MARKETING OF SCIENTIFIC AND RESEARCH ORGANIZATIONS, 2025, Vol. 57, Issue 3, p. 1–23
pISSN 2353-8503
eISSN 2353-8414

TECHNOLOGY INFRASTRUCTURES AS ENABLERS OF ABSORPTIVE CAPACITY: EVIDENCE FROM OF SMES IN THE EU AND POLAND

Marcin Kardas
Faculty of Management, University of Warsaw, 1/3 Szturmowa St., 02-678 Warsaw, Poland
E-mail: mkardas@wz.uw.edu.pl
ORCID: 0000-0003-4689-6458

DOI: 10.2478/minib-2025-0011

ABSTRACT

This study explores the role of technology infrastructures as enablers of absorptive capacity of small and medium sized enterprises within the European Union and Poland. The study investigates the key drivers motivating firms to use technology infrastructures, the barriers they encounter, and the measures that can help overcome these obstacles – considered through the lens of the key components of absorptive capacity: acquisition, assimilation, transformation, and exploitation. The study takes advantage of literature review, results of the survey and interviews conducted with users of technology infrastructures.

Analysis points out that drivers and barriers were very similar for Polish firms and those from other European countries, but several diffrences have also been observed. Polish enterprises identified opportunities to use technology infrastructures mainly in more advanced phases of research and innovation projects. They face barriers in accessing information about technology infrastructures, funding cooperation with its operators, and the confidentiality of research results.

The article seeks to apply the concept of technology infrastructures to the Polish context and to promote its awareness among organizations that operate technology infrastructures, as well as those responsible for innovation policy development at national and regional levels. The study links the main drivers and barriers associated with the use of technology infrastructures to examples of instruments that could address these barriers, aiming to improve their utilization and enhance firms' absorptive capacity.

Key words: technology infrastructure, research infrastructure, research orgnisation, innovation, absorptive capacity, innovation policy.

Type of the work: research article

Article History
Received: October 18, 2025 | **Revised:** January 13, 2026 | **Accepted:** January 14, 2026

1. Introduction

The history of technologies having a major economic or technological impact shows that technologies emerge and become established with important role of supporting infrastructure. The provision of highways, electricity distribution networks or cable networks have powerful effects in initating and driving many technologies. The knowledge infrastructure, compared to physical one, is often less tangible, more differentiated and specific, serving narrower constituencies and answering needs less clearly articulated. It also involves the articulation of new needs that can only be met through the generation of new capabilities within markets that have yet to be created (Morris and Teubal, 1995, p. 260). Historically, many major technological innovations were developed in government laboratories, publicaly-owned enterprises, univeristies equipped with modern knowledge infrastructures (Smith, 2005, p. 88; Smith, 2009, p. 89). However, the knowledge infrastructures can also be a source of valuable, external knowledge for firms and could help them to recognize the value of new, external information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990, p. 128).

For many years, knowledge infrastructure was referred as research or scientific infrastructure and linked mainly with large-scale and complex research facilities. The examples of such facilities, called also Big Science, are: The European Organization for Nuclear Research (CERN), The European Spallation Source (ESS), The European Space Observatory (ESO), International Thermonuclear Experimental Reactor (ITER). Research infrastructures on a European scale have been a subject of political intrest since the early 2000s with the launch of the Lisbon Strategy and the European Research Area. The intrest in European research infrastructure reflects in the new modes of coordination (the European Strategy Forum for Research Infrastructures – ESFRI and Roadmaps), the incentivization through generous financial schemes (the Framework Programmes) and the implementation of tailor-made legislation (specific legal framework the European Research Infrastructure Consortium - ERIC) (Cramer and Ruffin, 2025, p. 45).

In recent years, a new dimension of knowledge infrastructure has gained increasing prominence among European research organizations, industry stakeholders, entrepreneurs, and policymakers. It reffers to technology infrastructure, which encompasses facilities, equipment, expertise, and resources that are essential for the development, testing, scaling, and validation of technologies. Its scope ranges from research services at the pre-competitive applied research stage to large-scale demonstration and validation activities. The concept of technology infrastructure appeared in European policy documents in 2015 (EC, 2015) in the context of Key Enabling Technologies and in 2019 in Staff Working Document concerning technology infrastructures. Then it was included in many Europan political

documents (Viscido et al., 2022, p. 2). It was also popularised in reports and documents presenting case studies of technology infrastructure prepared by the European Association of Research and Technology Organisations (EARTO, 2022). Pararelly, it has been examined in several projects funded through European programs — such as the RITIFI project (RITIFI, 2025) — and has been the subject of discussion at numerous conferences, including the event jointly organized by the European Commission and the Łukasiewicz Research Network in Warsaw in May 2025 (EC 2025a). Most recently, technology infrastructure has been formally incorporated into „the European Strategy on Research and Technology Infrastructures" published by the European Commission (EC, 2025b).

The role of infrastructures, in particular technology infrastructures, seems to be very valuable for many countries and regions in strengthening cooperation between science and business, but also from the perspective of smart specialisation strategies as well as technological independence and sovereignty (EGTI, 2025, p. 43; Lewandowski and Falkowski, 2025, p. 26). It concerns situation in many Central and Eastern European countries facing challenges such as outdated or missing infrastructure for specialized research, weak cooperation among firms and research organisations, high pressure to spend budget funds effectively as well as exploiting synergies and complementarities between innovation policy instruments implemented at European, national and regional levels (EC, 2017, p. 15; Timofejevs and Avotins, 2020, p. 1547; Gittova K., Sipikal M., 2022, p. 648). However, the domain of technology infrastructure remains less clearly defined than research infrastructures and raises a number of unresolved issues. A central challenge concerns the boundaries between technology and research infrastructures, drivers and barriers associated with access to infrastructures and instruments supporting the use of infrastructures, especially by small and medium sized enterprises. This corresponds to the firms' ability to value, assimilate and apply new knowledge and its absorptive capacities. The literature on absorptive capacity discusses the impact of research and development activities on this capacity, but does not refer to the role of infrastructures, especially technology ones. The objective of this article is to address these ambiguities and contribute to a clearer understanding of the concept of technology infrastructures and their role as enablers of firms' absorptive capacity.

The article is structured as follows: part two provides a review of the relevant literature, part three details the research methodology, part four reports the empirical findings and the final sections offer a summary of discussion and conclusions.

2. Literature review

The infrastructures used for research and development are a central components of the national innovation systems (Smits, 2005, p. 103). However, they are not homogeneous category and include scientific or research infrastructures, technology infrastructures or industrial infrastructures (EGTI, 2025, p. 22). Among them research (or scientific) infrastructures are well recognized and widely described in the literature, mainly due to the popularity of large-scale and complex research facilities. One of the most popular definitions, used among others by ESFRI, indicates that research infrastructures are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Research infrastructures include major scientific equipment (or sets of instruments), knowledge-based resources such as collections, archives and scientific data, einfrastructures, such as data and computing systems and communication networks and any other tools that are essential to achieve excellence in research and innovation (Regulation, 2013). The main challenges facing research infrastructures, especially large-scale infrastructures, are among other fings engagement of users throughout the entire life cycle and strengthening their impact (ESFRI, 2021, p. 20; Ulnicane, 2020, p. 9).

Significantly fewer studies concern technology infrastructures. Tassey (1992, p. 10) defined technology infrastructure as the body of scientific, engineering, and technical knowledge accessible to private industry. It encompasses generic technologies, infratechnologies, and technical information, as well as data relevant to strategic planning and market development, mechanisms for collaboration, and frameworks for the allocation of intellectual property rights. Typically, technology originates outside the boundaries of individual firms and is disseminated through direct transfer, codification in standards, or institutionalized programs such as quality assurance systems. However, technologically complex infrastructures face significant challenges, most notably insufficient resource allocation, which stems from a limited recognition of their role in fostering long-term economic growth (Tassey, 2008, p. 10).

According to Justman and Teubal (1995, p. 260), technology infrastructure can be understood as a set of collectively provided, industry-relevant capabilities designed for application across multiple firms or user organizations. They distinguish between two ideal types of technology infrastructure:

- Basic or sectoral infrastructure, which primarily supports small and medium-sized enterprises (SMEs) engaged in low- to medium-technology activities, typically by delivering technological services through sectoral technology centers;
- Advanced or functional infrastructure, which serves high-technology, leading-edge firms by providing research and innovation inputs.

Both forms of technology infrastructure correspond to two fundamental governmental roles in its promotion: *market-building* and *capability creation*. The former involves fostering the capabilities required for the provision of technological services within the local economy—for example, by stimulating demand through awareness-raising initiatives and user-needs assessments, supporting the development of independent supply sources through learning-by-doing, training consultants, and facilitating the spin-off of independent consulting services. The latter role, capability creation, focuses on developing collaborative capacities among users. This may include promoting interaction, establishing temporary joint laboratories and research teams that integrate researchers from different organizations, encouraging information exchange, and undertaking parallel research and development activities in critical areas such as fine-processing equipment, with sub-teams led by different user groups (Justman & Teubal, 1995, p. 277).

Antonelli, Link and Metcalfe (2009, p. 6) indicates that technology infrastructure supports the design, deployment and use of both individual technology-based components and the systems of such components that form the knowledgebased economy. In narrow sense, technology infrastructure is a set of physical and virtual tools, methods, and data to conduct research and development as well as to control of production processes to achieve target quality and yield. In broad sense, it includes organizational or institutional forms that leverage knowledge creation and knowledge flows in technology developers and users, including research/science parks, incubators, university research centers, and focused public–private partnerships (Antonelli, Link, Metcalfe, 2009, p. VII).

Technology infrastructures have appeared in many European documents for the last few years. The reference to technology infrastructure was made in the smart specialization strategies as a part of a wider eco-system complementing research infrastructures and encompassing science parks, incubators, sectoral excellence centres, living labs, prototyping centres, intellectual property right (IPR) centres, technology transfer offices, etc. which often facilitate the commercialisation of research results into market applications (EC, 2012, p. 76). It appeared also in the context Key Enabling Technologies (KETs) and defined as „public or private organisations carrying out research and innovation in technology readiness levels (TRLs) 3 to 8 for one or more KETs (not necessarily the whole TRL range) and providing at least one type of technological service and infrastructure in one or more KETs to industry and SMEs that corresponds to a TRL equal to 5 or higher" (EC, 2015, p. 5). From this perspective, SMEs represent a "demand side" for the KETs expertise that technology infrastructures (the "supply side") need to respond to. According to Staff Working Document published in 2019 technology infrastructures are understood as „facilities, equipment, capabilities and support services required to develop, test and

upscale technology to advance from validation in a laboratory up to higher TRLs prior to competitive market entry. They can have public, semi-public or private status. Their users are mainly industrial players, including SMEs, which seek support to develop and integrate innovative technologies towards commercialisation of new products, processes and services, whilst ensuring feasibility and regulatory compliance". (EC 2019, p. 3). The reference to the above definition also includes the „European Strategy on Research and Technology Infrastructures", which indicates that the primary purpose of technology infrastructure is to boost industrial competitiveness through enabling and accelerating technological innovations towards societal/market adoption. It also presents the main barriers faced by industrial users when accessing technology infrastructures such as insufficient financial and human resources, asymmetry of information and cultural barriers (EC, 2025b, p. 13).

Given the purpose of technology infrastructures discussed in the literature and policy documents, it seems that technology infrastructures could serve to enhance absorptive capacity of firms. Absorptive capacity means firm's ability to value, assimilate and apply information towards commercial ends (Cohen and Levinthal, 1990, p. 128). It could also be defined as distinct but complementary capabilities including four components: acquisition, assimilation, transformation and exploitation (Zahra and Geogre, 2002, p. 189). Absorptive capacity depends on a firm's prior knowledge and skills and it's created as byproducts of a firm's R&D investment and manufacturing operations. However, it also depends on external sources of information like acquisitions, purchasing, through licencing and contractual agreements, interogranisational relationships such as research and development consortia, alliances and joint ventures. Firms could take advatage of external sources of information when there is a knowledge complementarity between firm's capabilities and these sources of information (Zahra and Geogre, 2002, p. 193). Technology infrastructures could help firms to recognize new information and take advatage of it. They could also maintain and diffuse elements of scientific knowledge or specific industry-relevant knowledge as well as help firms to identify technological opportunities, possible applications, their consequences and strategies requires to do them (Bergek, 2009, p. 122).

The relationships between R&D activities, knowledge transer and absorptive capacity are widely described in the literature (Lau and Lo, 2015, p.110; Miller et al., 2016, 386). However, issues related to technology infrastructure and absorptive capacity are rarely integrated and mainly limited to the use of infrastructure concerning information and communication technologies. There is a gap concerning the relationship between the role technology infrastructures as enablers of firms' absorptive capacity. It will be particularly interesting to learn about the motives why companies use technology infrastructure, the

barriers they encounter in this regard, the activities that can help them overcome these barriers and how it translates into enhancing firms' absorptive capacity (Viscido et al., 2022, p. 19).

Building on the prior research on the literature on technology infrastructures and absorptive capcity the following research questions were proposed:

Q1: What are the primary drivers of technology infrastructure use from the perspective of firms' absorptive capacity?

Q2: What are the main barriers associated with the use of technology infrastructures from the perspective of firms' absorptive capacity?

Q3: In what ways can the current system of support for technology infrastructures be organised to more effectively foster the absorptive capacity of enterprises?

3. Methods

The present study was exploratory in nature and aims to improve understanding of relations between the role of technology infrastructures as enablers of firms' absorptive capacity. The first step in the study was an investigation of current knowledge base, especially articles and reports concerning research and technology infrastructures. The sources of information on the articles were the Scopus and Web of Science databases. The results of the search in both databases is presented in Table 1.

Table 1. Publications related to research and technology infrastructures in Scopus and Web of Science databases.

Scopus (search within article tittle, abstract, keywords)		Web of Science (search within tittle, abstract, author keywords)	
words: "technology infrastructure" or "technological infrastructure" or "research infrastructure"	13232	words: "technology infrastructure" or "technological infrastructure" or "research infrastructure"	7372
limit to words: „facilities or facility or equipment"	1385	limit to words: „facilities or facility or equipment"	605
limit to subject area: „Business, Management and Accounting" and „Economics, Econometrics and Finance"	109	limit to WoS Categories: Management, Business, Economy, Operations Research Management Science	46

Source: Scopus and Web of Science.

Analysis of 109 publications from Scopus and 46 from WoS showed that most of them concern mainly information technology (IT) infrastructures or e-infrastructures. Only few of them relate to both categories: absorptive capacity and technology infrastructures, but even in these cases they concern IT infrastructure. Due to the small number of publications, a bibliometric analysis was not performed. These publications were supplemented by reports and documents published by the European Commission and EARTO, which were made available thanks to the author's cooperation with EARTO and participation in the European Commission Expert Group on Technoalogy Infrastructures (EGTI) as a Member.

The study takes advantage of data obtained from a survey on technology infrastructures organised by EGTI. Invitations to participate in the survey, launched on 19 August 2024, were sent through umbrella organisations, Member States contact points for ERA action 12 and disseminated nationally by Members of EGTI. The survey was open until the 30 November 2024. In total, 328 answers were received, including 5 from Poland. The survey consisted of 28 questions, which are presented in analitical report „User Needs for Technology Infrastructures" (EC 2025c, p. 52). The author obtained access to source data concerning Polish enterprises participating in the survey.

The number of enterprises from Poland that responded to the survey was too small to conduct quantitative research, therefore it was decided to conduct qualitative research to gain a better understanding of the responses provided by the respondents that completed the survey. For this purpose, in-depth 12 interviews with managers and employees from these enterprises were conducted (at least 2 from each). It was decided that, for the purposes of this study, only representatives of companies that completed the survey would be interviewed. The aim was to better understand the motives that prompted them to complete the survey and to clarify additional issues relevant to the research questions posed in the article. The interviews lasted from 30 to 90 minutes and were based on open-ended questions that allowed respondents to express themselves freely. All interviews were conducted in Polish, recorded with the respondents' consent, and subsequently transcribed for analysis. In addition, six short interviews were conducted with representatives of companies that did not complete the survey. The purpose of these interviews was to obtain information on why the survey had not been submitted. The research method used in this study allowed to capture the overview of the role of technology infrastructures as enablers of firms' absorptive capacity. It also provides a starting point for further research and more in-depth research in this topic in the future.

4. Results

4.1. General information about enterprises covered by the survey and interviews

The article takes advantage of the results of a survey conducted in 2024 by the European Commission and Members of the European Commission Expert Group on Technology Infrastructure (EGTI) to understand the industrial perspective on user needs for technology infrastructures. Among 328 responses were 208 SMEs or start-ups and 120 enterprises with more than 250 eployees. Table 2 presents the status of enterprises responding to the survey.

Table 2. The status of enterprises responding to the survey.

Status of enterprises	EU	Poland
SMEs (up to 250 employees)	149	4
Start-ups (younger than 5 years)	59	1
Enterprises with more than 3000 employees	54	0
Enterprises with 250-500 employees	27	0
Enterprises with 1000-3000 employees	23	0
Enterprises with 500-1000 employees	16	0
Total	328	5

Source: EGTI report.

Summary information about the enterprises is provided in Appendix 1. The Polish firms participating in the survey were small or medium-sized enterprises (up to 250 employees). One described itself as a start-up (established in 2021), but falls within the category of small and medium-sized enterprises. The other enterprises were established between 1984 and 2022 and did not identify themselves as start-ups in the survey. According to the information obtained in the interviews, all of them operated on the basis of simple organizational structures and flexible project teams ensuring good communication and quick decision-making processes. Their founders were involved in day-to-day operations as managers or supervisors. Four enterprises offer products or services to customers, while one is working on a product that will be available on the market as a finished product in a few years (with funding secured from external investors). From the perspective of the start-up life cycle (although only one identifies with it), these enterprises can be placed in the growth stage.

For three enterprises, the current main market was the domestic market, for one the regional market, and for another the European market. In turn, two enterprises indicated the European market as their target market, one indicated the regional European market (several European countries), and the remaining two indicated the domestic market. For the latter two, the domestic market is a starting point for expansion into the European market: one began its foreign expansion in 2025, while the other is launching a new product that will be offered on foreign markets from the outset. All enterprises indicated the need to enter new markets and acquire new customers, while three of them indicated the need to stabilize revenue generation.

Two enterprises operated in the electronics industry, two in the energy industry, and one in the metal industry. Despite operating in the same industries, the enterprises did not compete directly and their products/services concerned various segments of the electronics or energy market. All of them are planning or already implementing work in the field of artificial intelligence and Industry 4.0 solutions. All of them had their own research and development departments, employing from a few to a dozen or so employees. Research and development activities were usually carried out in the form of projects and based on matrix structures (selected tasks are also carried out by employees from other departments). Three of them carried out research and development activities mainly on their own, while two outsourced them to external contractors. Four enterprises indicated that they use technology infrastructure 1-3 times a year, allocating less than 20% of their research and development expenditures to this purpose.

4.2. The awareness about technology infrastructure

Among the surveyed enterprises, 122 repondents (37% of total answers) indicated that they were familiar with the concept of technology infrastructure and had knowledge of the available infrastructure. In turn, 104 (32% of total answers) enterprises had knowledge of the infrastructure corresponding to their needs, but were not familiar with the concept of technology infrastructure, 65 (20% of total answers) enterprises indicated that they were familiar with the concept, but had no knowledge of the infrastructure available to them, and 37 (11% of total answers) were not familiar with the concept and had no knowledge of the infrastructure (EGTI, 2025, p. 11).

Three of the Polish enterprises participating in the survey indicated that they were familiar with the concept, but did not have information about the technology infrastructures available for them. The interviews confirmed that the managers of these enterprises have extensive knowledge of European-level activities resulting from their involvement in project consortia or European partnerships, which explains their familiarity with the concept of technology infrastructures. In turn, two enterprises indicated that they

have information about technology infrastructure relevant to them, but are not familiar with the concept of technology infrastructures. One of the interviewees explained that his company has been cooperating with universities for many years and, from his perspective, the terminology (i.e. research or technology infrastructure) is a secondary issue. Another interviewee pointed out on the practical benefits of the concept of technology infrastructure, which could help identify those areas of activities at universities and institutes that are closest to cooperation with enterprises and, through appropriate support, contribute to its improvement: "Universities and institutes are large organizations, and not all scientists who work there need to cooperate with business, but it would be good for enterprises to know which of them are ready and open to such cooperation and are prepared for it." [C1].

The interviewees also pointed out that, from their perspective, the poor availability of information about the infrastructure and the rules for using it is a major obstacle to its use. They usually get information about infrastructure based on many years of cooperation, but it is much more difficult for them to find such information about universities and institutes with which the enterprises have not had any previous contact. One interviewee pointed out: "Information about the equipment is scattered and incomplete, which makes it difficult to figure out who can specifically help us, when, and with what. There is no single place where we could find out what different institutes have to offer." [D1].

Among Polish enterprises, four ipointed out that they used technology infrastructures, while one responded that it did not use technology infrastructure due to lack of knowledge about such infrastructure available in Poland in the field of its activities. This company outsources research work to other entities operating abroad. According to the information obtained during the interviews, this is due to the highly specialized knowledge and experience that the company needed and which was not available at Polish universities and institutes, but the company planned to include Polish universities and research organisations in its cooperation in the future.

4.3. The reasons for using technology infrastructure

The enterprises that indicated in the survey that they use technology infrastructure (264 or 80% of total answers) cited the following as the main reasons for using it: development of new technologies, methods, products, processes, and solutions they are working on (253, 77% of total answers), testing products or processes in an environment close to real life conditions (239, 65 of total answers), increasing competences to be able to adopt new technology (233, 61% of total answers), and performing some tests on their products manufacturing methods and processes (232, 60% of total answers). Enterprises that did not use the technology infrastructure indicated that this was due to a lack of

knowledge and information about this infrastructure, remote distance, difficulties with access, lack of adequate resources, or more favorable conditions for conducting tests directly at their customers' premises (EGTI, 2025, p. 13).

Among the five Polish enterprises that completed the survey, one indicated that it does not use technology infrastructure because it lacks knowledge about the availability of infrastructure that could address its needs. This is due to the fact that the solutions the company is intrested in "[…] are innovative on a global scale, and we are currently unaware of any center that would be able to comprehensively meet our needs. To our knowledge, such infrastructure is not currently available in Poland or Europe." [E1]. Nevertheless, the company does not rule out using the infrastructure in the future, provided that it meets its needs.

The four remaining Polish enterprises pointed out that they use technology infrastructure and indicated as highly necessary for testing products or processes in an environment close to real life conditions (4 responses) and for making products and/or processes comply with standards (3 responses). Compared to all enterprises, Polish enterprises indicated less interest in the needs related to the development of new technologies, methods, products, processes, and solutions, as well as the development of prototypes. During the interviews, representatives of enterprises explained that they work independently on the development of new products and processes, while the use of technology infrastructure takes place at later stages of product launch, especially testing and adaptation to standards: "We worked independently on the development of our product and did not need the help of an external organisations. However, it was useful when we already had an advanced product and needed to test it outside our laboratory. In this respect, the assistance [...] was very helpful." [D1]. Compared to the other respondents, Polish enterprises indicated a lower needs to increase the competences, which was largely due to the high assessment of the current level of knowledge and competence of employees. One of the enterprises explained in an interview: "We have qualified employees who have been developing our technology for years [...], and the solutions we are working on are so niche and require such specialized knowledge that currently none of the academic centers or institutes in Poland have it." [B1].

All Polish enterprises participating in the survey planned to develop products or new technologies within the next two years and to use technology infrastructure. However, they indicated that there is insufficient technology infrastructure to address their needs or that they are unaware of its existence.

4.4. The forms of access to technology infrastructure

The most popular form of access to technology infrastructure among the surveyed enterprises (273 answerd to the question) was collaboration with research organizations and/or universities hosting technology infrastructure, followed by own testing and scale-up facilities and participation in collaborative projects (EU, regional, national). Less popular forms of using technology infrastructure were direct procurement of research and technology services (research contracts) from technology infrastructure hosts, paid access to facilities on market terms, use of the services of intermediaries to get acces to facilities and through publicly supported schemes (e.g. using innovation vouchers or through specific programs) (EGTI, 2025, p. 16).

For the Polish enterprises, the most common form of access to technology infrastructure was collaboration with research organizations and/or universities hosting technology infrastructure. However, next came direct procurement of research and technology services (research contracts) from technology infrastructure hosts, which were less popular among foreign enterprises. As one of the interviewees pointed out: "Research contract is a very attractive form of cooperation for us, as we clearly define what we want to receive from the university or institute and when. We also have secured intellectual property rights, which remain on our side and, in the case of research, are transferred to us." [D2]. Another interviewee pointed out: "Cooperation on joint research projects is a big challenge, while contract research is much faster and simpler for us. When we use funding, we have to follow procurement procedures, but even so, from my perspective, they are faster and simpler than negotiating joint projects and then writing proposals, especially with several consortium members." [B1]. One of the interviewees explained that the popularity of research contracts may also result from the funding rules for research projects in Poland: "Many calls published by the National Centre for Research and Development or Polish Agancy for Enterprise Development are addressed only to enterprises, and even if we wanted to form consortia, there is no formal possibility to do so, and the only form of university involvement in these projects is to purchase research services from them." [B2]. Another interviewee pointed out: "Often when we obtain a large foreign contract, only one entity can participate in the procurement procedure, not a consortium, and then we have no choice. If we want to cooperate with universities or instituties, we take advanateg of contract research." [A1].

At the same time, two Polish enterprises indicated that they do not intend to use access to infrastructure through publicly supported schemes in the near future. In interviews, they explained that the reasons for this are excessive bureaucracy associated with obtaining and accounting for support: "When our customers are interested in a new product, we cannot wait for a call to be launched and then for the application to be

evaluated, with the risk that we may not receive the support in the end because we fill incorrectly some fields in application. We have to act quickly and efficiently because that is what our customers expect from us." [D1]. The second interviewee pointed out, "We operate in the European market, where quality and timely delivery are what count. National calls are complicated, and even small grants require the engagement of significant resources to obtain them. We don't have the time and money for that." [A1].

4.5. The barriers to access to technology infrastructure

Among the main barriers to access to technology infrastructure, the surveyed enterprises primarily indicated two challenges: lack of financial resources and lack of staff within the enterprise. Lack of financial resources was primarily reported by SMEs and start-ups (69%), and to a lesser extent by large enterprises with more than 250 employees (47%). In turn, large enterprises indicated lack of staff within the enterprise (42%) and fear of losing research and development results and industrial secrets (44%) or legal issues like IPR (38%) as barriers to a greater extent than SMEs and start-ups (respectively 30%, 21% and 18%) (EGTI, 2025, p. 17).

The main barriers to accessing technology infrastructure identified by Polish enterprises are:

- lack of financial resources (4 enterprises),
- legal issues and fear of losing control over own IPR results (3 enterprises),
- lack of staff within our enterprise (2 enterprises).

The responses of Polish enterprises are similar to those provided by small and medium-sized enterprises and start-ups from other countries. According to the access to finance, three Polish enterprises took advantage of public funding to develop new products and services, mainly domestic and regional. They acted as leaders and partners in these projects. Of the remaining two enterprises, one is considering obtaining funding in the near future, while the other indicated that it does not use and does not plan to use funding at the national and regional level. Among the main challenges related to obtaining funding, firms indicated the need to provide own contribution (in cash), the complicated process of preparing applications, and the long application evaluation processes. Three respondents stressed that in the future they will focus on obtaining international projects, because despite high competition and low success rates, the application evaluation process is, in their opinion, more transparent and faster. [A1].

One of the enterprises also pointed out the following barriers related to access to technology infrastructure: lack of the required expertise or support in the field of technology to be taken into account, geographical proximity of the appropriate technology

infrastructure for company, outdated or insufficiently modern equipment, lack of resources within the technology infrastructure to support the industry/our company. The interview explained that these result, among other things, from the geographical presence of the company, which is located in a considerable distance from major academic and research centers.

During the interviews, other barriers to accessing university and institute infrastructure were also pointed out, resulting from regulations concerning the system of evaluating scientific results in Poland: "Sometimes it is difficult to encourage them to cooperate because they have other priorities and activities, such as scientific publications. We are not interested in this, and often disclosing information is problematic for us, while scientists are held accountable for this and it is sometimes difficult to convince them to give up publishing." [D2].

4.6. The actions to increase the access to technology infrastructure

The results of the survey suggests that the most useful options to increase the usage of technology infrastructure depend on the size of the responding enterprise. For SMEs and start-ups the most important was better knowledge of/insight into the offering of technology infrastructures (60% answers from 208), but above issue among larger enterprises is of less importance (only 5% answers from 120). SMEs and start-ups are also more intrested in funding to purchase access to technology infrastructures than larger enterprises (48% versus 22%). On the other hand, larger enterprises are more intrested in „one stop shop" access point than SMEs or start-ups (63% versus 37%). This confirms observations that large enterprises seek to overcome administrative barriers in accessing technology infrastructure, while SMEs have less experience in working with technology infrastructures and need information and financial support for that (EGTI, 2025, p. 20).

Among the measures that could contribute to better use of technology infrastructure, Polish enterprises primarily pointed to better knowledge of/insight into the offering of technology infrastructures (equipment, capabilities, services). During the interviews, it was explained that although databases containing descriptions of research equipment and services are available, they often relate to individual universities or institutes and vary in terms of content, often presenting mainly detailed technical parameters of the equipment. As a result, there is no single database presenting the research equipment and apparatus available in Poland and the services that can be provided by universities and institutes. One of the interviewees pointed out: "Several universities offer well-developed catalogs of services and available equipment. They provide contact details for technology brokers or researchers. This significantly speeds up the process of obtaining information, but it only applies to a few universities, and only the largest ones." [D1].

Among other factors that could facilitate access to technology infrastructure, Polish enterprises pointed to:

- geographical proximity of technolog infrastructure with fitting offer (or help in using/collaborating on further distance) (2 enterprises),
- services from/cooperation with higher education institutions, related to technology development, testing and scaling up (2 enterprises),
- a "One stop shop" access point (for technology infrastructure and related services) (2 enterprises),
- training (development of skills) (2 enterprises),
- funding to 'purchase' access to technology infrastructure (1 enterprises).

According to the survey, two types of services were highly needed by European enterprises to enhance its capabilities to innovate: support to develop new technology, method, product, proces, solution (145 answers, 44% of total answers) and support to test products or processes in an environment close to real life conditions (131 answers, 40% of total answers). For all other types of services listed, the positive replies significantly outnumber the neutral or negative ones (EGTI, 2025, p. 22). In turn, Polish enterprises pointed to support to make products and/or process(es) comply with standards, legal norms, or similar as well as to perform some tests on product(s) manufacturing methods and/or process(es). The least interest was shown in acivities dedicated to increase the competences of companies to adopt new technology and/or automate industrial production. These responses were consistent with their earlier statements regarding the reasons for using the technology infrastructure. The Polish enterprises participating in the study developed new products or processes independently and based on internal resources, while support from technology infrastructures was desired during the testing and market launch phases of new solutions. The lower interest in support for competence development among Polish enterprises participating in the survey results, among other things, from the fact that enterprises have qualified employees and implement staff development activities based on their own resources or take advantage of personnel support programmes offered by various national and regional agencies. One of the interviewees pointed out: "Currently, there are many opportunities to take advantage of support in the field of human resources development offered, for example, by the Polish Agency for Enterprise Development or the Marshal's Office. However, our products are so niche that it is difficult to find valuable external training, so we mainly educate ourselves through internal workshops and daily work." [B1]. Another interviewee explained: "The stage of development we are at now does not require hiring additional employees, but we may need them in the future. That is why we are constantly expanding our network of contacts." [D1].

5. Discussion

The primary goal of technology infrastructure is to "accelerate technological innovations toward societal and market adoption while promoting industrial competitiveness" (EGTI, 2025, p. 24). From this perspective, the concept of technology infrastructures is familiar with initiatives designed to strengthen firms' absorptive capacity. Table 3 provides a summary of the analysis regarding the components of absorptive capacity (acquisition, assimilation, transformation, and exploitation), as well as the motives for using technology infrastructures, the barriers to accessing them, and the instruments available to overcome these barriers.

Table 3. Components of absorptive capacity from the perspective of motives, barriers and instruments related to technology infrastructures.

	Motives	Barriers	Instruments
Acquisition	Identify and acquire externally generated knowledge	Lack of or scattered information about infrastructure available to firms	Mapping of technology infrastructures to promote information about them
Assimilation	Analyze, process, interpret, and understand the information obtained from external sources	Difficult to understand and replicate context and specific knowledge	Innovation vouchers to test ideas Mobility schemes
Transformation	Combine existing knowledge and the newly acquired/assimilated knowledge	Lack of knowledge and skills how to combine information	Workshops with firms Advisory services Trainings
Exploitation	Harvest and incorporate knowledge into firms' operations	Lack of finanse Fear of losing control over own IPR	Collaborative research projects Innovative public procurements IPR services including patent protection

Source: Own elaboration based on Zahra and George (2002, p. 189) and the results of interviews.

It appears that Polish enterprises are interested in utilizing technology infrastructures; however, there is a lack of accessible information about them. The interviews confirmed that establishing a database of such infrastructures would be highly beneficial in facilitating cooperation between enterprises and technology infrastructure providers. Interviewees cited examples of Polish universities that maintain clear and up-to-date offers for infrastructure access and related services, though these cases are isolated and there is no systematic, nationwide approach in this area. They also emphasized that the first step of mapping technology infrastructure should involve developing a methodology for inventorying existing infrastructures. The database should be accompanied by transparent rules for access—ensuring openness, non-discriminatory use, and adaptability for diverse users, which could help firms more effectively identify and acquire externally generated knowledge.

An interesting finding from the survey and interviews is that Polish firms, compared to those in other countries, tend to show greater interest in using technology infrastructures during the later phases of the innovation process, while demonstrating less engagement in the early phases, such as research and development activities. The Polish firms participating in the survey placed more emphasis on testing products or processes under near-real conditions and on ensuring compliance with standards, whereas they tended to develop new products and services independently. According to the opinions of respondents, it resulted from the lack of adequate and valuable knowledge offered by infrastructure providers, which is essential from the perspective of the development of new products and processes. On one hand, this highlights the crucial role that the competences of infrastructure providers in effectively utilizing these facilities (skills and competences are just as important as equipment). On the other hand, it reveals a mismatch between the services offered by technology infrastructures and the actual needs and expectations of firms. To overcome these barriers to cooperation, instruments such as small grants for the rapid verification of technological concepts and ideas proposed by companies, as well as programs supporting mobility and staff exchanges, could be beneficial. A notable example is ESA BIC Poland, which provides grants and support for startups developing space-related business ideas—offering up to €50,000 in non-repayable funding for business, technical, and legal assistance, along with access to office space and an international network of partners and incubators.

Facilities and equipments are only tangble elements of technology infrastructures, while intangible elements such as the knowledge and skills of the employees who operate and use it on a daily basis are of key importance from the perspective of its utilization by firms. Referring to the idea of absorptive capacity, the use of external sources of information by firms requires appropriate knowledge and skills on the part of both firms and technology

infrastructures. This presents a significant challenge for technology infrastructure operators, who must not only modernize and maintain their facilities and equipment but also focus on developing the skills and competences of personnel responsible for operating the infrastructure and conducting research. In terms of typology proposed by Justman and Teubal (1995, p. 260), the results of the study suggest that local technology infrastructure available for firms does not meet the needs of *capability creation* (high-technology firms), but rather delivers technological services valuable for *market-building* (low-medium technology activities).

Both European and Polish enterprises primarily identified a lack of financial resources, legal challenges, and concerns about losing control over intellectual property rights as major barriers—issues that are particularly significant for the exploitation component of absorptive capacity. These challenges could be addressed through programs that fund collaborative research projects and offer support for research and intellectual property rights (IPR) services. However, insights from the interviews reveal that Polish companies often encounter administrative constraints, such as the labor-intensive process of preparing project proposals, as well as cultural barriers, including conflicting goals and expectations between firms and researchers. Firms highlighted the importance of securing demand for their products or services, which suggests the need to consider a broader use of innovative public procurement in the future as an instrument to stimulate demand and support innovation-driven growth of companies.

This article is among the first to explore the topic of technology infrastructures in Poland. The research conducted is therefore exploratory in nature and subject to several limitations. The survey results should be interpreted with caution, as they were dominated by small and medium-sized enterprises (SMEs), whose responses differed from those of large firms. The Polish participants in the survey consisted exclusively of SMEs and start-ups, and only five enterprises ultimately took part. All of these firms were engaged in R&D activities and possessed considerable experience in conducting research projects. The small Polish sample and the qualitative nature of interviews limit the possibility of generalising results and they should be treated as a hypothesis for a more comprehensive study. For future research, it would be valuable to include larger group of firms including those that do not conduct R&D activities, in order to better understand the barriers they perceive and the measures that could encourage them to utilize technology infrastructures. To investigate the reasons for low response rate to the survey among Polish firms (the survey was distributed to several dozen Polish firms, only five responses were received), short interviews were conducted with six companies. One cited technical difficulties in submitting the survey, while the remaining five explained that, after reviewing the survey, they found the survey was not relevant—or only partially relevant—to their operations,

and therefore chose not to fill in it. In light of these findings, it would be advisable to raise awareness about technology infrastructures and repeat the survey with a larger and more diverse group of Polish enterprises, particularly large companies.

6. Conclusions

This article aims to apply the concept of technology infrastructures to the Polish context and to raise awareness among organizations that manage technology infrastructures, as well as those responsible for national and regional innovation policy development. The study connects the main motives and barriers related to the use of technology infrastructures with examples of instruments that could address these challenges, with the goal of improving their utilization and enhancing firms' absorptive capacity.

Taking into account the limitations of the study discussed above, it can be pointed out that the drivers and barriers associated with the use of technology infrastructures were very similar for Polish firms and those from other European countries. However, several differences were identified from the perspective of Polish firms:

- collaboration focused primarily on more advanced phases of research and innovation processes (e.g. testing products or processes in environments close to real-life conditions),
- a lower perceived need to enhance competences, largely resulting from a high self-assessment of employees' existing knowledge and skills,
- research contracts being a particularly common form of collaboration with technology infrastructures,
- the need for improved awareness and understanding of the technology infrastructure offer available in Poland,
- administrative constraints, such as the labor-intensive process of preparing project proposals (national and regional levels), as well as cultural barriers like conflicting goals and expectations between firms and researchers (i.e. resulting from the evaluation criteria).

The concept of technology infrastructures is a relatively new in Poland, although the construction, maintenance, and the use of research infrastructure has been a topic of discussions for many years. In Poland, as at the European level, these discussions have focused mainly on the so-called large-scale research facilities included in the Map of Polish Research Infrastructure, as well as Poland's participation in ESFRI projects. Nevertheless, in many universities and research institutes, research infrastructures have been thoroughly modernized and upgraded, mainly due to European funds and operational programs such

as Integrated Regional Development Programme (2004-2006), the Operational Programme Innovative Economy (2007-2013), the Operational Programme Smart Growth (2014-2020), the European Funds for Smart Economy (2021-2027), Regional Operational Programmes, and the National Recovery and Resilience Plan. Therefore, the concept of technology infrastructures can be applied to a wide range of facilities and equipment financed under these programs, facilitating more effective collaboration with firms and supporting the enhancement of their absorptive capacity.

Although the concept of technology infrastructure is relatively new, it builds on initiatives that are already well established at the national and regional levels, such as smart specialization strategies and Key Enabling Technologies, which can help facilitate its practical implementation. From this perspective, it also constitutes a promising area for future research and practical application of the concept by national and regional organisations responsible for research and innovation policies.

References

Antonelli, C., Link, A. N., & Metcalfe, S. (2009). *Technology infrastructure* (pp. 6–10, VI–X). Routledge Taylor & Francis Group.

Chaminade, C., & Edquist, C. (2009). Rationales for public policy intervention in the innovation process: Systems of innovation approach. In R. E. Smits, S. Kuhlmann, & P. Shapira (Eds.), *The theory and practice of innovation policy* (pp. 95–114). Edward Elgar.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152.

Cramer, K. C., & Ruffin, N. V. (2025). The Europeanisation of research infrastructure policy. *Minerva*, *63*, 45–68. https://doi.org/10.1007/s11024-024-09544-0

EARTO. (2022). *EARTO case studies on technology infrastructure*. https://www.earto.eu/wp-content/uploads/EARTO-Case-Studies-on-Technology-Infrastructures-Final.pdf

European Commission. (2012). *Guide to research and innovation strategies for smart specialisations (RIS3)*. Publications Office of the European Union. https://doi.org/10.2776/65746

European Commission (2013). *Regulation (EU) No 1291/2013 of 11 December 2013: Establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014–2020)*, Article 2 (6). https://eur-lex.europa.eu/eli/reg/2013/1291/oj/eng

European Commission. (2015). *Promoting the access of SMEs to KETs technology infrastructures action plan*. Publications Office of the European Union. https://doi.org/10.2769/92236

European Commission. (2017). *Peer review: Poland's higher education and science system*. Publications Office of the European Union. https://doi.org/10.2777/193011.

European Commission (2019). *Staff Working Document „Technology Infrastructures"* (SWD(2019) 158 final). https://data.consilium.europa.eu/doc/document/ST-8411-2019-INIT/en/pdf

European Commission (2023). *The Commision Regulation 2023/1315 of 23 June 2023 amending Regulation (EU) No 651/2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty and Regulation (EU) 2022/2473 declaring certain categories of aid to undertakings active in the production, processing and marketing of fishery and aquaculture products*

compatible with the internal market in application of Articles 107 and 108 of the Treaty. https://eur-lex.europa.eu/eli/reg/2023/1315/oj/eng

European Commission. (2025a). *Technology infrastructures: A strategic asset for European competitiveness – Conference report*. Publications Office of the European Union. https://doi.org/10.2777/8029491

European Commission (2025b). *The European Strategy on Research and Technology Infrastructures*. Communiaction (COM(2025) 497 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2025:497:REV1

European Commission. (2025c). *User needs for technology infrastructures: Analytical report*. Publications Office of the European Union. https://doi.org/10.2777/4186567

EGTI. (2025). *Towards a European policy for technology infrastructures*. Publications Office of the European Union. https://doi.org/10.2777/0876395

ESFRI. (2021). *Roadmap 2021. Strategy Report on Research Infrastructures.* https://roadmap2021.esfri.eu/media/1295/esfri-roadmap-2021.pdf

Gittova, K., & Sipikal, M. (2022). University science parks as an innovative tool for university–business cooperation. In *Proceedings of the 17th European Conference on Innovation and Entrepreneurship (ECIE 2022)* (pp. 648–656).

Justman, M., & Teubal, M. (1995). Technological infrastructure policy: Creating capabilities and building markets. *Research Policy*, *24*, 259–281. https://doi.org/10.1016/0048-7333(93)00765-L

Lau, A. K. W., & Lo, W. (2015). Regional innovation system, absorptive capacity and innovation performance: An empirical study. *Technological Forecasting & Social Change*, *92*, 99–114. https://doi.org/10.1016/j.techfore.2014.12.003

Lewandowski, P., & Falkowski, R. (2025). *Bezpieczeństwo technologiczne UE. Przegląd inicjatyw UE w obszarze działań na rzecz suwerenności technologicznej*. Sieć Badawcza Łukasiewicz-ITECH Instytut Innowacji i Technologii, Warszawa. https://itech.lukasiewicz.gov.pl/publikacje/bezpieczenstwo-technologiczne-ue-przeglad-inicjatyw-ue-w-obszarze-dzialan-na-rzecz-suwerennosci-technologicznej/

Miller, K., McAdam, R., Moffett, S., Alexander, A., & Puthusserry, P. (2016). Knowledge transfer in university quadruple helix ecosystems: An absorptive capacity perspective. *R&D Management*, *46*(2), 383–399. https://doi.org/10.1111/radm.12182

Smith, K. (2009). Globalisation and innovation systems: Policy issues. In R. E. Smits, S. Kuhlmann, & P. Shapira (Eds.), *The theory and practice of innovation policy* (pp. 75–94). Edward Elgar.

Tassey, G. (2008). *The roles and economic impacts of technology infrastructure* (Working paper). https://www.nist.gov/system/files/documents/2017/05/09/Measurement_Infrastr_Roles_Impacts_v3.pdf

Tassey, G. (1992). *Technology infrastructure and competitive position*, Springer Science+Business Media.

Timofejevs, A., & Avotins, V. (2020). Institutional cooperation models for enhanced utilization of research infrastructure in the BSR: Case of Latvia. *Engineering for Rural Development*, *20*, 1547–1533. https://doi.org/10.22616/ERDev.2020.19.TF383

Ulnicane, I. (2020). Ever-changing big science and research infrastructures: Evolving European Union policy. In K. C. Cramer & O. Hallonsten (Eds.), *Big science and research infrastructures in Europe* (pp. 76–100).

Viscido, S., Taucer, F., Grande, S., & Jenet, A. (2022). *Towards the implementation of an EU strategy for technology infrastructures. JRC and EARTO*. Publications Office of the European Union. https://doi.org/10.2760/4834

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualisation, and extension. *Academy of Management Review*, 27(2), 185–203. https://doi.org/10.2307/4134351

Annex 1. General characteristics of Polish enterprises, which participated in the survey on technology infrastructure (TI).

Compnay	A	B	C	D	E
Status	SME	Start-up/SME	SME	SME	SME
Stage of development (start-up)	Growth stage	Growth stage	Expansion/ ready for exit	Growth stage	Growth stage
Organisation of RDI activities	Internal department and outsourcing	Internal department and in-house	Internal department and outsourcing	Internal department and in-house	Internal department and outsourcing
Current target markets	The whole EU market	The whole EU market	A regional EU market (few MS)	National market and the whole EU market	National market and the whole EU market
Primary Target market	A national market	The whole EU market	A regional EU market (few MS)	A national market	A national market
Primary industrial ecosystem	Metals and metal components	Electronics and health	Aerospace and defence, energy intensive industries	Electronics	Energy intensive industries
Development of new products or technologies in the next 2 years	Yes, to a large extent	Yes, to a large extent	Somewhat	Yes, to a large extent	Somewhat
To what extent does your enterprise use TI	Somewhat	To a large extent	Somewhat	Somewhat	Not at all - we are not aware of any current TI addressing our needs.
How often do you use TI?	1-3 times per year	1-3 times per year	1-3 times per year	1-3 times per year	
How much of RDI is carried out with TI?	Less than 20%	Less than 20%	Less than 20%	Less than 20%	
Some tech areas are lacking relevant TI	We're not aware they exist or what they offer	There are not enough TI	There are not enough TI	There are not enough TI	There are not enough TI

Source: EGTI survey.