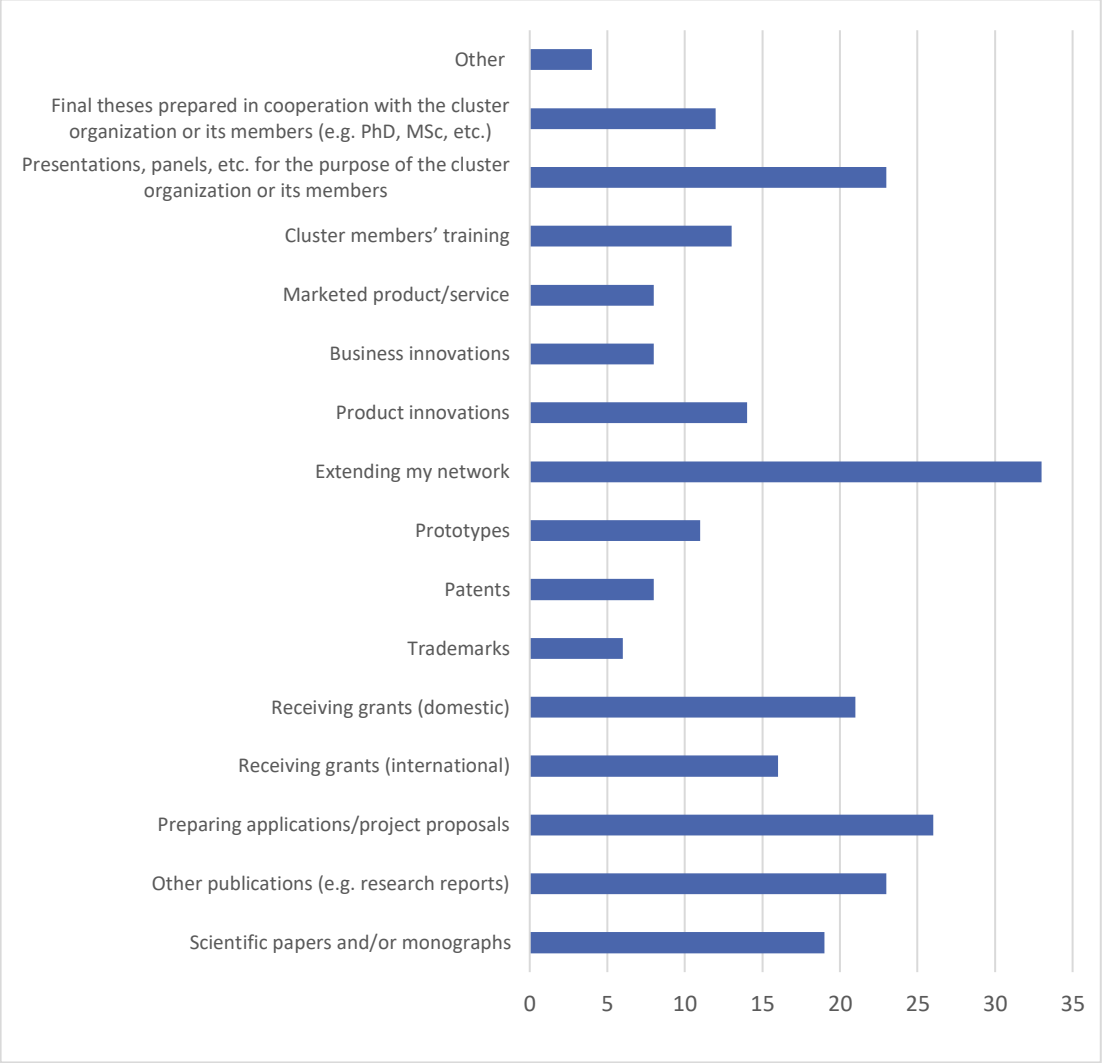


Figure 30. The results associated with cooperation with the cluster organization and its members in V4 countries – multiple choice answer

Source: own elaboration based on survey results

The researchers from Slovakia recognized preparing applications/projects proposals as a most important result of cooperation with cluster organizations (Figure 30). But it must to be said that only 4 researchers answer the questionnaire. As far as extending researchers' network is concerned, a high share of indications is observed (more than a half of respondents from Czech Republic and 82% researchers from Hungary).

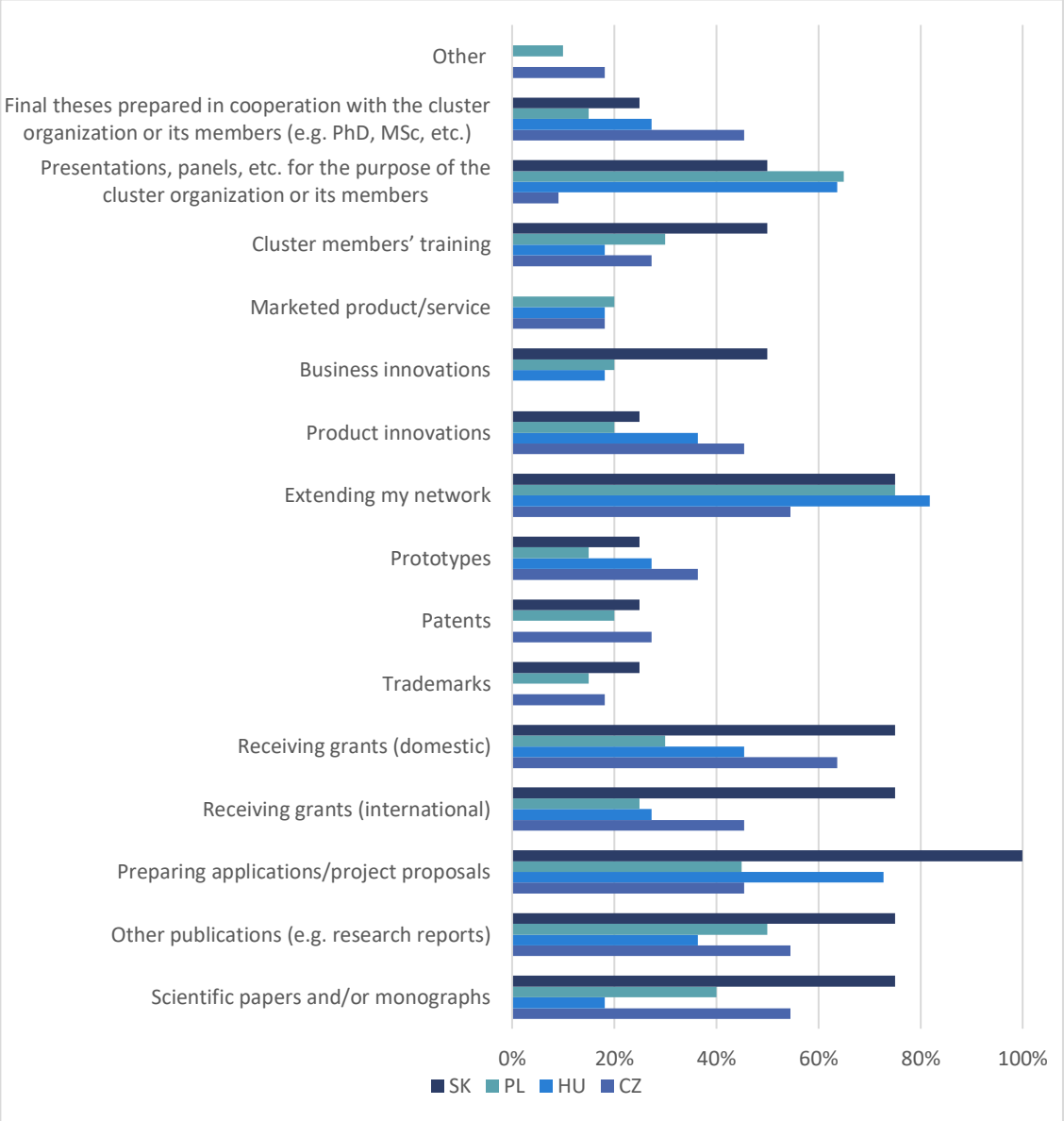


Figure 31. The results associated with cooperation with the cluster organization and its members – the structure of answers

Source: own elaboration based on survey results

The research results reveals that V4 countries had similar effects of cooperation (although with different structure of results):

- final theses prepared in cooperation with cluster organizations;
- presentations and panels;
- cluster members' training;

- product innovations;
- extending researchers' network;
- prototypes;
- receiving grants (domestic and international);
- preparing applications/projects proposals;
- other publications;
- scientific papers/ monographs, which are extremely important from researchers point of view.

It should be noted that not every result was reported in particular country. There were no marketed products/services in Slovakia and researchers from Czech Republic did not indicate the business innovation as an effect of cooperation between business and science. Whereas in Hungary there were no trademarks and patents were implemented.

Most of evaluated results of cooperation were indicated by researchers from V4 countries. However, the structure of responses cannot be considered uniform. According to different aspects of science and business environment, different aspects will decide about the aim of starting the cooperation between business and science. The most important is that the joint work should provide the development of every person and entity involved. The results of our research show satisfactory quantitative and qualitative effects of B2C/C2B cooperation, especially when those effects contributed to the development of researchers, companies and research organization and universities.

4.4. Challenges and barriers for B2R/R2B cooperation

Table 8 offers the opposite view on the evaluation of cooperation between cluster managers and research institutions in the V4 countries. This reverse view is meant by the challenges and barriers to cooperation. The results of Table 8 show a division of barriers into four groups. The first group of barriers represents the combined share of cluster managers' "Significantly hinders" and "Hinders" responses with more than 50% of the total row responses for the respective evaluation criterion. Thus, for the first group we observe the highest share of the sum of responses "Significantly hinders" and "Hinders" for the variables Capacity constraints of R&D&I in SMEs" (58%), "Cost of collaboration due to administrative overheads" (57.5%), Organization interests and culture (differences between the world of RO/UNIV and industry)" (55%) "Organization structure (RO/university administrative structure and firm structure)" (53.6%). In the first case, it can be inferred from the busy-ness of SMEs with the day-to-day operations of the firm and the lack of dedicated human resources to do the research. In the second and fourth cases, we find a persistent problem of administrative management and costs

of research institutions, with a predominance of public sector research institutions that experience more complex decision-making processes due to their multi-tier management because of the use of public funds for operations, their autonomy, and the implementation of. other activities not directly related to R&D&I. Furthermore, administrative overhead costs also point to the administrative complexity of the use of public funds on projects as well as the complexity of decision-making processes mentioned above. In the third case, the variables point to the different interests of business institutions, for which profit is the primary concern, and research institutions, which are overwhelmingly recruited from public universities. However, the latter are evaluated on criteria other than profit and must diversify their activities between teaching, primary, and applied research. The second group is made up of a share of the sum of responses "Significantly hinders" and "Hinders" in the interval 30-40% and contains one variable - Financial resources (38,5%). However, this determinant can be considered as a general problem of all cooperation activities depending on its scope, objectives, and requirements, where the possibilities of the public sector budget must always be considered to support it. The third group is formed by the share of the sum of responses "Significantly hinders" and "Hinders" in the interval 20-30%. It contains the variables "Human resources (26.6%)", "Cross-sector differences" (24.1%), Facility (22.2%), and Mutual trust (and personal relationships) between cluster members (20%). The variable Human resources can be seen as complementary to the variable Capacity constraints of R&D&I in SMEs, where on the side of SMEs it is related to the lack of specialized human resources for research, and on the side of research institutions to activities outside research, i.e., teaching, and administrative activities, as well as participation in basic research projects. The remaining variables then point to issues of finding common communication, building lasting relationships, or the lack of capacity to carry out applied research. The last, fourth group is represented by the group of Neutral Factors, where the impact of digitalization and global shrinkage shows 100% for the variable "Geographical proximity", "Communication between cluster members".

Table 8. Hindering factors of cooperation between business and research institutions in V4 clusters by cluster managers (in %)

	Significantly hinders	Hinders	Neutral
a) Financial resources	15,4	23,1	61,5
b) Human resources	13,3	13,3	73,3
c) Facility	0,0	22,2	77,8
d) Capacity constraints of R&D&I in SMEs	16,1	41,9	41,9
e) Geographic proximity	0,0	0,0	100,0
f) Communication between cluster members	0,0	14,3	85,7
g) Mutual trust (and personal relationships) between cluster members	0,0	20,0	80,0
h) Cross-sector differences	0,0	24,1	75,9
i) Cross-sector similarities	0,0	15,8	84,2
j) Organization interests and culture (differences between the world of RO/UNIV and industry)	15,0	40,0	45,0
k) Organization structure (RO/university administrative structure and firm structure)	14,6	39,0	46,3
l) Cost of collaboration due to administrative overheads	17,5	40,0	42,5
m) Capacity and fields of research of RO/UNIV in relation to needs of firms in the cluster	4,8	23,8	71,4
n) Personnel exchange	4,0	0,0	96,0
o) Enhancement in reputation/prestige	0,0	0,0	100,0

Source: own elaboration

Considering above mentioned barriers of cluster cooperation, we would like to highlight certain differences that appear between counties. The cost of collaboration brought on by administrative overheads were identified as most prevalent in hindering collaboration primarily in Poland, while Slovak and Hungarian clusters face challenges concerning capacity constraints of R&D&I in SMEs. On a positive note, we acknowledge capacity constraints of R&D&I as factors

limiting collaboration in Poland to a relatively small extent. Additionally, the barrier regarding organization interests and culture (differences between the world of RO/UNIV and industry) was prevalent among Czech clusters, also with challenges of organization structure reflecting differences in RO/university administrative structure and firm structure. Organizational structure as a barrier was likewise emphasised among clusters in Poland. We acknowledge capacity of research of RI/UNI in relation to needs of firms in the cluster and human resources as relatively specific barriers regarding cluster collaboration among Slovak clusters. Cluster collaboration in Hungary face the challenge concerning the role of trust, especially in terms of personal relationships between cluster members that might hinder B2R/R2B cooperation in the long run.

5. Best practices from V4 countries

Interviews with cluster managers and researchers provided an overview on best practices concerning B2R/R2B collaboration, supplemented with several parallels for sustainable R&D&I between firms and RO/UNIV within clusters. Additionally, both managers and researchers highlighted the role of platforms for collaboration, which should be primarily based on its users, respecting the variety of their needs, the size of the business, and the stage of development. The crucial part of sustaining the platforms is to identify, evaluate and respond to the needs of companies that are struggling to fulfil individually. Hence, the rationale behind most of best practices from V4 countries is based on timely and efficient response to these needs. Equally important is the personalization of services nurturing B2R and R2B collaboration and knowledge flow in clusters that go beyond.

Platforms provide basis for joint projects leading to new technologies that were identified as the most preferable procedure for nurturing R&D&I collaboration. In this case, both managers and researchers highlighted activities concerning networking between firms and RO/UNIV, with systematic approaches to monitor the needs and demand of members to cooperate. Maintaining cooperation between firms and RO/UNIV is also achieved through projects supporting student internships as part of human resources development within clusters. Best practices reflect on matchmaking events, which are crucial to align the needs and opportunities for members to advance R&D&I collaboration. Matchmaking events are regularly organized internationally to connect diverse stakeholders and support internationalization of clusters to participate in international projects i.e. Horizon2020, COSME, Interreg. Generally, the above-mentioned activities are crucial to for sustainable R&D&I collaboration with purpose to:

1) initiate;

2) develop;

3) maintain B2R and R2B in a wide-ranging way;

4) provide a stimulus to further enhance the collaboration.

Country reports provided many examples of B2R/R2B collaboration summarized below, some of them were identified as being temporary (project-based), and others permanent. Both temporary and permanent examples of B2R/R2B collaboration reflect on the role of platforms, joint projects, human resources development, and knowledge sharing as solutions that enable effective B2R/R2B collaboration and may be implemented on a wider scale. These examples reflect on motives, forms and factors conditioning B2R/R2B collaboration.

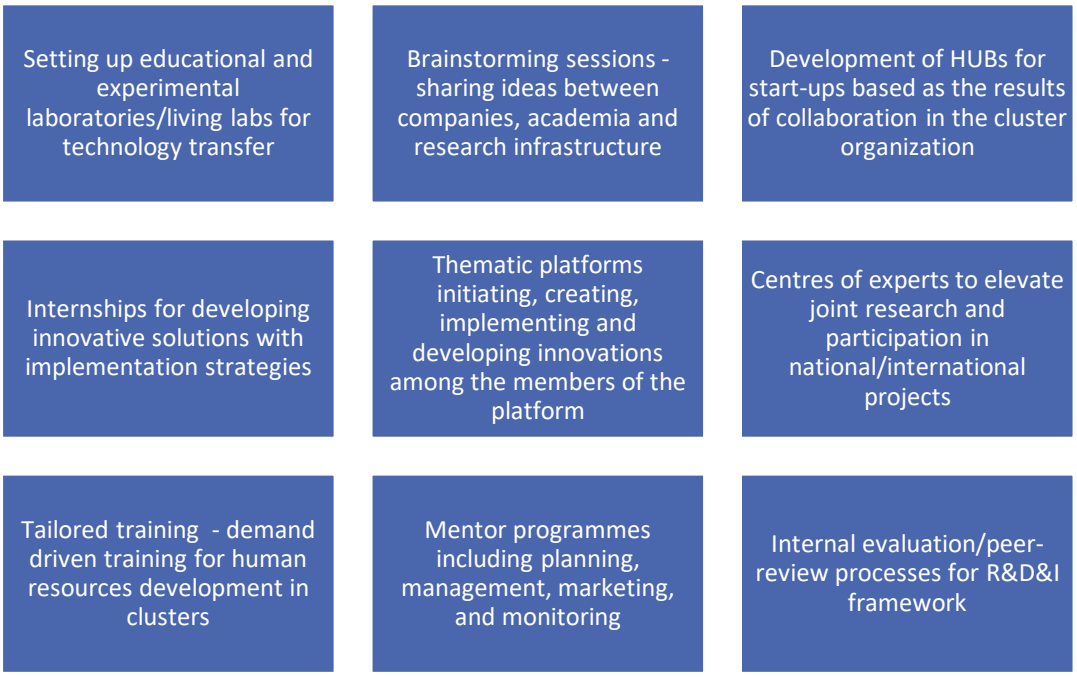


Figure 32. common features of best practices of B2R/B2R collaboration

Common characteristics of best practices were identified and selected with potential implementation across cluster organizations in V4 countries as following: selecting the best practices were:

- Systematic collaboration between companies and research organizations,
- Management and active role in initiating and maintaining the cooperation,
- Networking through formal and informal activities (workshops, conferences, fairs meetings, gatherings, round tables),
- Mobility of human resources (internships, mentoring, shadowing).
- Sustainable knowledge-sharing processes between members,
- Collective learning based on interactive platforms (HUBs, living labs),

The selected good practices are of a different nature and can be adjusted to the needs. More detailed best practices that were identified in V4 countries are presented below with the structure: 1) short summary, 2) details, 3) resources, 4) timescale, 5) results, 6) challenges, 7) potential for transfer.

Table 9. Description of best practice – Experts' centre

Detailed description	
Short summary of the practice:	Establishing the centre of experts (experts from both academia and industry) to generate R&D ideas and develop joint research projects
Detailed information on the practice:	Generating ideas for formal and informal meetings based on brainstorming/sharing ideas within the group of more than 80 companies, which eventually leads to identifying experts for specific research topics. Each research topic has an expert from industry and academia to combine practical and theoretical knowledge. This practice serves as a communication platform to share best practices in the automotive industry. Additionally, this practice addresses the lack of communication and cooperation between companies and research infrastructure (B2R/R2B) by establishing the centre of experts. The centre of experts helps to generate new project ideas for national/international project frameworks. The lack of systematic cooperation of B2R/R2B triggered the introduction of the practice, while the main stakeholders and beneficiaries of the practice come from both the private and public sector. Join research project combine expertise of practitioners and researchers to engage in R&D&I with matchmaking activities linking various stakeholders in the process. The Join platform serves as a tool to maintain contact between researchers with an outlook on real capacities and opportunities to engage RO in projects. The practice also revolves around mediating activities focused on needs of companies and opportunities for universities in joint activities.
Resources needed:	The financial resources used for the practice are negligible as the platform is financed by internal sources for meetings/gatherings. More importantly the practice revolves more around human resources to make it efficient, preferably linking diverse stakeholders from both private and public sectors to run the practice.
Timescale (start/end date):	Recurring practice that does not have a certain schedule, more frequent, the better outcomes from brainstorming/matchmaking activities.
Evidence of success (results achieved):	Generating projects to increase competitiveness of companies in the automotive industry under the Operational Programme

	Enterprise and Innovations for Competitiveness based on B2R & R2B cooperation in the cluster.
Challenges encountered	Overcoming organizational interests and culture, especially differences between private and public sectors (industry and RO/UNIV differences) along with organizational structures (differences concerning administrative structures). Matchmaking and pinpointing experts require human resources and mutual trust.
Potential for learning or transfer:	This practice can be implemented in clusters seeking the participation of various stakeholders (members) by setting up a similar centre of experts on specific topics for brainstorming/matchmaking ideas. Key success factors for a transfer are to tap into human resources of clusters and to create a common communication platform to share ideas and pinpoint specific topics for joint projects (internal, national, international). The lack of mutual trust/interest could potentially hamper practice. Additionally, this practice requires overcoming differences in organizational interests (differences in scope of activities firms/research organizations) and cultures (private/public sectors).
Keywords related to the practice	Matchmaking, experts, communication platform

Source: own elaboration based on interviews with cluster managers and research organizations

Table 10. Description of best practice – Demand driven training

Detailed description	
Short summary of the practice:	Demand driven “needle-type” trainings
Detailed information on the practice:	Needle-type trainings dig deep in a niche subject and train colleagues from cluster SMEs in that. The trainings are intense and short (~1 week duration). Areas in which the niche subjects are defined range from mobile application development; software development methodology, testing, quality control; back-end systems. The trainings are organised by the cluster management company based on the needs of SMEs. The training material is validated by the Faculty of Electrical Engineering and Informatics of the Budapest University of Technology and Economics that is a member of the cluster. Annually 2-4 trainings provided.
Resources needed:	Design, content development and launch had a cost of roughly EUR 100,000, annual running costs are around EUR 15,000

	depending on the number trainings. The cluster was successful obtaining grants for the development and launch of the trainings, nevertheless contribution from participating SMEs is requested.
Timescale (start/end date):	Recurring practice that does not have a certain schedule, more frequent, the better outcomes from brainstorming/matchmaking activities.
Evidence of success (results achieved):	Increasing interest from SMEs and successful initiative for human resources development. Demand driven trainings provide basis for capacity building.
Challenges encountered	Operationalization of the tool that needs to be implemented through a joint effort between different stakeholders. Inefficient use of the tool
Potential for learning or transfer:	The way the cluster management organisation reflected on cluster company needs is an important learning point. The type of trainings, the way they are organised may be transferred to other organisations too.
Keywords related to the practice	Training, HR development, skills

Source: own elaboration based on interviews with cluster managers and research organizations

Table 11. Description of best practice - Barometer of the business cycle

Detailed description	
Short summary of the practice:	Barometer of the business cycle
Detailed information on the practice:	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 cluster members. 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. 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 analysed 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.
Resources needed:	Depends on the scale of the tool and its features. Similar practices might differ in clusters due to operationalization, design, features and a standardized survey.
Timescale (start/end date):	Recurring practice that does not have a certain schedule but rely more on data availability and forecast methods that might be short/mid/long term.
Evidence of success (results achieved):	The tool gives the cluster manager a better picture of the directions/scope of support provided to cluster members. More informed (evidence-based) decision-making processes among stakeholders,
Challenges encountered	SMEs often face challenges concerning lack of skilled workforce, especially in knowledge/technology transfer. In many instances what is needed is a short but very intense training for would-be or current colleagues in niche subjects.
Potential for learning or transfer:	This practice can be implemented in clusters seeking the joint tool for diverse stakeholders (members) by setting up a similar tool. Key success factors for a transfer are to setup the tool. Additionally, it serves as a diagnosis and a forecast tool for assessment of demand across domestic and foreign markets, any planned reductions or downtime in production, and barriers to development.
Keywords related to the practice	Barometer, tool, methodology, forecast.

Source: own elaboration based on interviews with cluster managers and research organizations

Table 12. Description of best practice – Working groups

Detailed description	
Short summary of the practice:	Working groups for multistage discussion on R&D project with internal peer review (informal teams) linking stakeholders for international cooperation

Detailed information on the practice:	This practice addressed the issue of systematic collaboration between disconnected groups in the cluster. The context that triggered the practice is subject to the inability to connect professionals with expertise to develop R&D&I projects. The practice reached its objective by creating working groups combining practitioners, early career researchers, and doctoral students with internal and international meetings to set up consortium for projects. Additionally, it is implemented and developed by multistage discussions comprising 1) discussion (project ideas; 2) development of proposals; 3) implementation; 4) evaluation. The main beneficiaries of the practice are working groups developing R&D&I projects with internal peer review in an informal environment to international projects with diverse stakeholders. Furthermore, diverse working groups are based on networking and monitoring needs/demand of members to cooperate and develop new project ideas. The practice maintains complex R&D&I projects, establishing spin-offs and research capacities for joint research and projects for new technologies.
Resources needed:	The practice requires human resources in project management and capacity (especially project support to aid each process) in multi-stage discussions. Financial resources depend on the size, expertise, and location of working groups. Internationalisation of working groups and their activity requires internal funding that can eventually move to public funding from international projects.
Timescale (start/end date):	Depends on the scale of projects and internationalisation activities in R&D&I
Evidence of success (results achieved):	Active participation in H2020 projects with knowledge sharing in working groups, along with joint projects leading to new technologies and patents that would be difficult to achieve without cooperation between firms and RO.
Challenges encountered:	The practice requires networking and monitoring needs/demand of members. The challenge feature is reflected in the nurturing of an informal atmosphere and communication channels. Additionally, the practice is a long-term process consisting of multistage discussions/meetings, which require human resources (sharing employees between organizations) and time to accommodate differences in organizational processes and cultures. Overcoming barriers to mutual trust is essential to create a network of stakeholders for the sharing of knowledge and information sharing

Potential for learning or transfer:	The practice is potentially interesting for clusters aiming to develop internationalisation activities through international projects that require a diverse pool of stakeholders. This can be done through knowledge/employees sharing between companies and RO, linking industry with academic sector to create multi-stage processes of project development (firstly internal than international). A key success factor for practice is the informal environment and communication channels to establish and maintain working groups with regular internal meetings and peer review of project proposals. Internationalization in project reflects on sharing contacts and expertise (tacit knowledge in project development, implementation, evaluation) and systematic internal peer review processes to achieve research excellence in the long run.
Keywords related to the practice	Working groups, multistage discussion, peer review, informal environment

Source: own elaboration based on interviews with cluster managers and research organizations

Table 13. Description of best practice - Centre of Advanced Technology

Detailed description	
Short summary of the practice:	Centre of Advanced Technology
Detailed information on the practice:	Centre of Advanced Technology is a multi-purpose 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. Additionally, the platform serves as a tool to improve educational and research equipment to advance research activities. Advanced research is likewise reflected in organizing and developing educational partnerships for aviation-related specializations between universities, research units and enterprises in Poland and abroad, especially in Europe. This practice highlights the analysis of issues related to air transport and air traffic organization, to setup more detailed solutions for current problems related to the modernization and optimization of technologies used in the aviation industry. The Centre is dedicated to increasing and modernizing the technical capacity

	and securing the human resource capacity for the aviation and related industries (cross-sectoral collaboration).
Timescale (start/end date):	Long-term practice that requires coordination and active involvement of cluster management, strategic decision-making (reflected in cluster strategy), internationalization, and multi-stakeholder participation.
Evidence of success (results achieved):	Participation in EU projects, internationalization of advanced research, higher university/research infrastructure involvement in cross-sectoral collaboration in research, effective implementation and commercialisation of new technologies aimed at the aerospace industry through undertaking interdisciplinary activities.
Challenges encountered	Funding the centre and setting-up collaboration between members and pursuing interdisciplinary activities.
Potential for learning or transfer:	There are working groups in the Centre 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. The centre and cluster members collaborate in the field of student education – companies offer student internships, 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 concerning cross-sectoral collaboration.
Keywords related to the practice	Centre, capacity, advanced research.

Source: own elaboration based on interviews with cluster managers and research organizations

Best practices were identified to lay the groundwork for modification and implementation of processes to support B2R/R2B collaboration across cluster organizations in other V4 countries. Underlying reason to describe best practices in the report is to: 1) provide an overview on

diverse models of cooperation, and to 2) describe overcoming challenges and to tap into opportunities collaboration offers. 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.

6. Model of cooperation

The countries of the Visegrad Group, alongside with other Central and Eastern European (CEE) nations, are usually classified in the group of economies with developing national innovation systems, generally acting as innovation absorbers and technological followers rather than innovation creators and technological leaders. According to the most recent European Innovation Scoreboard, three countries of the Visegrad Group (Hungary, Poland, and Slovakia) are considered as "emerging innovators", while Czechia is a "moderate innovator" (European Commission 2021). All four countries perform below the EU average as performance of "moderate innovators" lies between 70% and 100% of the EU average and performance of "emerging innovators" lies below 70% of the EU average. Despite ongoing advancement, the V4 countries remain visibly less innovative than "strong innovators" and "innovation leaders".

An in-depth analysis of 12 dimensions of the European Innovation Index (Human Resources, Attractive Research Systems, Digitalisation, Finance and Support, Firm Investments, Use of information technologies, Innovators, Linkages, Intellectual Assets, Employment Impacts, Sales Impacts, Environmental Sustainability) leads to the following conclusion: V4 countries fall behind in most of them. The reasons behind relatively lower innovativeness of V4 countries are various. They include lower R&D expenditures (both in the public as well as in the private sector) as well as non-existent/weak linkages built around companies, which include relations established with the public sector (including research institutions and universities).

Building relationships between enterprises and research organizations is one of the imperatives to boost innovativeness of the V4 economies. Evidence suggests that clusters and cluster organizations can serve as a platform which fosters developing linkages between science and business as they create an environment which facilitates conducting collective activities. Analyzing the nature of cooperation established within cluster organizations may help to grasp the nature of processes which lead to effective cooperation. Models of such cooperation can then be disseminated to provide knowledge which can allow to better manage cooperation between science and business outside cluster organizations.

Through the conducted research the following **model of cooperation between business and research organizations (universities/research institutions) in cluster organizations** is proposed (see chart below). The model is composed of two main elements:

1) the **process of cooperation** (which includes cooperation motives, cooperation initiation, cooperation (including forms of cooperation), and cooperation effects/results);

2) the **framework of determinants** of cooperation (which includes cooperation factors (facilitators and inhibitors), funding, and government (EU/national/regional/local)).

Cooperation effects/results can be different in nature. Given their extent we can distinguish between: personal, organizational, and external effects. On the other hand, effects can be research-related, education-related, industry-related, and other. Cooperation effects/results are usually related to: knowledge transfer (human resources development), a new solution of

technical problem/issue (advanced techniques for manufacturing, more effective use of resources) and patents and industrial designs (for example: speed control device and zip line system equipped with braking and / or speed control device; method of stimulating the growth of insecticidal fungi and their pathogenicity to insects in biological plant protection; method of manufacturing wires of Cu-Ag alloys).

There are a number of innovations resulting from cooperation between firms and RO/UNIV managed by cluster organizations which were identified in interviews:

Carbon layer on implants	Use of cryogenic freezing operation to improve bending tools	Solutions for the protection of people and buildings against vibrations caused by rail traffic	Development of fire-resistant filter tannin for cabin
Development and implementation of pressure casting technology in innovative casting molds	Recovery of precious metals in the recycling of electronic scrap	Development of an innovative method of recovering pigment soot and plastics from used toners and electro-waste	New methods of advanced thermal barrier and environmental barrier coating deposition and characterization
Volcanic Ash Resistant Thermal Barrier Coatings for Jet Engines	Technology of biorefining vegetable oils for production	Development of an innovative method of recovering pigment soot and plastics from used toners and electro-waste;	An intelligent control system for a solar roller shutter powered by photovoltaic cells

The type and extent of results depend on previous phases of the process of cooperation. First, they are dependent on cooperation motives (their types as well as intensity). We propose to distinguish between the following types of **cooperation motives**:

- ➔ personal – e.g. extending the network, gaining expertise, etc.,
- ➔ intraorganizational – motives of research organizations include e.g. institutional access to funding or opportunities for commercializing research findings, while motives of business include e.g. access to research infrastructure (e.g. lab equipment),
- ➔ interorganizational – include motives which are shared by at least two actors,
- ➔ external – motives rooted outside research organizations and business.

Cooperation motives can lead to **cooperation initiation**. In general, cooperation between business and research organizations in cluster organizations can be initiated by different actors. We can identify the following modes of initiating cooperation:

- ➔ cooperation initiated by cluster organizations (including CO manager):

o CO2B – cluster organizations to business,

- CO2R – cluster organizations to research organizations,

  ➔ cooperation initiated by business,

- B2CO – business to cluster organizations,

- B2R – business to research organizations,

  ➔ cooperation initiated by research organizations (including researchers),

- R2CO – research organizations to cluster organizations,

- R2B – research organizations to business.

  ➔ other.

After the phase of initiation, cooperation can take many forms in cluster organizations. Cluster organization's management can but does not have to be involved in cooperation between companies and research organizations. However, it is frequent occurrence that cluster organization management is actively involved in this process in emerging cluster organizations. **Forms of cooperation** include: occasional cooperation, long term agreements (research organisations and universities are cluster members), technology platforms, alliances and endowed chairs and advisory boards.

After the phase of initiation, cooperation can take many forms in cluster organizations. Cluster organization's management and/or employees can but do not have to be involved in cooperation between companies and research organizations. However, it is frequent occurrence that cluster organization management is actively involved in this process in emerging cluster organizations. **Forms of cooperation** include: occasional cooperation, long term agreements (research organisations and universities are cluster members), technology platforms, alliances and endowed chairs and advisory boards.

Cooperation between business and research organizations which are members of cluster organizations can take place between a different number of actors and both sides – business and research. The cluster organization itself (CO management/ CO employees) can but does not have to be directly involved in it. Moreover, cooperation can take place with or without overlaps between the three elements presented in Figures 33–36. An overlap occurs when a person engaged in cooperation is simultaneously working in or associated with two types of entities (a research organization and an enterprise – Figure 34, a research organization and cluster organization management/ cluster organization bodies – Figure 35Figure 34, cluster organization management/ cluster organization bodies and an enterprise Figure 36).

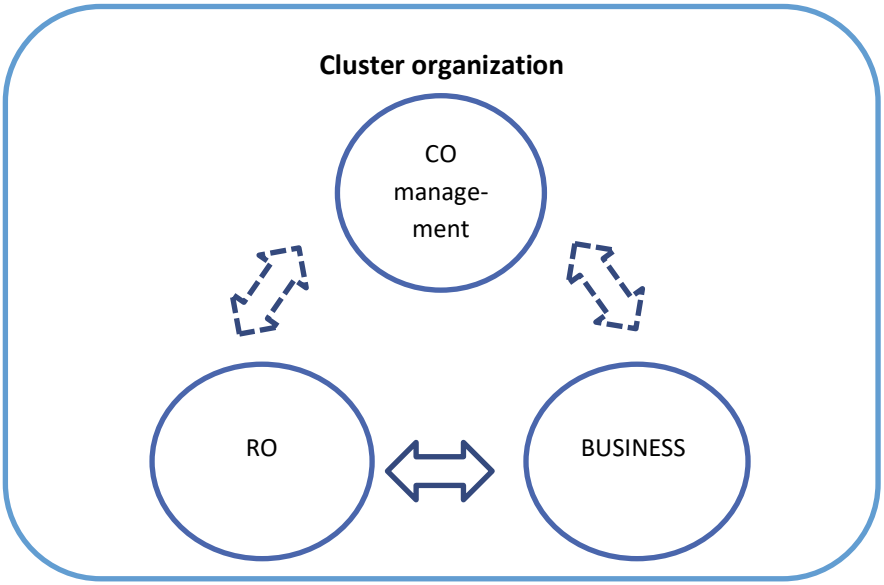


Figure 33. Cooperation between business and research in cluster organizations: no overlap

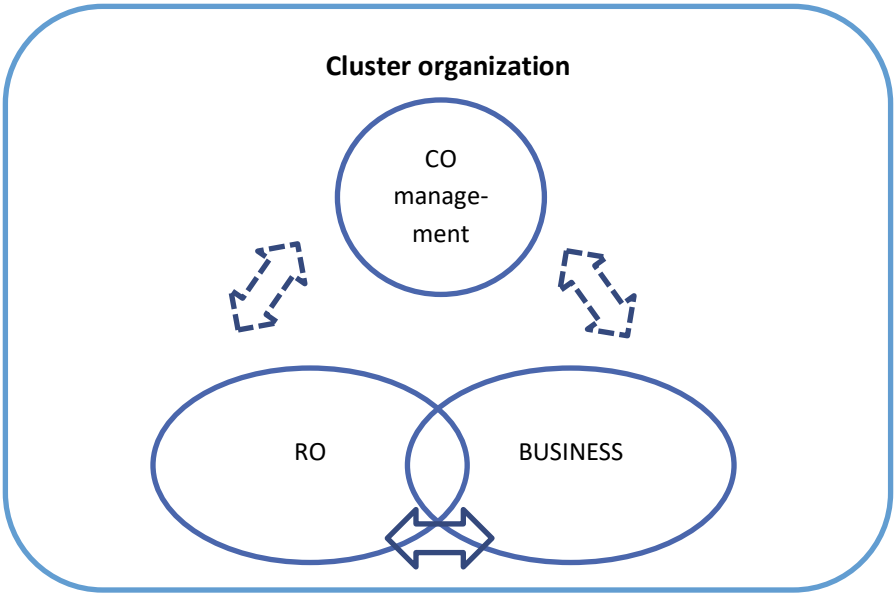


Figure 34. Cooperation between business and research in cluster organizations: overlap between research and business

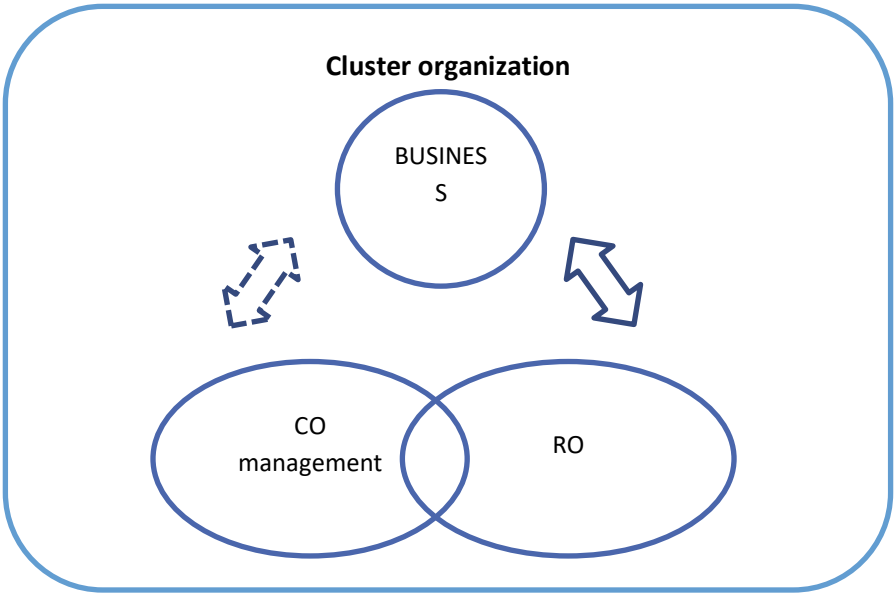


Figure 35. Cooperation between business and research in cluster organizations: overlap between research and cluster organization management/ bodies

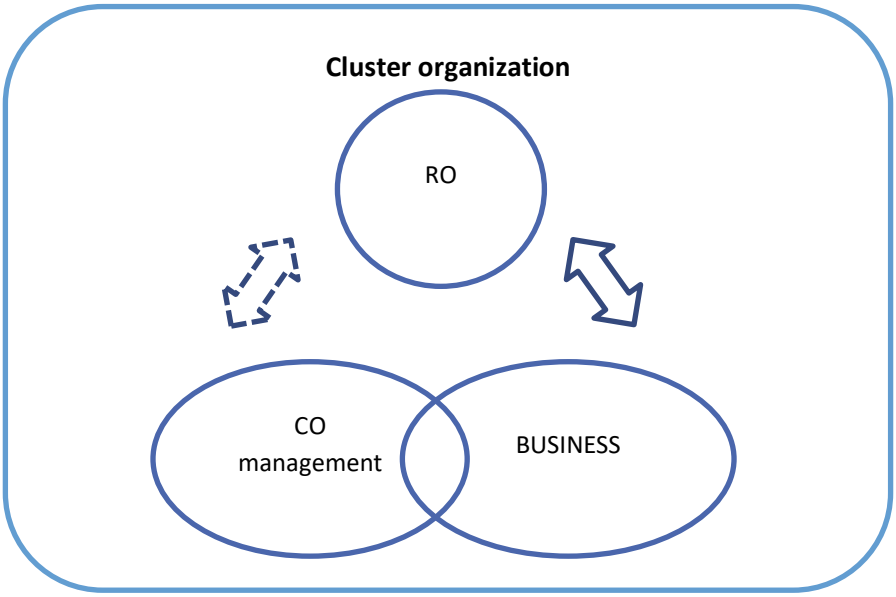


Figure 36. Cooperation between business and research in cluster organizations: overlap between cluster organization management/ bodies and business

The type and extent of results of cooperation are also dependent on the framework of

determinants – facilitators, inhibitors, funding as well as actions by the government (including but not limited to cluster policy, education policy, research policy, etc.).

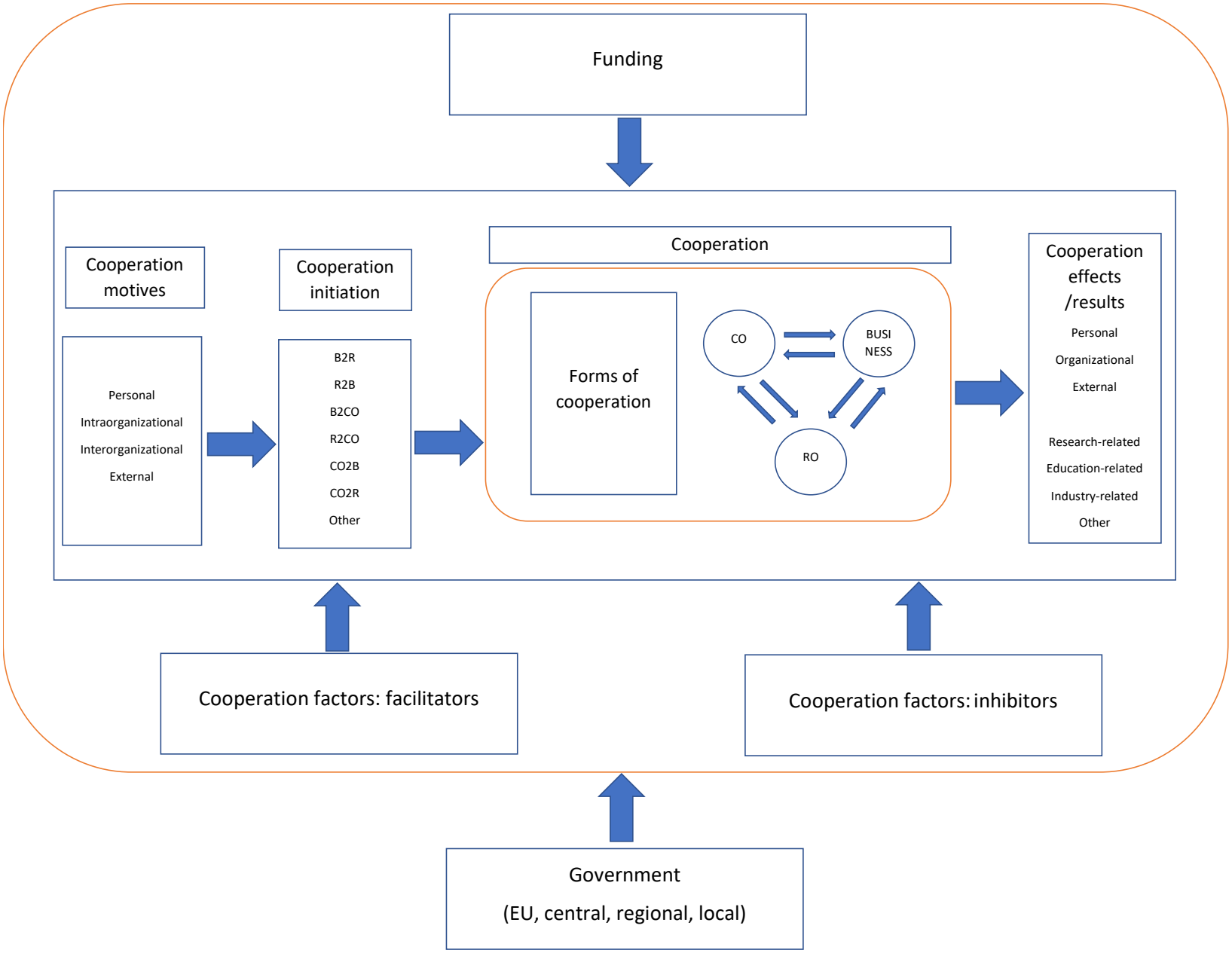
The most important **cooperation facilitators** are: mutual trust (and personal relationships) between cluster members and communication between cluster members.

Cooperation inhibitors include: cost of collaboration due to administrative overheads, organization structure (RO/university administrative structure and firm structure), organization interests and culture (differences between the world of RO/UNIV and industry).

Funding comes both from private and public sources: companies interested in some practical solutions that can be implemented in the production process or grants for R&D projects.

Government plays a role in creating the conditions for cooperation, in particular by designing instruments and funding schemes that encourage business – research cooperation.

Chart 1 Model of cooperation



B – business
R – research
CO – cluster organization (management, bodies or employees)

7. Concluding remarks and recommendations

One of the key problems of the innovation system in V4 countries is the 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 assumed by clusters organizations, which bridge the gap between enterprises and research institutions.

In Slovakia, the number of clusters has increased recently. Research has shown that this emergence has been driven mainly by a number of EU grants supporting the activities of COs. Our research has shown that B2R/R2B cooperation has mainly been affected in the last two years by the COVID-19 pandemic, mainly in the area of scientific research. COs that were used to working from home have not had huge problems with cooperation, but this was mainly in the IT sector. R2B/B2R cooperation is based mainly on personal relationships, but common conferences became a proven method for starting and expanding cooperation, where the RI and firms present their offers and requirements, and conditions were created for the development of such cooperation. Most collaboration was based on a request from one of the cluster members, most often solving tasks in connection with final theses. Different working cultures are often a barrier to cooperation between companies and ROs.

It is recommended to organize *innovation days* for the purpose of presenting the activities of individual companies and ROs, finding overlaps in mutual focuses and objectives, creating new collaborations, strengthening competitiveness, and networking. Another recommendation is to establish a data platform to create cooperation B2R/R2B to develop joint research projects.

In Hungary, clusters would like to be more the focus of innovation policy, and be entrusted with some assignments. They have gained a lot of experience by implementing numerous projects, but despite this do not play a significant role in the economy. Clusters are able to bring together business and research, but this is not exclusive to clusters. As there is no compromise on the role of clusters in Hungary, the results of the study can be used to present the potential of clusters to public authorities. Better coordination of policy between public institutions is needed as fragmentation of the cluster policy is hindering the process of cluster growth.

The situation in the Czech Republic is similar - there is a need for a holistic cluster policy. Public authorities can see clusters as important actors in the innovation policy, but this is not reflected in the national development strategies - there are no documents devoted solely to cluster policy, they are just mentioned in some national and regional strategies.

The results of the study in Poland 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. Clusters have entered a new stage of evolution in which, after engaging with partners chiefly at the local level, the time has come to build trans-regional and cross-border collaboration networks. Therefore, internationalization is becoming an important direction in the development of Polish clusters, which are going beyond their local frameworks for cooperation and are entering international collaboration networks.

Government support should focus on strengthening the scientific/research capacity and using it in actual business by promoting knowledge and technology transfer from universities to enterprises in clusters. Examples of 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.

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 using it in actual business by promoting knowledge and technology transfer from universities to enterprises in clusters.

The recommendations are presented in the tables below. The formulated recommendations were classified into three categories: recommendations for creating conditions for cooperation, recommendations for initiation of cooperation, and recommendations for the process of cooperation itself.

The starting point was consideration of the appropriate environment for establishing cooperation between science and business. Creating such conditions includes providing incentives to start cooperation and limiting barriers, the overcoming of which could require too much input in relation to the expected results. One such condition is enabling cluster organizations to use various support programs. First of all, there must be a wider awareness of what a cluster is and what legal forms it may take. The instruments identified at this stage include, for example, assistance in applying for funding from the European Commission, and grants for joint projects stimulating cooperation between enterprises and scientific institutions.

The next stage is initiating cooperation. Establishing partnerships between business and science is difficult due to completely different organizational structures (difficulty in reaching decision-makers in science sector institutions), as well as due to beliefs hindering cooperation on both sides (business and science). On the one hand, the scientific institutions are convinced that SMEs have little capacity for conducting research and development works, while enterprises believe that the costs of such cooperation are very high. Therefore, the initiation of contacts and the elimination of stereotypes is a factor that often determines the success of the partnership. The support offered at this stage may focus, for example, on the organization of science-business networking meetings. The proposed instruments are networking meetings, as well as typical promotional activities, such as fairs, science days, innovation festivals, etc.

Further stages of cooperation include joint development of a solution, and then its implementation in practice. In order for the cooperation to be effective, it is advisable to employ a person responsible for implementation in the team and a person responsible for mediation and resolving possible conflicts. An instrument that can play an important role is a special purpose vehicles in science sector institutions operating within a cluster organization. The special purpose vehicle should be managed by people with extensive business experience.

Table 14. Recommendations - Creating conditions for cooperation

Stakeholders responsible for implementing recommendation	Recommendation	Recommendation relevant for
Public authorities	Specifying long-term cluster policy at national and regional levels	CZ
Public authorities	Development of a system of tax reliefs for R&D activities conducted in consortia of research units and enterprises	PL, CZ
Public authorities	Adaptation of the rules for granting state aid to the functioning of consortia in the science sector and enterprises in R & D & I projects	PL,
Public authorities	Better coordination of policy between public institutions. There should be one public institution responsible for supporting clusters. Stronger involvement of clusters in policy making	HU, SK, CZ
Public authorities	Delegating to cluster organizations experts who have experience in developing applications for co-	PL

	financing for R & D & I projects in programs financed directly by the European Commission (e.g. Horizon Europe)	
Public authorities & science sector	Adoption of rules on intellectual property rights at universities, providing greater opportunities to protect intellectual property for scientists implementing R&D projects within clusters	PL, HU
Public authorities & science sector	Systemic regulation / marketization of the possibility of implementing contracts with scientists at universities, encouraging scientists to implement cluster projects within universities	PL, HU, CZ
Public authorities	Introducing support measures that result in the growth of clusters in terms of their membership	HU
Public authorities	Introducing direct and indirect support measures for the training of cluster managers	HU, CZ
Public authorities	Support for R&D activities should be primarily focused on accredited cluster organizations.	HU
Public authorities & Cluster manager & Science sector	Strengthening links between regional stakeholders with respect to regional innovation strategies (RIS3)	CZ
Public authorities & cluster manager	Conducting an information campaign aimed at making a wide range of stakeholders aware of what a cluster / cluster organization is	PL, CZ
Cluster manager	Promotion of best practice, e.g. Innovation days to present how business-science collaboration can work in a cluster organization.	SK, CZ
Cluster manager	Encouraging new members to join a cluster in order to build the potential for implementing public tasks and assignments from the government.	HU
Cluster manager	Convincing policy-makers that there is added value in clusters, e.g. organizing events and workshops to present the potential of clusters to public authorities	HU, CZ
Public authorities	Entrusting clusters with implementing public tasks and acting as quasi-intermediary bodies in key projects	HU

Public authorities & Science sector	Facilitation of clusters' and cluster members' participation in international projects	HU, CZ
Cluster manager & Science sector	Support of access to qualified HR through mobility programs (e.g. Internships, industrial PhDs)	CZ, PL
Public authorities , science sector & cluster manager	Prioritization of interdisciplinary R&D&I to stimulate science-business cooperation and identification of cross-sectoral opportunities in R&D&I	CZ
Public authorities , science sector & cluster manager	Using the sharing economy (costs, knowledge, resources, infrastructure, values...) concept to stimulate science-business cooperation	PL, CZ
Public authorities	Simplification of project documentation, minimizing administrative changes in the implementation phase, and lowering administrative burdens within support schemes/programs	CZ

Table 15. Recommendations - Initiation of cooperation

Stakeholders responsible for implementing recommendation	Recommendation	Recommendation relevant for
Science sector	Promoting greater interdisciplinarity in science and cross-industry cooperation	PL, HU, CZ
Science sector	Decentralization of decisions made in science sector institutions, e.g. through special purpose vehicles dedicated to cooperation	PL, HU, CZ
Science sector & Public authorities	Reduction of overheads on fixed / administrative costs in projects commissioned by cluster enterprises	PL, HU, CZ
Cluster manager, public authorities & science sector	Organization of science - business networking meetings (in the form of substantive meetings related to networking); e.g. brokerage events, innovation days	PL, HU, CZ

Stakeholders responsible for implementing recommendation	Recommendation	Recommendation relevant for
Cluster manager, Public authorities & science sector	Promoting and explaining the benefits of cooperation between units in the science sector and enterprises	PL, HU, CZ
Cluster manager	Initiating cooperation by directing inquiries about interest in solving a specific research / technological problem to all cluster members and forming task groups around topics. After selecting the interested parties - signing an NDA and closing the group of associates.	PL, HU, CZ
Cluster manager	Building awareness in a cluster organization - inviting people to take advantage of joint investments	PL, CZ
Public authorities	Facilitation of collaboration among clusters	HU, CZ
Public authorities	Support measures that help clusters become international (membership in international networks, international projects, international labelling)	HU, CZ
Cluster managers	Promoting long-term agreements among business and research in clusters	HU, CZ
Cluster managers	Making clusters active in European Digital Innovation Hubs	HU, CZ

Table 16. Recommendations - Cooperation and its results

Stakeholders responsible for implementing recommendation	Recommendation	Recommendation relevant for
Cluster manager	Promoting the achievements of cluster companies outside the cluster - building credibility of their activities	PL, HU, CZ

Science sector	Establishing self-financing special purpose vehicles managed by people with extensive business experience at universities / research institutes. The purpose of the activities of these companies would be to identify research work with commercialization potential and help in the commercialization of research results, e.g. through spin-off companies.	PL
Cluster manager	Drawing up an agreement that clearly defines the principles of cooperation, tasks and benefits for each party	PL
Public authorities	Providing a person responsible for mediation, resolving possible conflicts	PL
Public authorities, science sector & cluster manager	Parameterization of strategic goals (at the level of each type of entity participating in the cluster cooperation)	PL
Science sector	Working meetings, which increase trust between cooperating parties	PL, HU, CZ
Science sector	Interdisciplinary approach on the site of the university	PL, HU, CZ
Science sector & enterprises (cluster members)	Greater emphasis on the implementation of university R&D results and applications in industry	PL, HU, CZ
Public authorities	Introducing a cluster trademark for products/services developed through business-research cooperation in clusters	HU, CZ
Public authorities	Long-term institutional support for R&D&I – balancing institutional/project funding	CZ

Literature

- Ankrah, S., AL-Tabbaa, O. (2015). Universities—industry collaboration: A systematic review. *Scandinavian Journal of Management*, vol. 31, pp. 387-408. DOI: 10.1016/j.scaman.2015.02.003.
- Balog, M. (2015). *Klastrová politika v podmienkach Slovenska*. Bratislava: SIEA. ISBN 978-80-88823-62-9.
- Balog, M., Duman, P. (2010). Clustering - Presumption of success. Bratislava: SIEA.
- Bonarccorsi, A., Piccaluga, A. (1994). A theoretical framework for the evaluation of university—industry relationships. *R&D Management*, vol. 24, pp. 229-247.
- Breslin, Sh. (2002). *New Regionalism in the Global Political Economy*. London : Routledge. 257 p. ISBN 0-415-27768-X
- Burger, P. (2013). Klastre ako nástroj na zvýšenie konkurencieschopnosti regiónov v Európskej únii. *Region Direct*, vol. 6, iss. 2, pp. 4 – 28.
- Chen, E. Y. (1994). The evolution of university—industry technology transfer in Hong Kong. *Technovation*, vol. 14, pp. 449-459.
- Cohen W.M., Levinthal, D.A. (1989), Innovation and learning: The two faces of R&D, Economic Journal, No. 99, pp. 569-596.
- Davey, T., Meerman, A., Galan Muros, V., Orazbayeva, B. Baaken, T. (2018). *The State of University-Business Cooperation in Europe*. Brussels: European Commission.
- David, P. A., Metcalfe, J. S. (2008). "Only Connect": Academic-Business Research Collaborations and the Formation of Ecologies of Innovation. Stanford Institute for Economic Policy Research - SIEPR Discussion Paper No. 07-33. Stanford: Stanford University.
- Dicken, P. (2007). *Global Shift*. 5th edition. SAGE Publications Ltd. London. 2007. 599 p. ISBN 978-1-4129-2955-4
- Edgington, D.W. (2008). The Japanese Innovation System: University–Industry Linkages, Small Firms and Regional Technology Clusters. *Prometheus*, vol. 26, iss. 1. DOI: 10.1080/08109020701846009.
- Etzkowitz, H., Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and ‘‘Mode 2’’ to a Triple Helix of university–industry–government relations. *Research Policy*, vol. 29, pp. 109–123.
- Etzkowitz, H., Webster, A., Gebhardt Ch., Cantisano Terra, B.R. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, vol. 29, pp. 313–330.
- European Commission. (20017). *The Concept of Clusters and Cluster Policies and Their Role for Competitiveness and Innovation: Main Statistical Results and Lesson Learned*. [Commission Staff Working Document SEC (2008) 2637.] Brussels: Commission of the European Communities. ISBN 978-92-79-09838-3.
- European Commission. (2011). *Connecting Universities to Regional Growth: A Practical Guide*. Brusels: DG Regional Policy.

- Geisler, E. (1995). Industry—university technology cooperation: A theory of inter-organizational relationships. *Technology Analysis & Strategic Management*, vol. 7, pp. 217—229.
- Goyal, S. (2007), Connections: an introduction to the economics of networks, Princeton University Press, Princeton and Oxford.
- Harman, G., & Sherwell, V. (2002). Risks in university—industry research links and the implications for university management. *Journal of Higher Education Policy and Management*, vol. 24, 3pp. 7—51.
- Havierniková K. (2018). Regional dimension of cluster policy: case study Slovakia. In: *Proceedings of the 4th international conference on European integration 2018: ICEI 2018,* pp.422-429
- Haviernikova, K. (2016). The Identification and Classification of Risks in terms of Cluster Cooperation. In: *Proceedings of the 1st International Conference Contemporary Issues in Theory and Practice of Management: CITPM 2016*, pp. 130-136.
- Karlsson, Ch. (2007). *Clusters, Functional Regions and Cluster Policies*. [CESIS, Electronic Working Paper Series. 2007, No. 84.] Stockholm: Centre of Excellence for Science and Innovation Studies.
- Kowalski A.M. (2020), Towards an Asian Model of Clusters and Cluster Policy: The Super Cluster Strategy, Journal of Competitiveness, Vol. 12(4), pp. 74–90, DOI:10.7441/joc.2020.04.05.
- Kowalski A.M., Mackiewicz M. (2021), Commonalities and Differences of Cluster Policy of Asian Countries; Discussion on Cluster Open Innovation. Journal of Open Innovation: Technology, Market, and Complexity. 7(1): 21, DOI:10.3390/joitmc7010021
- Kowalski, A.M. (2022), Regional approach to innovation and the role of clusters. In: Kowalski, A.M. (Ed.), The Dynamics of the Innovation Divide between China and Europe. London: Routledge, pp. 21-47, DOI:10.4324/9781003199052.
- Krugman, P. R., Obstfeld, M., Melitz, M. (2014). *International Economics: Theory and Policy*. 10th Edition, New York: Pearson Series in Economics. Prentice Hall. 2014. ISBN 978-0133423648
- Lee, Y. (2000). The sustainability of university—industry research collaboration: An empirical assessment. *Journal of Technology Transfer*, vol. 25, pp. 111—133.
- Lukasík, N., Janovčík, M., Kavecký, J. (2007). *Príručka pre založenie klastra*. Žilina: Žilinská univerzita
- Nadabán, M., V. (2009). Clusters: Definition, tipology and characteristics of some clusters in the Észak-Alfold region- case study. 2009. 4th Aspects and Visions of Applied Economics and Informatics March 26 - 27. 2009, Debrecen, Hungary. 772- 779 s. [online]. [cit.2017-06-20], retrieved from: http://www.avacongress.net/pdf/230.pdf
- OECD. (2001). *Cities and Regions in New learning Economy*. Paris: OECD, 2001
- Oerlemans, L.A., Meeus, M.T., Boekema, F.W. (1998), Do networks matter for innovation? The usefulness of the economic network approach in analysing innovation, Tijdschrift voor economische en sociale geografie, Vol. 89, No. 3, pp. 298-309.

- Oliver, C. (1990). Determinants of interorganisational relationships: Integration and future directions. *Academy of Management Review*, vol. 15, pp. 241-265.
- Orazbayeva, Balzhan, Todd Davey, Carolin Plewa, and Victoria Galán-Muros. 2020. "Engagement of Academics in Education-Driven University-Business Cooperation: A Motivation-Based Perspective." Studies in Higher Education 45 (8): 1723–36. DOI:10.1080/03075079.2019.1582013.
- Pavelková, D. (2009). *Klastry a jejich vliv na výkonnost firem*. Praha: Grada Publishing, 2009. 272 p. ISBN 978-80-247-2689-2
- Pavelková, D., Bialic-Davendra, M., Jircikova, E., Homolka, L. (2013). Clusters' Activities and Economy Stage of Development: Evidence from V4 and Advanced Economies. *Ekonomický časopis*, vol. 61, iss. 2, pp. 187 – 205.
- Paytas, J., Gradeck R., Andrews, L. (2004). *Universities and the Development of Industry Clusters*. Pitsburg: Carnegie Mellon University, Center for Economic Development.
- Porter, Michael E. (1990). Clusters and the New Economics of Competition, *Harvard Business Review,* (November December 1990), pp. 77-90
- Powell, W.W., Grodal, S. (2005), Networks of innovators, in: J. Fagerberg, D.C. Mowery, R.R. Nelson, The Oxford handbook of innovation, Oxford University Press, pp. 56-85.
- Prno I. (2005). Klastre - nové nástroje ekonomického rozvoja In: *Marketing a obchod: Zborník z medzinárodnej konferencie*. Zvolen : Technická univerzita, 2005, pp. 314-318. ISBN 80-89029-97-3
- Ripoll Feliu, Vicente, and Anadairin Díaz Rodríguez. 2017. "Knowledge Transfer and University-Business Relations: Current Trends in Research." Intangible Capital 13 (4): 697. DOI:10.3926/ic.990.
- Rothwell, G., Rothwell, R., & Zegveld, W. (1985), Reindustrialization and technology technology. New York, ME Sharpe.
- Santoro, M. D., & Gopalakrishnan, S. (2000). The institutionalization of knowledge transfer activities within industry—university collaborative ventures. *Journal of Engineering and Technology Management*, vol. 17, pp. 299-319.
- Sölvell, Ö., Lindqvist, G., Ketels, Ch. (2003*). Zelená kniha klastrových iniciativ*. [online] [cit. 2016-01-14], retrieved from: http://www.czechinvest.org/data/files/zelena-kniha-klastrovych-iniciativ-64.pdf.

Figures

Tables

The project is co-financed by the Governments of Czechia, Hungary, Poland
and Slovakia through Visegrad Grants from International Visegrad Fund.
The mission of the fund is to advance ideas for sustainable regional cooperation in Central Europe.