

Technological infrastructure: a literature review of firm effects and support instruments

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Summary in Danish

Dette review omhandler teknologiske infrastrukturer (TI) og deres rolle i at understøtte virksomheders innovationsprocesser, økonomiske resultater og samarbejde med eksterne vidensaktører. Mere specifikt undersøges det, hvordan virksomheders adgang til og brug af TI påvirker innovation, økonomiske resultater og samarbejdsmønstre, samt hvilke støtteinstrumenter der kan fremme adgangen til disse infrastrukturer.

Reviewet bygger på 20 akademiske artikler og 21 ikke-reviewede publikationer, herunder rapporter fra centrale institutionelle og policy-orienterede aktører, f.eks. EU. Litteraturen belyser både virksomhedseffekter af TI og de støtteinstrumenter, der kan fremme adgang til og brug af disse infrastrukturer. I dette review forstås TI som specialiserede faciliteter, udstyr, kompetencer og støtteydelser, som virksomheder ofte ikke selv kan etablere internt. De spiller især en rolle i de præ-kommercielle faser af innovationsprocessen, hvor nye produkter, processer og teknologier skal testes, demonstreres, valideres og opskaleres i realistiske miljøer, før de kan bringes tættere på markedet.

Den gennemgåede litteratur peger samlet set på positive effekter af TI, særligt i relation til innovation. Den oftest forekommende evidens findes for, at TI kan reducere teknologisk og finansiell usikkerhed, understøtte eksperimentering og validering samt bidrage til læring, kapacitetsopbygning og øget teknologisk modenhed. Evidensen for direkte økonomiske effekter er derimod mere begrænset. Selvom litteraturen ofte kobler TI til konkurrenceevne, markedsdannelse, investeringsparathed og industriel udvikling, er disse effekter i høj grad indirekte afledt af innovationsmekanismer frem for målt direkte. Reviewet viser også, at TI kan styrke samarbejde i innovationsøkosystemer ved at give virksomheder adgang til ekstern viden, relevante samarbejdspartnere og forsknings-, teknologi- og industriaktører. Dette fremstår særligt relevant for SMV'er og startups, som ofte mangler interne ressourcer, specialiseret viden og etablerede netværk. Samtidig afhænger effekterne af TI i høj grad af de støtteinstrumenter, der omgiver dem. Finansiering, adgangsmodeller og styring har betydning for, om TI etableres, vedligeholdes, opgraderes og anvendes effektivt af virksomheder.

Det nuværende evidensgrundlag er fortsat fragmenteret. TI-begrebet anvendes ikke entydigt på tværs af litteraturen, hvor relaterede betegnelser som testbeds, living labs, pilot plants og demonstrationsfaciliteter ofte bruges. Det gør det vanskeligt at sammenligne resultater på tværs af studier. Derudover er en stor del af litteraturen kvalitativ, case-baseret eller policy-orienteret, mens robuste kvantitative studier af effekter på virksomhedsniveau fortsat er begrænsede. Der er derfor behov for yderligere forskning og analyser, som kan styrke det empiriske evidensgrundlag, fx gennem longitudinelle, komparative og quasi-eksperimentelle studier med større samples og relevante kontrolgrupper. Disse vil kunne forbedre grundlaget for fremadrettet evidensbaseret politik og beslutninger om, hvorledes teknologiske infrastrukturer bedst finansieres, organiseres og gøres tilgængelige for virksomheder.

Abstract

This review examines the role of technology infrastructures (TIs) in supporting firms' innovation processes, economic performance and collaboration with external knowledge actors. It explores how firms' access to and use of TIs influence innovation outputs, economic outcomes and collaboration patterns, as well as which support instruments may facilitate access to these infrastructures. The reviewed literature suggests that TIs can create value for firms by providing access to specialised facilities, equipment, capabilities and support services that firms often cannot establish internally. The most frequently occurring evidence concerns innovation effects, as TIs enable testing, demonstration, validation and upscaling in realistic environments and help reduce technological and financial uncertainty. Evidence on direct economic effects is more limited and is often inferred from innovation mechanisms rather than measured directly. The literature also suggests that TIs may strengthen collaboration by functioning as intermediary spaces where firms access external knowledge and relevant partners. However, the effects of TIs depend on surrounding support structures, including funding models, access arrangements and governance. The current evidence base remains fragmented, with much of the literature being qualitative, case-based or policy-oriented. More studies are therefore needed to strengthen the empirical basis for evidence-based policymaking on TIs.

1. Introduction

In recent years, a number of actors, including the European Commission, have called for increased investment in and improved firm access to technology infrastructures (TIs) to support European industry's capacity to stay competitive in an increasingly fierce global market and to contribute to sustainable solutions to so-called 'wicked problems'. Equally, Danish actors such as Danish Association of Research and Technology Organisations and Industriens Fond have argued that TIs serve critical functions in the innovation ecosystem, and that societal underinvestment in these facilities is a central barrier to national innovation (EARTO, 2020; Rambøll, 2022). TIs comprise an important step in the firm innovation process, as development and commercialization of new products and methods depend on testing and demonstration in production- and market-proximate settings; TIs provide companies with services specifically aimed at these activities.

Technology infrastructures (TIs) is an umbrella term which is widely employed in the EU policy context to capture a range of test and demonstration facilities accessible by industry (e.g. in the Danish context these translate to "test-, demonstrations- og udviklingsfaciliteter"). The European Commission defines TIs broadly 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." (European Commission, 2019, p. 5)

The theoretical reasoning behind public support programs for TIs can be found in economic theory, where firms' optimization of their own actions creates externalities from a societal point of view. Since firms cannot capture the entire societal win, they only invest to their own margin. This creates suboptimal societal solutions, since larger investments in e.g. TIs would be beneficial at society's margin. The difference between the two margins is the externalities, which are sometimes also referred to as the 'market failure'. Even though the single firm behaves rationally, the entire market, i.e. society, does not, and can increase societal win by e.g. public support to or coordination of TIs, thereby increasing total societal efficiency and resulting wealth. Hence, it can be argued that underinvestment in TIs will result in wealth loss, as this reduces productivity growth, weakens innovation, competitiveness and technological diffusion thereby reducing national GDP growth. A public support program to fix 'market failures' could therefore be establishment of open access TIs. (e.g. European Commission, 2019; Teubal et al., 1996).

While several influential actors have argued exactly this, there is insufficient empirical knowledge about and evidence for TIs' actual effects on firm innovation, economic performance and collaboration. This review aims to remedy this by collecting and synthesizing existing academic and expert-based literature on TIs and firm effects as well as literature covering instruments (e.g. funding, governance and access models) supporting realization of these effects.

The paper is structured as follows. Section 2 elaborates on the review focus and introduces the two main research questions. Section 3 describes the review methodology, including the development of the search strategy, the

resulting literature sample, and the delineation of technology infrastructure as concept. Finally, section 4 synthesizes the identified literature in relation to the stated research questions and concludes with discussing implications for policymakers and further research agendas.

2. Research questions

The main aim of this review is to synthesise available academic peer-reviewed literature and relevant non-reviewed literature that sheds light on how the establishment of TIs can be supported in ways that create positive effects for firms that demand test, development and demonstration as part of their innovation processes. We translate this objective into the following research questions:

- How do companies' access to and use of technological infrastructures influence their innovation processes and outputs, economic performance, and collaboration with knowledge and research institutions?
- Which support instruments (including funding mechanisms, governance arrangements, and access models) are most effective in promoting companies' access to technological infrastructure?

As such, we are interested in understanding the role of TIs in the innovation ecosystem and the value added for firms that access these. This also requires developing an understanding of the structures that support and govern these facilities.

Approaching these questions through the available literature requires a clear conceptualization and delineation of TIs in terms of their purposes and overall characteristics compared to similar types of infrastructures in the research and innovation ecosystem. Relying on definitions provided by the European Commission (European Commission, 2019, pp. 11-12), we conceptualize TIs as "facilities, equipment, capabilities and support services required to develop, test and upscale technology", products or services to higher TRLs, typically in the range from TRL4 to TRL7, cf. table 3.1. TIs can be publicly, semi-publicly or privately owned, and they are accessible to public and private companies by demand (although access models may differ). In many countries, as is the case in the European innovation ecosystem, TIs are often hosted by Research and Technology Organisations, RTOs, which are specialized institutions or firms that address practical industry challenges and operate as independent entities that bridge academic knowledge and commercial applications (Viscido et al., 2022).

3. Review Methodology

The following chapter describes the search strategy and the software employed in the literature screening process.

3.1 AI-assisted literature search

In the beginning of the project, the research team initiated a systematic search in relevant databases: Scopus, EconLit, Open Alex and Web of Science. For this purpose, the two main research questions were translated into possible search strings, which were tested in a series of test searches. All search strings included the concept of technology infrastructure (and its synonyms) and then either effect types or support instruments (and relevant synonyms). The number of hits varied greatly across both search strings and databases (from a handful to many thousand hits), however, an immediate screening of results revealed that extremely few of these were relevant

to the review's RQs. Consequently, it became clear that the approach to the literature search needed to be re-considered.

Guided by a librarian from AU Library, we explored the added value of AI-assisted searching as an alternative to traditional database searching. While traditional tools rely on keyword matching and Boolean operators (meaning that results depend heavily on the exact wording of the query), AI tools use semantic searches which means that they 'understand' the *meaning* of the query and not just the exact words (Malo & Alzebari, 2025). As such, AI tools allow you to pose your question in natural language, where traditional tools cannot interpret long-form questions (Malo & Alzebari, 2025). Furthermore, the ranking of search results is often different; while traditional tools rank e.g. based on citations, publication date, journal indexing and keyword frequency, AI tools rank based on semantic relevance and topic similarity. This means that AI tools also surface newer and less-cited publications that might be highly relevant to the research question. This also makes these tools particularly helpful for exploratory questions as the present (Shelke et al., 2023). Finally, AI tools are able to produce synthesised answers to your research question based on the identified literature.

The promising features of the AI tools in literature search have resulted in a surge in the different AI tools offered on the market. However, critics still point to the pitfalls of these LL models. Especially, the black-box character of the models is highlighted; the tools do not show reasoning which means that these are less transparent than traditional database searching. In addition, the user cannot always know when the models hallucinate or misinterpret sources (Lau & Golder, 2025). Consequently, AI tools must be used with awareness of these conditions.

In this review, we used AI-tools recommended by AU Library. These included: Asta, Consensus, Elicit, Scite, Undermind and Google Scholar Labs. The models were prompted with our two research questions, which generated a broad and diverse set of publications as well as publication types. In addition, different words describing TIs as concept were identified and included in the prompts (see table 3.1). These synonyms were used in combination with the research questions to maximize and focus hit rate.

Table 3.1 Synonyms for TIs were identified to include

Synonyms for TIs		
Living labs	Testbeds	Testing facilities
Demonstration facilities	Development facilities	Experimental facilities
Pilot plants	Pilot lines	Pilot facilities
Cleanrooms	Technology platforms	

Unlike traditional database searches, AI-driven queries do not generate a fixed or fully reproducible set of results; models continuously generate new outputs, and identical prompts may produce different results across attempts. The results in each prompt were immediately screened for relevance based on title, abstract and (where available) the summary generated by the AI-model. After a period of iterative prompting, the team observed that fewer novel publications appeared in the results. This decline in new findings was interpreted as an indication of saturation in the search process.

While this approach cannot be counted as systematic and transparent, it was clear that the AI-assisted search generated a larger and more relevant output than traditional literature searches. Consequently, this review must

be classified as a scoping review mapping the emerging field of literature on TIs and their function and value in the innovation ecosystem.

3.2 Screening process

In total, the AI-assisted search process resulted in 46 publications, including peer reviewed journal articles and non-reviewed reports. These were uploaded to the software Covidence, which provides a systematic management tool in the screening process. Covidence removes duplicates and supports the review process in two separate phases: (1) title and abstract screening and (2) full text review. In both phases, agreement from two reviewers is required for inclusion/exclusion of a publication, while a third reviewer will make the final decision in cases of conflict. Furthermore, Covidence makes it possible to manage the identified articles using tags that systematize the articles in relevant categories, e.g. effect types.

After duplicates were removed, 44 publications remained for screening. Due to the AI-assisted search process, which involved immediate title and abstract screening of search outputs, it was decided to progress directly to full text screening in Covidence. This screening involved an in-depth reading, where each publication was assessed according to the research questions and the predefined inclusion criteria (see table 3.2). Accordingly, we included literature that covered facilities with firm access and literature discussing firm effects of using TIs and/or the support instruments or structures behind these facilities. Also, it was a requirement that the context of the included publications should be relevant to the Danish National Innovation System, meaning that focus was largely on publications with a European context or something comparable. Finally, we aimed to include only publications from 2015 and newer to maintain relevance to a present context, but we accepted older studies if they demonstrated special relevance to the research questions.

Table 3.2: Inclusion criteria for relevant literature

Inclusion criteria
Address TIs with firm access
Examine empirical effects of TIs on firms OR address TI support instruments
Relevant to the Danish National Innovation System (context), i.e. a European context or something comparable
Newer than 2015 (unless considered particularly relevant)

The full text review excluded 16 publications, which left 28 publications for the final review – more specifically, 20 reviewed articles and 8 non-reviewed publications (reports).

In addition to the sources identified via the AI-assisted search, 14 non-reviewed contributions were identified, hereof 6 European Commission-reports. They were found through an internet-based search using similar keywords as for the reviewed literature and required to be made by either an expert-based policy actor, e.g. EC (2019; 2024a; 2024b; 2025a; 2025b; 2025c) or a key player in the ecosystem of TIs, e.g. EARTO (2020; 2022). The contributions therefore consist mainly of reports. The contributions were screened through an in-depth reading, where each publication was assessed according to the research questions and the predefined inclusion criteria (see table 3.2).

In sum, 41 pieces of literature were included in the review, including 20 peer-reviewed studies and 21 non-reviewed publications. An overview of the final sample can be found in appendix 1.

3.3 Distinguishing Technology Infrastructure from Research Infrastructure

The primary purpose of TIs is to serve the needs of public and private sector companies in the pre-commercial phase through trial and demonstration of innovative or improved products, services or industrial processes, thereby supporting firm competitiveness (European Commission, 2025b). In accordance, Rambøll (2022) defines TIs as facilities where users can “perform or have performed tests, demonstrations and/or development of new products, services, processes or organizational solutions” (p. 33, own translation). In addition, a facility must be accessible by agreement” (p. 33, own translation).

Hence, TIs are distinct from Research Infrastructures (RIs) which are established for research purposes and thus typically only are accessible in cooperation with the infrastructure owner, e.g. via industry-science research collaboration in the lower end of the TRL scale, typically TRL 1-4. This means that even though both types of infrastructures may have positive impact on firms and society, they have complementary roles in the RD&I ecosystem and address the demands from different types of users and provide different types of services, cf. table 3.3. In addition, the TI landscape is much more diverse and much less integrated than the RI landscape. The TI landscape has been developed over decades from a variety of needs and funding models, resulting in a plethora of large and small entities with various ownership and business models (Edström, Dalunde & Andersson, 2022).

Table 3.3. Characteristic differences between TI and RI

Characteristics	Technology Infrastructures TI	Research Infrastructures, RI
TRL	TRL 4-7: validation, demonstration, prototype in relevant environment	TRL 1-4: concept, proof, validation in lab
Functionality	Technology development: from technology validation to demonstration in the relevant environment	Fundamental research: from scientific discovery to formulation of technology concept
Main driver	Addresses society's need for technological and innovative solutions	Advancing scientific knowledge
Host	Mostly by applied research and technology performing organisations (e.g. RTOs) and occasionally public or private firms (e.g. certification or approval).	Research Performing Organisations (e.g. universities or special purpose organisations e.g. CERN or ESA)
Users	Public and private users (incl. SMEs) receiving knowledge transfers from TI owner Internal technology development projects (e.g. competence or TI development)	(Public) research producing organisations (RPOs) individually or in collaboration with other RPOs Occasionally in collaboration with knowledge intensive industry (e.g. R&D labs)
Activities	Applied research and technology transfer Specialised test, demonstration and development (TDD) services for sale or collaboration	Collaborative research and technological development (RTD) The economic gains from infrastructures remains limited as they are used in collaboration
Public added value	Enable industry (incl. SMEs) to innovate and scale technology or services (e.g. access essential skills, knowledge and expensive facilities, thereby lowering their risk) Enhance TI owners' knowledge and skills to develop technologies, to be used horizontally in different sectors (spillovers)	Essential to enable RPOs to advance scientific research and strengthen the knowledge base according to public interest
Examples	See table 3.1: Living labs, Testbeds, Testing facilities, Demonstration facilities, Development facilities, Experimental facilities, Pilot plants, Pilot lines, Pilot facilities, Cleanrooms, Technology platforms	Major scientific equipment and hosting facilities, open for collaborating RPOs, archives and scientific data collections, e-infrastructures

Note: Inspired by Viscido et al (2022), RITIFI D1.1 (2024), EC (2019) and the present literature review.

The main users of TIs are private for-profit companies (incl. SMEs) or public developers working on technology development and implementation. Here, “TIs support technology development and co-creation from proof of concept and validation in labs to prototype demonstration in industrial environment, with the aim to ensure technology uptake with high socio-economic impact” (EARTO, 2020, p. 2). This differs from RIs “who focus on scientific discovery at very earlier stages”, meaning that TIs operate on higher TRLs than RIs (EARTO, 2020, p. 2; European Commission, 2019).

The two types of infrastructures typically also differ in terms of funding. Most investments in establishment and funding for operation of RIs come from the public sector's funding of universities and special purpose R&D organisations, e.g. CERN or ESA. Parallely, funding establishing TIs is often covered by the public sector through e.g. Research and Technology Organizations, RTOs, but private funding is also involved to a greater extent, e.g. through foundations, technological or industrial cluster organizations, larger companies in partnerships and through the RTOs' surplus. However, the primary share of funding for operational costs of TIs comes from users, i.e. private sector companies. (European Commission, 2025b). From a policy or support program planning point of view, it is therefore important to take the two infrastructures' specificities into account when e.g. designing programs and policies aiming to enhance their respective capacities and foster their use. (Viscido et al., 2022).

The distinction between RIs and TIs is particularly important for defining the scope of the review. Although RIs may contribute to innovation and generate value for firms, especially R&D intensive firms, they do so primarily through the production of scientific knowledge and research collaboration at lower TRL-levels. There is a vast literature on industry-science collaboration, some of which explores the role of RIs and their firm level impact. However, this literature differs from the emerging field on TIs which addresses interactions between firms and infrastructures specifically established to support firms' innovation processes on the higher TRL-levels, i.e. test, demonstration and validation. As part of the review, an extensive deep text search using the synonyms in table 4.1 was performed to identify whether important studies on firm effects of TI owned by e.g. universities but “disguised” as RI or industry-science collaboration exists. Neither this nor literature on firm access to university-owned TI mediated through e.g. RTOs was found in the literature.

A few studies addressing RIs have been included however, since they contribute to answering the research questions in other ways. These are: Edström, Dalunde and Andersson (2022) who contributes to drawing delimitations between RIs and TIs; Catalano et al. (2021) who traces complex and multiple pathways from experiments (performed on RIs) to economically relevant innovations; and Cundeva-Blajer (2025) who investigates how accredited research laboratories can improve collaboration, resource efficiency, knowledge sharing, and innovation for external users through open access to RIs similar to open access to TIs. The primary differences to the TI literature are the longer and more complex timeline, the R&D intensive users and the embedded higher initial project risk.

4. Review outcome

In this chapter, we start with presenting an overview of the included literature, describing its overall characteristics (section 4.1). Then we turn to the analysis and present a synthesis of the literature's contribution to our understanding of firm effects of TIs as well as the structures enabling the existence and operation of these facilities (section 4.2).

4.1 Literature overview

As mentioned in section 3.2, the final literature sample can be divided into two subsets: 20 academic reviewed articles and 22 non-reviewed publications (see overview under References and Appendix 1). While peer-reviewed academic literature can generally be considered as the most objective sources to answer the research questions, the inclusion of non-reviewed publications is deemed important to qualify and generalize the evidence found in this review. Especially, the included literature from the European Commission and the European Investment Bank contributes with expert-based views and arguments for a usable and valuable common EU Technology Infrastructure policy and the policy recommendations for a possible way towards it.

Some general observations can be made about the nature and characteristics of these two streams of literature and their added value to this review. Starting with the academic articles, these are generally published in international, interdisciplinary journals focusing on innovation, sustainability and technology development. Across fields, this literature is characterized by its application-oriented approach and its focus on the relationship between technology, market and policy, especially in terms of supporting the transition from applied research, development and innovation to commercialization. From a methodological point of view, the studies represent both quantitative and qualitative studies (though with clear predominance of the latter) as well as four reviews.

To create an overview of the extent to which the literature addressed our research questions, all publications were provided with tags. These included the three effect types (economic, innovation, collaboration) and 'support instruments' (referring to our second research question). It is important to note that although the distinction between effect types is analytically beneficial and helps to create an overview of the field, it is also somewhat artificial. The three areas of interest are very much entangled. For instance, it should be assumed that firms' improved economic performance is driven by innovation; that is, outcomes such as productivity gains or employment growth can be interpreted as indicators of enhanced innovative activity (e.g. the introduction of new-to-firm or even new-to-market products or processes). Likewise, networking and collaboration with external knowledge sources are closely linked to innovation, as knowledge sharing is a key component of the innovation process.

While bearing this condition in mind, the provided tags still indicate clear predominance of studies addressing the innovation effects of TIs, whereas economic effects are more rarely discussed. It is important to point out that publications have been tagged regardless of how they address these effects, i.e. even if it is expert-based statements and not investigated empirically. Similarly, 15 of the included articles have the collaboration tag, i.e. discuss collaboration effects as primary effects. However, as section 4.2.3 shows, many studies analyze collaboration effects imbedded in studies of the other effects, e.g. innovation. In addition, 15 studies address the support structures related to the establishment and operation of TIs.

The non-reviewed literature is significantly characterized by being produced by institutional actors rather than academic researchers. The majority (11) is published by EU actors, mainly the European Commission and EARTO (European Association of Research and Technology organizations), but a smaller number of publications represent other actors e.g. The Nordic Council of Ministers. As a result, this subset of the literature is strongly action- and mission oriented: it primarily targets policymakers and serves to inform and support the development of new regional policies on TI. These publications are thus valuable in addressing the second research question regarding the structures supporting TIs. That said, it is still important to consider that these are not peer-reviewed articles; emphasis lies mostly on strategy and implementation not on empirical analysis or conceptual exploration of TIs.

Nonetheless, these non-reviewed publications still originate from a solid knowledge base, where contributors hold different positions in the innovation ecosystem: e.g. funding organs, research and technology organizations

(RTOs) and policy experts. Accordingly, their authority on the topic is based on their institutional position and practical experience in the domain. In addition, some of the reports include empirical insights, for instance, case studies or survey data, which adds to the empirical evidence on the firm effects of TIs. Consequently, the non-reviewed literature is seen as a valuable complement to the peer-reviewed sample in addressing the research questions, while we, as reviewers, remain attentive to the institutional interests and agendas that shape these publications.

Looking at both streams of literature, it becomes evident that there is a lot of variation in the typology describing TIs. The umbrella term 'technology infrastructure' (which we have also adopted in this review) dominates the EU-based literature, demonstrating that this term has been coined in an EU policy context. As described in a report by the EU Commission:

"'Technology Infrastructures' is not mainstreamed at national and regional levels. However, many other terms (or 'proxies') are used to characterise similar facilities in different policy contexts across the EU countries. Those include for instance: innovation infrastructures, (open innovation) testbeds, living labs, pilot lines, technology equipment, technology platforms, technology (co-creation) labs, cleanrooms, open innovation facilities, biohubs, prototyping labs, testing and experimentation facilities, demonstrators, etc." (European Commission, 2024, p. 8).

Consequently, TI as a category includes a number of different facilities that each have different characteristics, but a common denominator is that they are open to industrial actors, who do not themselves have access to similar relevant (testing) facilities. Other terms that figure prominently across the literature are 'test beds' and 'pilot and demonstration plants' (particularly in the peer-reviewed literature).

Importantly, the initial literature screening revealed that definitions of the concepts are not always aligned across literature. 'Living labs' provides a good example, since this in some cases describes a technological facility while in other cases it describes a "method" or "community platform", which does not fit our conceptualization of TI (Sofronievska et al., 2025, p. 8). Therefore, the screening process also involved careful assessment of these individual definitions to only include publications covering facilities relevant to the purpose of the review.

The conceptual fragmentation can also be understood in the light of the different streams of literature. The non-reviewed literature, which is largely policy oriented, tends to use umbrella terms (e.g. 'technology infrastructures' or 'test-, demonstration- and development facilities'), whereas academic literature introduces more nuanced categories depending on their specific field (e.g. 'pilot plants' or 'real world test beds'). This makes sense considering the different purposes and audiences of academic vs. policy-oriented literature. Thus, we can see this lack of a single, stabilized conceptual framework as an expression of different perspectives (policy, funding, interest organization, academic, etc.) but also as an indication of this being an emerging evidence-based policy field.

Finally, the identified literature mainly covers the European context. This was also in line with our search strategy aimed at finding literature relevant to the Danish national innovation system. However, there are a few examples of publications covering either a Non-European context or both Non-European and European (4 reviewed and 3 non-reviewed publications). They contribute nonetheless with relevant perspectives to the research questions and are therefore included.

Table 4.1 Tag groups and tags identified and added during the full text assessment

Tag groups	Identified tags
Effect types	Economic effects; Innovation effects; Collaboration effects
Support instruments	Support instruments
Geographical scope	EU and EEA; Non-EU
Synonyms for infra-structures	Living labs; Pilot plants; Pilot lines; Collaborative platforms; Demonstration projects; Testbeds; Real-world test beds; Pilot and demonstration plants; Research infrastructure; Test and demonstration facilities; Pilot-, test- and demonstration projects; Test-, demonstration and de facilities; Open innovation test beds; Innovation facilities

Note: Some publications are provided with multiple tags referring to the two research questions (effect types and support instruments), illustrating how individual publications may cover several topics related to the review objective.

4.2 Findings

In this section, we synthesize the identified literature on TIs according to the main research questions. This results in four sections: the first three cover the innovation, economic and collaboration effects that can be connected to firms' access to TIs, and the final section covers the support instruments or structural conditions that promote or hinder the potential benefits of these facilities.

4.2.1 Innovation effects

Pursuing new technological endeavours generally poses a sizeable financial risk to firms, which may often result in path dependence. Access to TIs can help mitigate this risk, as innovative firms need not invest in critical capital to establish the infrastructure required to test and validate new inventions (European Commission, 2025c). As phrased by Moore et al. (2021): "Innovation facilities help to de-risk the innovation process by limiting the capital expenditure required to get a product up and running since innovators do not need to invest in their own facilities, which likely allows innovators to get something done faster than otherwise possible and/or undertake projects innovators otherwise would not have considered" (p. 24). As such, TIs function as "protected environments" where products and processes can be developed and tested in the appropriate context, without considerable financial risk (Tolio et al., 2019, pp. 481-482). Within this broader role of TIs, test beds are particularly important for transforming research into marketable solutions, as they enable testing in realistic settings, reduce uncertainty, and support the development of solutions that are closer to commercial application (Engels et al., 2019; Malmer et al., 2018). Malmer et al. (2018), for instance, argue that Europe needs a coordinated "Test Bed Europe" strategy to improve access, harmonise practices, and strengthen collaboration across industry, research and public actors (p. 14). Similarly, real-world testbeds can reduce barriers to testing by helping firms manage risk and gain access to relevant environments and user groups (Arntzen et al., 2019).

Another challenge that firms face in the innovation process is upscaling. Firms might develop promising products or processes at lab scale, but commercialisation requires extensive knowledge on the performance and potential barriers in larger scale. In a review on the role of Pilot and Demonstration Plants (PDPs), Frishammar et al. (2015) found that such TIs can act as a bridge between lab research and real-world industrial application. Hendry et al. (2010) arrives at a similar conclusion; in an extensive case study of companies engaging in publicly funded demonstration projects and trials (in the field of low carbon energy systems), they find that these projects enable "scaling up of a technology from laboratory models to small commercial scale" (p. 4508). Indeed, several publications support this claim, arguing that TIs provide a unique environment for upscaling and validation, improving technology performance, thus allowing inventions to reach higher TRLs (Bäckström, 2015; European Commission,

2019; European Investment Bank, 2025; Mihelcic et al., 2017; Prieto et al., 2020). In addition, policy-oriented publications argue that this function accelerates firm innovation processes which results in shorter time-to-market for new products and processes (European Commission, 2019; European Commission, 2025a; European Commission, 2025b; European Investment Bank, 2025).

While the literature above primarily highlights the functions of TIs, a smaller body of research attempts to quantify their innovation effects more directly. Both Palage et al. (2019) and Bäckström (2015) examine innovation effects of pilot and demonstration plants (PDPs) in the advanced biofuel technology sector that had received public (co)funding. Both papers are built on essentially the same empirical foundation: patent data¹ from eight EU member states from 1980-2011. They identify a positive correlation between previous investments in advanced biofuel PDPs and patenting in this specific field. The effect is seen in both so-called experimental and exemplary PDPs – where the first aims at testing “the technical viability of a new technology” and the second “demonstrate[s] the value of new technology to potential adopters” (Palage et al., 2019, pp. 43-44). However, the effect is strongest for experimental PDPs, arguably because these have a “stronger focus on reducing technical risks through, for instance, testing, evaluating and characterizing technology for particular applications” (Palage et al., 2019, p. 49).

These findings can be further understood in the light of Bossink (2015), who takes a process-oriented perspective rather than measuring outputs directly. In an extensive literature review on demonstration projects within clean technologies, he finds that the effectiveness of these increases when technologies move through different stages of demonstrations in sequence: 1) technical demonstrations that test and improve prototypes, 2) organizational demonstrations that develop production systems and 3) market demonstrations that adapt new products to market demands. From this perspective, the stronger impact of experimental PDPs can be interpreted as reflecting the importance of early-stage experimentation and risk reduction in generating subsequent innovation outcomes.

Whereas the studies above focus on technological development, patenting and demonstration activities, other contributions examine innovation effects of TIs at the firm level and through broader measures of learning and capability development. Alexandrakis et al. (2022) provide such a perspective by investigating how participation in Living Labs projects affects SMEs’ “innovation outputs, activities, capabilities and knowledge flows” (p. 1). Their study is based on a survey of 12 European SMEs involved in a Living Lab focused on urban sustainability. The indicators were derived from a prior qualitative interview study and assess the extent to which respondents perceived participation in a specific Living Lab as having a positive impact on these different dimensions of innovation. The findings suggest moderate but uneven effects. A majority of respondents (58.3%) reported positive impacts on innovation outputs (e.g. introduction of new products/processes), while knowledge flows and capabilities—such as access to new ideas, expanded networks, and enhanced competencies—were among the most consistently reported benefits. However, impacts were weaker in areas such as access to innovation services and financial outcomes, indicating that Living Labs primarily support learning and incremental innovation rather than delivering strong overall improvements in SMEs’ innovation performance. These results must, however, be considered preliminary given the small size of the sample.

¹ It is important to note that while patent counts are often used as measure for innovation in both research and policy contexts, this has significant limitations. For instance, only a minority of firms choose to patent their innovations. This could be due to trade secrets or lacking resources. Furthermore, there is great variation in patent quality; some signify breakthrough innovations while others are just minor, incremental improvements or strategic, defensive patents. Finally, patenting does not mean that an invention is implemented; many patents are never commercialized, meaning that they do not necessarily create societal impact. As such, this is a measure that should be addressed with some caution.

Taken together, the studies reviewed in this section suggest that TIs support innovation by reducing the risks and costs of experimentation, enabling validation and upscaling, and facilitating the development of new products, processes and knowledge collaboration, although the strength of these effects varies across sectors, TI types and stages of technology development.

4.2.2 Economic effects

Overall, the reviewed literature contains very limited direct, empirical evidence on the economic effects of TIs. Most publications that argue for such effects are either conceptual, policy-oriented or based on assumptions of market mechanisms. This means that claims on economic impact are mostly inferred indirectly or embedded in broader arguments on innovation effects. For instance, Mousavi et al. (2023) argues that PDPs' ability to reduce both supply and demand uncertainty "enable technology actors to show that their technologies are operationally stable and economically feasible." (p. 16). This in turn means that such facilities support market formation of new technologies (Mousavi et al., 2023).

A key challenge that is repeated several times in the literature is that innovation often fails due to a lack of funding. By providing a space where inventions can be validated in proper settings, TIs help construct a promising narrative that make innovations investable and thereby enable transition from R&D to market (Mihelcic et al., 2017; Mousavi et al., 2023; Prieto et al., 2020). As such, it is implied that TIs have a positive impact on R&D investment (European Commission, 2025b; Viscido et al., 2022).

Finally, several policy-oriented publications link TIs to industrial competitiveness, since firms' access to these facilities is assumed to give them a stronger position in the increasingly fierce global market (EARTO, 2020; European Commission, 2019; Rambøll, 2022; Viscido et al., 2022).

While these assumption-based arguments tend to dominate discussions on economic effects, it is central to highlight the only publication that provides empirical evidence on the subject. EARTO (2020) includes a summary of three TI cases that accordingly demonstrate "high socio-economic impact" (p. 5). The cases are: CEA's Jules Horowitz Reactor (JHR), Imec's clean room, and the Danish Technological Institute's investments in several technological facilities, including an ion accelerator. Across all cases, a central pattern emerges: public and institutional investments in advanced research and testing infrastructures translate into measurable economic activity at both firm and regional levels.

Firstly, JHR generated significant economic returns within a single year. A €66 million investment resulted in over 1,200 jobs, €140 million in revenue, and substantial value added and tax returns. This highlights how large-scale, strategically important infrastructures can act as major economic multipliers, creating employment and industrial activity beyond their immediate research function. The second case, Imec's cleanroom facility, demonstrates similar dynamics at a smaller scale but within a high-tech industrial context. The cleanroom enables the development of cutting-edge semiconductor technologies under highly controlled conditions, which are critical for nanotechnology innovation. A €20 million investment generated 420 jobs and €46 million in revenue, alongside notable value added and fiscal returns. Finally, the case on Danish Technological Institute (DTI), provides an example of smaller-scale investments in technology facilities. Here, investments in equipment such as an ion accelerator and upgrades to existing facilities enabled new industrial applications and innovation opportunities. Even with a relatively modest investment of €2 million, measurable economic effects were achieved, including job creation, revenue generation, and fiscal returns. This case demonstrates that even smaller, targeted infrastructure investments can yield consistent and reproducible economic benefits, particularly when aligned with

industrial needs (EARTO, 2020). Taken together, these cases suggest that TIs can generate direct and measurable economic effects, including employment, revenue, and public returns on investment.

4.2.3 Collaboration effects

A recurring theme across the literature is that TIs play a central role not only as providers of technical capabilities, but as collaboration spaces within innovation systems (e.g. Frishammar et al., 2015; Nemet et al., 2018). Accordingly, Mossberg et al. (2020) notes that “PDPs are important arenas for collaboration among various types of actors, i.e., industrial firms, academia, government agencies, and equipment suppliers” (p. 2). Rather than operating as isolated facilities, TIs thus function as intermediary spaces that enable firms to access complementary knowledge, resources and partnerships that are often unavailable internally.

This function is also emphasized in policy-oriented literature, which highlights how collaboration effects are catalyzed through TIs’ central role in the innovation ecosystem. As noted by EARTO (2020): “TIs connect technologies to non-technological disciplines and services, including feasibility and regulatory compliance. TIs ensure the connection between a broad range of stakeholders, supporting companies to find the right partners to reach their goals” (p. 4). In this sense, TIs contribute to building strong innovation networks by providing spaces where actors can meet and engage in joint problem-solving. Similarly, Kreiling et al. (2020) argue that collaborative platforms can “catalyse innovation ecosystems” by coordinating diverse actors (p. 18). This function is particularly important in fragmented innovation ecosystems, where identifying suitable collaborators can be costly and time-consuming, especially for SMEs and startups (Viscido et al., 2022). These potential ecosystem impacts must, however, depend heavily on efficient support structures and organization (see 4.2.4).

This network-oriented function is also reflected in the Danish evaluation framework for innovation infrastructure. The Danish Ministry of Higher Education and Science (2016) describes innovation networks as instruments that should provide firms with access to networks of other companies, relevant knowledge institutions and public authorities within the same field, while also helping to create collaborations across traditional industry boundaries. A similar ecosystem perspective is found in Chatti et al.’s (2024) review of innovation ecosystem performance indicators. While their study does not focus specifically on TIs, it highlights the broader mechanisms through which firms may benefit from resources and capabilities located in their surrounding business environment. They note that firms can gain competitive advantages not only from their own internal capabilities, but also from geographically proximate competencies and resources, which previous research has linked to positive effects on productivity, innovation, growth and resilience (Chatti et al., 2024).

Taking an ecosystem approach also allows a broader understanding of how TIs create value. As Kreiling et al. (2020) argue, collaborative platforms “drive and coordinate systems of stakeholders that may be beyond individual projects and contractual relationships,” thereby extending collaboration to a broader system level (p. 18). In this view, firm-TI interactions are not isolated events; they are part of a network of ongoing interactions that generate both tangible and “intangible, relational value” (Kreiling et al., 2020, p. 27). Their case study of two collaborative platforms within the advanced material sector demonstrates that platform activity resulted in “long-term partnerships” that led to new projects outside the platform (Kreiling et al., 2020, p. 27). A similar point is made by Viscido et al. (2022), who argue that TIs network expansion and partner identification enable firms to build relationships with relevant actors.

Efforts to generate collaboration and ecosystem effects can also be identified with TI initiatives adopting an open innovation approach. Aiming to foster a more connected European innovation ecosystem and accelerate European innovation, the EU has invested significant sums in improving access to Open Innovation Test Beds (OITBs)

in the field of advanced materials. According to the European Commission, “by pooling resources and existing knowledge at the EU level, while supporting all kinds of users independently of their geographical location, OITBs stimulate collaboration across Europe, contributing to the creation of a more open and connected innovation ecosystem” (European Commission, 2023b, p. 2). This assumption is also supported by Salvalai et al. (2023). In a systematic review on open innovation in the construction sector, they find that open innovation approaches in the construction sector enhance innovation performance by enabling knowledge sharing beyond firm boundaries. Indeed, collaborative ecosystems are seen as essential to overcome sector barriers and accelerate sustainable, energy-efficient solutions in construction (Salvalai et al., 2023; Salvalai et al., 2025).

It is important to note that the extent and nature of collaboration vary across different TIs. In the case of pilot and demonstration projects, collaboration is often formed in large-scale and sometimes multi-national settings. Bossink (2015) notes that “technical demonstration projects are often large cooperative settings with many organizations” (p. 1419), highlighting their inherently collaborative structure. As Bäckström (2015) observes, PDPs are “important not only for technical development but also for market creation and network formation” (p. 2). This indicates that collaboration within PDPs extends beyond knowledge production to include the formation of relationships and networks that sustain innovation over time.

Living labs (LLs) represent a form of TI where collaboration is more explicitly designed and structured around open innovation principles. According to Sofronievska et al. (2025), LLs are characterized by “public-private-people partnerships, real-life experimentation, iterative co-creation, and open innovation,” all of which are intended to foster collaboration and value creation (p. 8). They actively involve users and societal actors in innovation processes, with studies noting that LLs “have a central role as networks of partners” and “actively involve end-users and customers in testing activities and innovation development phases” (Sofronievska et al., 2025, pp. 6–7). Compared to PDPs, LLs thus extend collaboration to the demand side, enabling firms to co-create innovations with users and gain insights into real-world application contexts.

While the above addresses collaboration from the firm perspective, it can also be seen from the TI perspective. According to the reviewed literature, the success of the TI is also connected to the network and ecosystem the facility is embedded in. This is illustrated in the case descriptions of test facilities in Jakobsen et al. (2018). For instance, the ROBOT-NEET (a network of robot technology facilities driven by four European RTOs) in which collaboration is seen as a “cornerstone”: “The four partners all have a good network and can assist the companies in the best way possible. This collaboration increases the value for the company as it can connect with and get input from the RTO with the most specific knowledge related to the problem of the company in question” (Jakobsen et al., 2018, p. 65, 68). Thus, successful collaboration between institutions hosting TIs can also be regarded as a driving mechanism in increasing value for firms.

Summing up, collaboration must be understood as a core mechanism through which TIs create value for firms by enabling access to complementary knowledge, facilitating network formation, and coordinating complex innovation processes across actors and sectors, though these effects vary across TI types and depend on governance and ecosystem context.

4.2.4 Support instruments

While the sections above have examined both the conceptual claims and empirical evidence regarding firm effects of TIs, it is important to recognize that access to and effective use of these infrastructures do not rise automatically. Rather, they are shaped by the underlying support structures that determine who can access these

facilities and under what conditions. In this review, support structures can be understood in terms of three interrelated elements: funding structures, access models and governance arrangements. The following section synthesizes the literature's perspectives on how these elements influence the accessibility and effectiveness of TIs.

Funding structures

Funding structures constitute a core element of the support systems surrounding TIs, as they shape both the existence of these facilities and firms' ability to access them. Across the literature, there is broad agreement that TIs require substantial upfront investments, long-term maintenance, and continuous upgrading to remain at the technological frontier (European Commission, 2019; European Investment Bank, 2025). Combined with long development horizons, significant technological uncertainty and the risk of knowledge spillovers, these characteristics often discourage private investment and thus contribute to persistent underinvestment by market actors (EARTO, 2020; European Commission, 2019; Frishammar et al., 2015; Mossberg et al., 2020; Nemet et al., 2018). As a result, the establishment and continued operation of TIs depend heavily on public funding. As the European Commission notes, "Technology infrastructures require high investment both in the set-up and for keeping up with the state-of-the-art. Despite the income generated from their clients, many technology infrastructures depend on public funding" (2019, p. 32). Public funding can, however, be challenged by policies aimed at avoiding market distortion (Kreiling et al., 2020). For instance, the EU State Aid rules will affect the design of funding models, since it imposes constraints on funding high-TRL activities (Mossberg et al., 2020).

Public funds do not entirely replace private funding; rather, public funding can also serve to de-risk financial engagement and mobilize private investors. As such, some TIs are based on hybrid funding models that vary considerably across different infrastructures, reflecting a fragmented funding landscape (EARTO, 2020, European Investment Bank, 2025). According to the European Investment Bank (2025), "[p]ublic-private co-financing remains rare, with operators reporting that the private sector appears reluctant to assume investment risks" (p. 9). Indeed, private funding only accounts for about 1 percent of the capital investment for TIs (p. 9). This is a challenge since blending investments is an essential means to meet the demand for TI services in the future: "[a]n estimated €13-16 billion in capital investment is required by 2030 to build and upgrade technology infrastructures across the European Union." (European Investment Bank, 2025, pp. v-vii). However, the problem is somewhat reduced as semi-private institutions, e.g. RTOs, reinvest their profit in technology infrastructure, accounting for approximately 21% of the average funding mix in EU (European Investment Bank, 2025, p. 9).

Firm access to TIs

Firm access to TIs is a central concern in parts of the literature, as the value of these facilities ultimately depends on whether companies are able to identify, enter, and effectively utilise them (e.g. European Commission, 2025b; Rambøll, 2022). As pointed out by Rambøll (2022) access is often a greater problem than the absolute number and physical availability of TIs; startups and SMEs often struggle to find, afford and gain entry while larger firms more often own such facilities themselves or have the resources utilize TIs in the international innovation ecosystem. As such, well-designed access models are essential to lower the barriers to smaller firms.

One of the most explicit discussions of access models is provided by Kreiling et al. (2020), who argue that access arrangements to TI (here: collaborative platforms) can generally be categorised into two broad types: "(1) membership and (2) open access models" (Kreiling et al., 2020, p. 14). They illustrate the first type with an example from an Austrian collaborative platform (COMET Centres). In this case, both firms and research institutions are eligible to participate if they become centre partners – this requires an application process, and granted membership is limited to a specific funding period. The open access model is illustrated by a case under the European Commission's Open Innovation Test Beds (OITB) initiative, in which users can access TIs without being part of a

consortium. Instead, access is granted via evaluation (Kreiling et al., 2020). While these types summarize some overall characteristics of the cases covered in the report, there are still many nuances to the individual access policies of the platforms, which suggests the complexity of access model design.

Access is closely linked to access to finance, meaning that firms must be able to cover the user fees in order to access facilities, which is often a challenge to smaller firms. A strand of the policy-oriented literature discusses how demand side access-instruments can lower the financial barriers for firms that might otherwise be unable to access advanced facilities. For instance, a voucher or innovation grant scheme targeting startups and SMEs is mentioned as a potential way to stimulate firm access and use (EARTO, 2022; European Commission, 2025a; European Investment Bank, 2025; Viscido et al., 2022). Furthermore, Rambøll (2022) finds European examples of co-ownership models or shared facilities, which aims to spread risk across multiple users and lower capital requirements. However, no empirical evidence for the effectiveness of these models is presented.

As mentioned, SMEs and startups often struggle to identify relevant TIs for testing and validating innovations. Some countries attempt to address this challenge by providing single-entry-point models; an example is the Swedish platforms *Test Bed Sweden* and *Smart City Sweden*, which provide firms with a common gateway to identify and access available test and demonstration facilities, thereby improving visibility, coordination, and utilization of infrastructure (Rambøll, 2022). In line with this, the European OITB initiative “bring[s] together academia, research and technology organisations (RTOs) and companies, in a consortium with a single-entry point (SEP). SEPs should offer open access to testing and experimentation spaces, in particular for small and medium sized enterprises” (European Commission, 2023a, p. 3). Finally, the Danish platform Danske Testfaciliteter provides firms with an overview of the accessible TIs in the Danish innovation landscape, and a Nordic initiative aims to map Nordic facilities “to make it easy for Nordic companies to gain an overview of relevant suppliers of testing and demonstration facilities” (Jakobsen et al., 2018, p. 7; Rambøll, 2022). Together, these initiatives illustrate a growing recognition that improving access to technology infrastructures is not only a question of expanding physical capacity, but also of increasing visibility.

Governance and ownership

The literature further highlights that access is closely linked to ownership and governance arrangements. According to Mossberg et al. (2020), there are various challenges connected to the governance of TIs (in this case pilot and demonstration plants, PDPs). In a longitudinal case study of four Swedish biorefinery PDPs, Mossberg and colleagues find that such challenges are often just as important as technical challenges in these facilities. They highlight that PDPs often operate under complex governance arrangements involving universities, research institutes, firms, and public actors. This diversity of owners and actors can create challenges in terms of alignment of long-term objectives and establishing shared priorities. At the same time, it is emphasised that it is key that these facilities are perceived as “neutral spaces” (p. 6). Indeed, “it would be problematic if a single commercial actor controlled the plant, as this would exclude a broader set of stakeholders” (p. 6). This was a challenge in the concrete cases, since some of the actor networks around the PDPs tended to be dominated by a specific commercial actor.

These findings align with Grimm et al. (2020) who demonstrate that the organizational setup of such projects can shape how potential participants perceive green technologies. In particular, they find that full cooperation between government, universities and industry leads to more positive perceptions than more partial setups, especially regarding a technology’s market potential, innovativeness, environmental friendliness and contribution to the energy transition. In addition, communication, information provision and personal support are identified as central design features for participation and may be more important than direct economic incentives (Grimm et

al., 2020). This suggests that support systems surrounding TIs should not only address financial barriers, but also consider how projects are organised, communicated and supported in practice.

5. Conclusion

The focus of this review was on technology infrastructures (TIs) and their role in supporting firms' innovation processes, economic performance and collaboration with external knowledge actors. More specifically, the review has examined how firms' access to and use of TIs influence innovation outputs, economic outcomes and collaboration patterns, and which support instruments may promote firms' access to these infrastructures.

Overall, the reviewed literature points towards positive firm-level effects of TI use, particularly in relation to innovation. TIs provide firms with access to specialized facilities, equipment, capabilities and support services that they often cannot establish internally. By enabling testing, demonstration, validation and upscaling in realistic environments, TIs reduce technological and financial uncertainty and help firms move new products and processes closer to market. The evidence on economic effects is more limited. While the literature often links TIs to competitiveness, market formation and investment readiness, these effects are mostly inferred from innovation mechanisms rather than measured directly. Only a small part of the literature provides empirical indications of economic outcomes such as employment, public returns on investment and revenue generation. The literature also suggests that TIs may strengthen collaboration in innovation ecosystems. TIs can function as intermediary spaces where firms access external knowledge, identify relevant partners and engage with research, technology and industrial actors. This appears particularly important for SMEs and startups, which may lack internal resources, specialized knowledge and established networks.

A central point is that the effects of TIs depend on the support structures surrounding them. Funding models, access arrangements and governance structures influence whether TIs are established, maintained, upgraded and effectively used by firms. Public funding appears essential due to high investment costs, long development horizons and spillover effects. At the same time, access models such as open access, single-entry points and vouchers may lower barriers for firms, especially SMEs. Governance arrangements are equally important, since TIs often involve several public, private and research-based actors and must be perceived as neutral and accessible spaces.

The current evidence base is, however, fragmented. First, the concept of technology infrastructure is not fully coherent across literature. Several related terms are used, including testbeds, living labs, pilot plants and demonstration facilities, which makes it difficult to compare findings across studies. Second, much of the available literature is qualitative, case-based or policy-oriented, while robust quantitative studies of firm-level effects remain limited. Future research that strengthens the empirical basis for assessing TI effects is therefore needed. This could be longitudinal studies examining how firms' use of TIs leads to sustained effects over time or comparative quasi-experimental studies with larger samples and relevant control groups isolating the effects of TI use from all other factors influencing firm's innovative, economic or collaborative performance.

Finally, further studies are needed on the effectiveness of different support instruments. While the literature discusses several types of instruments, it provides limited evidence on which instruments work best, for whom and under what conditions.

Taken together, the reviewed literature points towards positive effects of TIs, particularly in relation to innovation, validation, upscaling and collaboration. However, the evidence is still mainly based on fragmented, qualitative and case-based studies, which limits the generalizability of the findings and makes it difficult to determine the

magnitude of these effects across firms and types of infrastructure. More robust empirical studies would therefore provide a stronger foundation for evidence-based policy and for future decisions on how technology infrastructure should be funded, organized and made accessible to firms.

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- Jakobsen, L. H., Rytz, B. K., Sørensen, S.Y., Hallin, G., Lindquist, P., Antikainen, J., Laasonen, V., & Ekambaram, A. (2018). *Nordic test and demonstration facilities: a mapping of test and demonstration facilities in the Nordic region* (TemaNord 2018:509). The Nordic Council of Ministers, 5-59.
- Jakobsen, L. H. (2020). *Building a Nordic innovation ecosystem around technology infrastructures and testbeds A feasibility study of Nordic testbeds collaborations*. Danish Technological Institute, 4-46.
- Kreiling, L., Robinson, D. K., & Winickoff, D. (2020). Collaborative platforms for innovation in advanced materials. *OECD Science, Technology and Industry Policy Papers*, 4-67.
- Malmer, T., Grande, S. & Andersdotter, C. (2018). *Workshop on good practices on increased accessibility of research/innovation infrastructure to industry for testing, demonstration and co-creation: Test beds as drivers for EU growth and innovation*. JRC Publications, 5-22.
- Moore, D., Bulatovic, V., MacIntyre, P., Woock, K., Woon, L., & Barton, B. (2021). *Analysis of Access to Innovation Facilities*. Sapere, 1-77.
- Rambøll (2022). *Danmark som Testland – Barrierer og Muligheder*. For Industriens Fond, 3-40.
- Edström, A., Dalunde, P. & Andersson, A. (2022). D1.1 Validated RIs-TIs Classification Report. *RITIFI – Research Infrastructure Technology Infrastructure For Impact*.
- The European Investment Bank (2025). *Unlocking innovation - Addressing the Funding Needs of EU Technology Infrastructures*, 1-38.
- The Ministry of Higher Education and Science (2016). *Metoderapport: Evalueringsramme for innovationsinfrastruktur*. Styrelsen for Forskning og Innovation, 4-26. No longer available online.
- Viscido, Sophie., Taucer, Fabio., Grande, Sergio., Jenet, Andreas. (2022). *Towards the Implementation of an EU Strategy for Technology Infrastructures*. Publications Office of the European Union, 1-26.

Appendix 1. Overview of included literature

Table A.1: Overview of reviewed literature

Reference	Purpose/Topic/Focus/RQ	Geography	Tags	Relevant findings/contributions
Alexandrakis, J., Hein, J., & Kratzer, J. (2022). Living labs and small and medium-sized enterprises: a symbioses propelling sustainable innovation. <i>Sustainability</i> , 14(19), 12729.	<i>Based on the concept of program evaluation, the effects on SMEs' innovation are determined with a preliminary qualitative study. The impact of Living Lab projects on innovation output, activities, capabilities, and knowledge flows of 12 European SMEs are then empirically tested in a quantitative study.</i>	EU and EEA	Living Labs; Innovation effects; Qualitative; Quantitative	• Significant effects on the innovation performance of SMEs resulting from participation in Living Labs are identified. • Living Lab projects mainly influence the sustainable innovation output and knowledge flows of SMEs.
Bäckström, K. (2015). <i>What are the Innovation Effects of Pilot and Demonstration Plants?: The Case of Advanced Biofuels in the Transport Sector</i> . European Biomass Conference and Exhibition 2015, Vienna, Austria.	Examines whether publicly funded pilot and demonstration plants (PDPs) stimulate innovation in advanced biofuel technologies, measured through patent activity across eight European countries (1980-2011)	EU and EEA	Pilot and demonstration plants; Innovation effects; Economic effects; Quantitative	• PDP activities are overall positively correlated with biofuel patenting activity; • both experimental and exemplary PDPs encourage biofuel innovation although the impact of the former is more profound; • and development activities in experimental PDPs encourage innovation also indirectly through knowledge spillovers across countries.
Bossink, B. A. (2015). Demonstration projects for diffusion of clean technological innovation: a review. <i>Clean Technologies and</i>	Reviews how demonstration projects help develop and diffuse clean technological innovations, asking how their effectiveness can be improved and how	EU and EEA; Non-EU	Demonstration projects; Innovation effects; Collaboration	• Demonstration projects are most effective when organized as a sequential process that progressively test, refine, and commercialize innovations.

<i>Environmental Policy</i> , 17(6), 1409-1427.	they contribute to moving technologies from prototypes to market adoption.		effects; Support instruments;	• They play a crucial role in reducing uncertainty, enabling learning, and linking technology development with real-world use and market uptake • Their success depends on key conditions, especially balanced risk-reward arrangements, cost reduction, stakeholder learning, supportive policy frameworks, and sufficient resources.
Catalano, G., López, G. G., Sánchez, A., & Vignetti, S. (2021). From scientific experiments to innovation: Impact pathways of a Synchrotron Light Facility. <i>Annals of Public and Cooperative Economics</i> , 92(3), 447-472.	Examines how research infrastructures (e.g., a synchrotron facility) generate innovation, tracing the pathways from scientific experiments to economic and technological impacts	EU and EEA	Research infrastructures; Economic effects	• Innovation pathways are complex and indirect, involving multiple actors and long time lags from research to application. • Most outputs are initially scientific (publications) rather than direct innovations, but they later contribute to technologies and patents. • Additional research and time are usually required before experiment results become economically relevant innovations.
Chatti, R., Drabo, M. & Gagnon, D. (2024). Innovation Ecosystem Performance Indicators: Review of the Literature. <i>Analytical Studies: Methods and References</i> , no. 11-633-X — No. 052.	Reviews existing literature to identify and systematize indicators for measuring the performance of innovation ecosystems and develop a comprehensive framework linking innovation inputs and outputs.	Non-EU	Innovation effects; Economic effects	• Innovation ecosystem performance can be understood through a structured input-output framework, combining factors like human capital, infrastructure, finance, and collaboration (inputs) with knowledge creation, employment, and production (outputs) • A standardized set of widely used indicators (38 key variables) provides a robust and comparable

				way to assess and benchmark innovation systems across regions and countries
Cundeva-Blajer, M. (2025). Research infrastructure open access approach—Implementation challenges and solutions for accredited calibration laboratories. <i>Measurement: Sensors</i> , 38, 101613.	Investigates how accredited research laboratories can implement open access research infrastructure policies while still complying with strict confidentiality requirements (ISO 17025), using a case study to identify challenges and practical solutions	EU and EEA	Research infrastructure; Test and demonstration facilities; Testbeds; Economic effects; Innovation effects; Collaboration effects; Support instruments	• It is possible to reconcile open access and confidentiality requirements through structured policies, risk-based procedures, and clear governance frameworks. • Implementing open access in research infrastructures improves collaboration, resource efficiency, knowledge sharing, and innovation, especially for external users
Engels, F., Wentland, A., & Pfothenhauer, S. M. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. <i>Research Policy</i> , 48(9), 103826.	<i>We develop an analytic framework for test beds and living labs as instruments for experimental innovation governance operating under real-world conditions</i>	EU and EEA	Innovation facilities; Living labs; Testbeds Support instruments	• <i>Test beds and living labs tentatively stabilize and test new sociotechnical orders on a local scale in an “as-if” mode of adoption and diffusion.</i> • <i>three characteristic tensions around controlled experimentation vs. open co-creation; learning from failure vs. public demonstration of success; local embedding vs. scalability.</i> • <i>Test beds/living labs offer opportunities to co-develop technology and regulatory frameworks in tandem.</i>
Frishammar, J., Söderholm, P., Bäckström, K., & Ylinenpää, H. (2015). The role of pilot and	<i>The objectives of this article are to synthesise and categorise existing research on PDPs, as well</i>	N/A	Pilot and demonstration	• PDPs act as a bridge between lab research and real-world industrial/commercial application.

demonstration plants in technological development: synthesis and directions for future research. <i>Technology Analysis & Strategic Management</i> , 27(1), 1-18.	<i>as to suggest an agenda for future research. We review the PDP phenomena in three literature streams: engineering and natural science research, technology and innovation management, and innovation systems.</i>		plants; Innovation effects; Support instruments; Qualitative	• They enable learning and reduce uncertainty by testing and scaling up new technologies. • They also support wider innovation systems, including market development, collaboration, and policy-driven technological change
Grimm, V., Kretschmer, S., & Mehl, S. (2020). Green innovations: The organizational setup of pilot projects and its influence on consumer perceptions. <i>Energy Policy</i> , 142, 111474.	Investigates how the organizational setup of pilot/test/demonstration projects (PTDs) (e.g. government, academia, industry involvement) influences consumer perceptions of green technologies and willingness to participate in such projects	EU and EEA	Pilot-, test- and demonstration projects; Support instruments; Quantitative	• The organizational setup significantly shapes perceptions—full collaboration (government-university-industry) leads to more positive views of technologies (e.g. innovativeness, market potential, environmental benefits) than partial setups • Non-financial factors matter most: communication, engagement, and support are more important for participation than economic incentives.
Hendry, C., Harborne, P., & Brown, J. (2010). So what do innovating companies really get from publicly funded demonstration projects and trials? Innovation lessons from solar photovoltaics and wind. <i>Energy Policy</i> , 38(8), 4507-4519.	Analyzes what companies gain from publicly funded demonstration projects in renewable energy (solar PV and wind) and how these projects support innovation.	EU and EEA; Non-EU	Demonstration projects and trials; Economic effects; Innovation effects; Qualitative	• Demonstration projects help reduce uncertainty and bridge the “uncertain middle” between R&D and commercialization • They enable learning, testing, scaling, and market validation, improving technology performance and identifying user needs. • Effective innovation requires coordinated policy and sustained support, combining technology development with market creation.

Mihelcic, J. R., Ren, Z. J., Cornejo, P. K., Fisher, A., Simon, A. J., Snyder, S. W., Zhang, Q., Cooper, W., Moeller, J., Rose, B., Schottel, B., & Turgeon, J. (2017). Accelerating innovation that enhances resource recovery in the wastewater sector: advancing a national testbed network. <i>Environ. Sci. Technol.</i> 2017, 51, 7749–7758	Investigates how a national testbed network can accelerate innovation and adoption of resource-recovery technologies in the wastewater sector, addressing barriers to technology development, testing, and commercialization	Non-EU	Testbeds; Innovation effects; Economic effects; Qualitative	• A coordinated national testbed network can accelerate innovation by linking facilities, stakeholders, and data, thereby reducing risk and speeding up technology adoption. • Innovation in the wastewater sector is currently hindered by financial, regulatory, and organizational barriers, including risk aversion, fragmented testing, and the “valley of death” between demonstration and market uptake.
Mossberg, J., Frishammar, J., Söderholm, P., & Hellsmark, H. (2020). Managerial and organizational challenges encountered in the development of sustainable technology: Analysis of Swedish biorefinery pilot and demonstration plants. <i>Journal of Cleaner Production</i> , 276, 124150.	Examines managerial and organizational challenges in pilot and demonstration plants (PDPs) during the development of sustainable technologies (biorefinery cases in Sweden)	EU and EEA	Pilot and demonstration plants; Innovation effects; Collaboration effects; Support instruments; Qualitative	• unclear roles, ownership, and coordination issues can hinder technology development • diverse stakeholders often have misaligned goals and limited coordination. • Better management of networks can improve outcomes: addressing these challenges can speed up commercialization and strengthen innovation systems
Mousavi, S., Hellsmark, H., & Söderholm, P. (2023). How can pilot and demonstration plants drive market formation? Lessons from advanced biofuel development in Europe. <i>Technological Forecasting and Social Change</i> , 194, 122703.	<i>This paper analyzes through what enabling mechanisms pilot and demonstration plants (PDPs) reduce supply and demand uncertainties, and thereby contributing to the market formation for novel sustainable technologies (case studies).</i>	EU and EEA	Pilot and demonstration plants; Economic effects; Innovation effects; Support instruments; Qualitative	• <i>PDPs contribute to supply uncertainty reduction through three enabling mechanisms: building credibility for the technology, technology learning, and business</i> • <i>Using PDPs, technology actors could reduce demand uncertainty through the following three mechanisms: technology stand-</i>

				ardization, constructing the narrative, and creation of legitimacy for the new technology Policy should facilitate ecosystem orchestration and stimulate the development of the value chain around the PDPs, particularly for the large-scale, market demonstration plants
Nemet, G. F., Zipperer, V., & Kraus, M. (2018). The valley of death, the technology pork barrel, and public support for large demonstration projects. <i>Energy Policy</i>, 119, 154-167.	RQ: <i>how public support for low-carbon technology demonstration projects can be structured to be most effective in overcoming the valley of death?</i>	EU and EEA	Demonstration projects; Support instruments; Quantitative	- Prioritize learning as a core objective: projects should focus on knowledge creation, monitoring, and sharing results. - Scale up iteratively: gradual, step-by-step expansion with learning from failures is crucial for successful commercialization. - Balance public-private roles: funding and risk-sharing vary widely, but strong private sector involvement is essential. - Ensure strong support systems: effective innovation needs both knowledge dissemination and robust market (demand-pull) conditions.
Palage, K., Lundmark, R., & Söderholm, P. (2019). The impact of pilot and demonstration plants on innovation: The case of advanced biofuel patenting in the European Union. <i>International Journal of Production Economics</i>, 210, 42-55.	<i>to investigate how pilot and demonstration plants affect innovation in the empirical context of advanced biofuel technology. Patent counts are used as a proxy for innovation; we employ data for eight EU Member States over the time-period 1980-2011,</i>	EU and EEA	Pilot and demonstration plants; Innovation effects; Economic effects; Support instruments; Quantitative	<i>the knowledge built up through investments in PDPs has had positive effects on advanced biofuel innovation</i> <i>both experimental and exemplary PDPs appear to stimulate innovation in the field but the effect of the former is much more profound (and robust)</i>

	<i>and negative binomial regression techniques. The focus is on plant investments that have received public co-funding</i>			• <i>there is no positive interaction between PDP investments and bio-fuel blending obligations;</i> • <i>experimental PDP activities also affect innovation via knowledge spillovers across EU Member States.</i>
Prieto, C., Fereres, S., & Cabeza, L. F. (2020). The role of innovation in industry product deployment: Developing thermal energy storage for concentrated solar power. <i>Energies</i> , 13(11), 2943.	<i>Despite the fact that the link between knowledge and firm growth has been deeply studied in the literature, there is a clear lack of empirical evidence This paper contributes in filling this gap by presenting a case study which shows that innovation in a company working a rapidly growing market was the key point to achieve successful commercialization of new technologies.</i>	EU and EEA	Pilot and demonstration plants; Innovation effects; Qualitative	• Innovation and collaboration are critical to reduce costs and successfully commercialize new energy technologies • Pilot and demonstration plants are essential for validating technologies and scaling them to market. • Sustained public and private investment is necessary, as high costs and risks limit innovation without strong support
Salvalai, G., Brutti, D., & Sesana, M. M. (2025). Design, construction, and operation of a novel Open Innovation Test Bed for real-life performance assessment of multilayer building envelope solutions. <i>Journal of Cleaner Production</i> , 525, 146511.	Discusses the creation of a unique ecosystem that can accelerate the transition of open innovations, towards the development of Open Innovation Test Beds (OITBs) for testing and up-scaling standard and pioneering envelope solutions.	EU and EEA	Open innovation testbeds; Living labs; Innovation effects; Collaboration effects; Support instruments; Quantitative	• Real-life Living Lab testbeds enable more accurate, holistic performance assessment of building technologies than traditional lab tests, supporting innovation uptake and decarbonization. • Networked Open Innovation Test Beds (OITBs) accelerate innovation diffusion by connecting research, industry, and real-scale testing facilities across Europe
Salvalai, G., Sesana, M. M., Dell'Oro, P., & Brutti, D. (2023).	Literature review.	EU and EEA	Testbeds; Innovation effects;	• Open innovation improves innovation performance by enabling

Open innovation for the construction sector: Concept overview and test bed development to boost energy-efficient solutions. <i>Energies</i> , 16(14), 5522.	Examines how open innovation and Open Innovation Test Beds (OITBs) can be applied to the construction sector to boost energy-efficient, sustainable building solutions and innovation ecosystems.		Economic effects; Qualitative	collaboration and knowledge sharing beyond firm boundaries • OITBs are key enablers, providing shared facilities to test, scale, and commercialize innovations more efficiently • Collaborative ecosystems are essential to overcome sector barriers and accelerate sustainable, energy-efficient solutions in construction
Sofronievska, A., Cheshmedjievska, E., Stojcheska, D., Taneska, M., Gjorgievski, V. Z., Kokolanski, Z., & Taskovski, D. (2025). Understanding Living Labs: A Framework for Evaluating Sustainable Innovation. <i>Sustainability</i> , 18(1), 117.	<i>This paper synthesises academic and policy literature to develop a comprehensive qualitative framework for assessing Living Labs across nine dimensions: governance, user engagement, methods, infrastructure, outputs, scalability, sustainability, equity, and learning.</i>	EU and EEA	Living labs; Innovation effects; Collaboration effects; Qualitative	• Living Labs are effective as real-world, co-creative innovation ecosystems, but their potential is limited by conceptual ambiguity, fragmented evaluation practices, and inconsistent stakeholder engagement
Tolio, T., Copani, G., & Terkaj, W. (2019). Key research priorities for factories of the future—part II: pilot plants and funding mechanisms. In <i>Factories of the Future: The Italian Flagship Initiative</i> (pp. 475-494). Cham: Springer International Publishing.	Discusses possible funding mechanisms for industrial research and innovation, and identifies <i>three types of industrial research and innovation infrastructure that can support mission-oriented policies: lab-scale pilot plants, industrial-scale pilot plants, and lighthouse plants.</i>	EU and EEA	Pilot plants; Innovation effects; Support instruments; Qualitative	• PDPs are essential bridges linking research to commercial use, but their role is more complex than just technical scaling • Learning and uncertainty reduction are central, yet not fully understood and need deeper study. • Successful PDPs depend on collaboration and policy support, as firms alone often lack incentives or resources

Note: Direct quotations are italicized

Table A.2: Overview of non-reviewed literature

Reference	Purpose/Topic/Focus/RQ	Geography	Tags	Primary findings
Arntzen, S., Wilcox, Z., Lee, N., Hadfield, C., & Rae, J. (2019). Testing innovation in the real world. <i>London: Nesta.</i>	Examines how real-world testbeds (controlled environments for testing innovations in real-life conditions) are used globally, how they support innovation, and how they should be designed as an innovation policy tool.	EU and EEA; Non-EU	Real world testbeds; Qualitative	- Real world testbeds <i>can reduce the barriers to testing by helping manage risk, change and test regulation, allow access to real-world environments and user groups or their associated data</i> <i>Public sector involvement in this kind of innovation infrastructure is important to incentivise the sector to innovate in a safe and controlled manner</i>
EARTO (2022). <i>Case Studies on Technology Infrastructures.</i>	This booklet presents various case studies on some key TIs created and managed by EARTO members to support Member States and the European Commission in their thinking on how to further develop the new EU strategy on technology Infrastructures envisioned in the ERA Policy Agenda. This booklet particularly aims to exemplify what is a TI, hence serves as a reference for the ongoing discussions with the European Commission and Member States on TIs.	EU and EEA	Technology infrastructures; Economic effects; Innovation effects; Collaboration effects; Support instruments; Qualitative	- As European industry's innovation capacity, productivity and international competitiveness heavily depend on possibilities to develop, test, validate and upscale new technological solutions at an even-faster pace, TIs are crucial elements of building bridges between science and the market. - The lab can support the entire process of product development and testing, ranging from the technology development to the early-stage experimentation, upscaling, prototyping, validation and demonstration. - Attracting small enterprises to use the facility: the daily price is market-oriented and for

				small companies this cost could be very high, particularly if the usage is for a long period. In this case, innovation grants (i.e. vouchers) would be appropriate to facilitate the usage of the infrastructure.
EARTO (2020). EARTO Paper: <i>Setting-up a European Strategy for Technology Infrastructures.</i>	The critical momentum for the EU together with Member States is addressed. EU must be more ambitious and jointly develop a European Strategy for Technology Infrastructures with relevant stakeholders (including both the providers and the users of such facilities), boosting technology co-creation, scale-up and diffusion across Europe. EARTO therefore puts forward a set of recommendations to contribute to the set-up and efficient implementation of a new EU strategy for TI's	EU and EEA	Technology Infrastructures; Economic effects; Innovation effects; Support instruments	- Public funding enables to lower the risk and the cost for companies, which often co-invest in the technology infrastructure, giving rise to a mixed model of public (regional/national/EU) and private funding. - Regardless of the size of the initial investment, investing in TI's always has a considerable impact. - TIs provide the necessary services to solve industry's challenges, turning innovative ideas into large volume production.
Edström, A., Dalunde, P. & Andersson, A. (2022). D1.1 Validated RIs-TIs Classification Report. <i>RITIFI – Research Infrastructure Technology Infrastructure For Impact.</i>	This document describes how RIs and TIs are defined in various EU and national publications, their conceptual recognitions, some key observations about the commonalities and discrepancies between the two, some policies af-	EU and EEA	Research Infrastructures; Technology Infrastructures; Innovation effects; Support instruments	- A common set of criteria for RIs and TIs is needed to enable visibility of plausible synergies, governance and investments to strengthen the research and innovation competitiveness in Europe. - The TI landscape is much more diverse and much less integrated than the RI landscape. The TI

	fecting Ris and TIs, and a discussion of various criteria used for these concepts			landscape has been developed over decades from a variety of needs and funding models, resulting in a plethora of large and small entities with various ownership and business models, scope and expertise, catering to all types of businesses large and small as well as the public sector. Depending on context, what we know as TIs today have previously been characterized as e.g., testbeds, pilot lines, living labs or test and experimentation facilities.
European Commission (2019). <i>Technology Infrastructures - Commission Staff Working Document</i> .	Suggests that there is a critical momentum for the EU together with Member States to be more ambitious, exploring with relevant national and regional stakeholders a shared vision and jointly developing a European strategy for technology infrastructures to support industry scale-up and technology diffusion across Europe.	EU and EEA	Technology infrastructures; Economic effects; Innovation effects; Collaboration effects; Support instruments	• Technology infrastructures are critical for the development of new technology-based innovative products and services. They help businesses to reduce risk when testing the technological feasibility of new ideas, shorten time-to-market by providing pointers for streamlining and scaling up internal operations, avoid expenditures on new equipment and/or avoid disruption of business operations. • Industry's competitiveness and ability to succeed on global markets critically depends on possibilities to test, validate and upscale new technological solutions. • For SMEs, and particularly those specialized in manufacturing, the impact of being able to access

				technology infrastructures can be significant. These companies experienced a 9 % increase in sales and a 7 % increase in employment.
European Commission (2023a). <i>Open innovation test beds for advanced materials : examples and lessons learnt from one type of technology infrastructure</i> . Publications Office of the European Union.	Analyses Open Innovation Test Beds (OITBs) as EU-funded technology infrastructures that support companies—especially SMEs—in developing, testing, and scaling advanced materials, while identifying best practices, challenges, and conditions for their long-term sustainability.	EU and EEA	Open innovation testbeds; Economic effects; Innovation effects; Support instruments; Quantitative	• OITBs are a promising and unique tool for accelerating innovation in advanced materials and helping SMEs bring technologies closer to market • Their main challenges are low visibility and difficulty achieving sustainable, market-based business models after public funding ends • Improving SME outreach, marketing, and financial sustainability (e.g. via strong single-entry points and business strategies) is crucial for long-term success
European Commission. (2023b). <i>Open Innovation Test Beds: Improving access to knowledge to accelerate European innovation</i> . Publications Office of the European Union.	presents and showcases EU-funded Open Innovation Test Beds (OITBs), examining how shared testing facilities and knowledge infrastructures help industries—especially SMEs—overcome barriers (cost, complexity, regulation) to develop, test, and commercialize advanced materials more quickly.	EU and EEA	Open innovation test beds; Innovation effects; Collaboration effects; Economic effects; Support instruments	• OITBs reduce costs, risks, and time-to-market by giving companies access to shared facilities, expertise, and integrated services for developing advanced materials • They are particularly beneficial for SMEs, helping them overcome financial, technical, and regulatory barriers that limit innovation capacity • OITBs strengthen collaboration and innovation ecosystems across Europe, enabling knowledge sharing, cross-sector networks,

				and faster diffusion of new technologies.
European Commission (2024a). <i>Policy Landscape Supporting Technology Infrastructures in Europe</i> .	The study gathered evidence-based information to provide an overview of existing policy initiatives, funding programmes and instruments, which aim at supporting the creation, upgrade, and long-term use and accessibility of Technological Infrastructures (TIs) The findings in this report are from the United Kingdom.	EU and EEA; Non-EU	Technology infrastructures; Economic effects; Innovation effects; Support instruments	- TIs are used to fill the requirement of translational infrastructure, to help bridge the gap between early-stage research and the later stage industrial commercialisation. - The most frequently cited examples of TI providers are the nine Catapult Centres, established from 2011 and now collectively receiving a core grant of £300-400m per year. They work with small, medium, and large businesses, to understand the challenges faced and support them in the development of solutions that will help improve their business performance, via access to expertise and facilities that enable them to test, demonstrate and improve their ideas.
European Commission (2024b). <i>Mapping of technology infrastructures supporting Clean and Renewable Energy industries in Europe</i> .	This report demonstrates the importance of technology centres in advancing CREI (clean and renewable energy industries) technologies and supporting the development of industries and companies in the CREI sector. Regarding the significant imbalance in the availability of the Technology Infrastructures in the EU, it suggests the need for a coordinated approach to support	EU and EEA	Technology infrastructures; Economic effects; Innovation effects; Collaboration effects; Support instruments	- It suggests the need for a coordinated approach to support the development of such infrastructures across the EU, and to facilitate access for companies to their resources, expertise and networks - Technology centres play a key role in supporting the development of industries and companies in the CREI sector by providing access to facilities, expertise, networks, and resources.

	the development of such infrastructures across the EU.			Technology centres and their technology infrastructures adapt their services to the general maturity level of a specific technology to better support the user needs.
European Commission (2025a). <i>Technology Infrastructures: A Strategic Asset for European Competitiveness</i> .	This report captures the discussions and insights from the first major EU conference on technology infrastructures. The conference was held in Warsaw on 6-7 May 2025. The conference highlighted that the strategic relevance of technology infrastructures is gaining growing recognition across Europe, with increasing momentum to position them as central enablers of innovation, resilience, and industrial leadership.	EU and EEA	Technology infrastructures; Innovation effects; Collaboration effects; Support instruments	- Technology infrastructures are increasingly recognized as critical enablers of innovation and industrial competitiveness. They provide the necessary facilities and services for research, development, and scaling of new technologies, thereby supporting Europe's twin transition. - Stakeholders from across the EU reiterate that technology infrastructures must be recognized not simply as facilities or service providers, but as strategic policy tools for advancing industrial innovation, strengthening Europe's resilience, and enabling the clean transition. - Discussions highlighted the importance of open-access models, which allow companies - especially SMEs - to test and scale innovations without needing to build their own facilities.
European Commission (2025b). <i>Towards a European policy for technology infrastructures - Building bridges to competitiveness</i> .	This report summarizes the work carried out by the Commission Expert Group on Technology Infrastructures (EGTI). The EGTI was established in November 2023	EU and EEA	Technology infrastructures; Innovation effects; Collaboration effects;	Develop support measures to improve the visibility of TIs (...) and to increase the opportunities and support for companies to access the infrastructure.

	with the main tasks to 1) advise and support the Commission in the analyses of the landscape of technology infrastructures, 2) to provide recommendations for a EU level investment prioritization and coordination mechanism for TIs, 3) to support the Commission in the analysis of access conditions and barriers to TIs and their services for different users.		Support instruments	• (TIs) enable and accelerate technological innovations towards societal/market adoption, fostering industrial competitiveness. • (TIs) are needed by companies to develop, test and validate new technologies and innovations. As they can shorten the time from lab to market and reduce the risks related to technology development and innovation activities. • Access to TIs for users where funding is an important barrier, such as SMEs, start-ups and scale-ups.
European Commission (2025c). <i>User needs for technology infrastructures - Analytical report.</i>	The Commission's objective is to develop an ecosystem approach to infrastructures supporting research, technology development and innovation, to ensure an adequate supply in Europe of world-class facilities and services, to strengthen synergies and complementarities between research and technology infrastructures as well as to address the specific challenges facing each type. This report presents the findings of a comprehensive collection of information and inputs performed in the framework of the Commission Expert Group on	EU and EEA	Technology infrastructures; Economic effects; Innovation effects; Collaboration effects; Support instruments	• TIs are important for industry to lower the costs and risks of technology maturation, prototyping, validation, and upscaling prior to industrial application and market entry. • The most significant barriers are on the side of the enterprises themselves, in particular the lack of financial resources to access TIs and the lack of staff. • The most used form of access to TIs is through collaborations with research organisations or universities hosting such facilities.

	Technology Infrastructures on the user needs.			
European Investment Bank (2025). <i>Unlocking innovation - Addressing the Funding Needs of EU Technology Infrastructures</i> .	This report presents the findings of a study commissioned by the European Investment Bank to assess the funding needs for capital expenditures and operational costs of technology infrastructures in the European union by 2030. The report is based on <i>desk research, a survey questionnaire to technology infrastructure operators, and interviews and workshops with operators and other stakeholders</i> .	EU and EEA	Technology infrastructures; Economic effects; Innovation effects; Collaboration effects; Support instruments	• An estimated €13-16 billion in capital investment is required by 2030 to build and upgrade technology infrastructures across the European Union. • Technology infrastructures primarily support industrial users, lowering the risks of private investments in technology and accelerating the uptake of cutting-edge and mature technologies across various industries. • Increase and facilitate access to technology infrastructures for startups and small businesses.
Jakobsen, L. H., Rytz, B. K., Sørensen, S.Y., Hallin, G., Lindquist, P., Antikainen, J., Laasonen, V., & Ekambaram, A. (2018). <i>Nordic test and demonstration facilities: a mapping of test and demonstration facilities in the Nordic region</i> (TemaNord 2018:509). The Nordic Council of Ministers.	<i>a mapping of test and demonstration facilities in the Nordic countries. In addition to the mapping, we have identified ten good practice examples of such facilities. Moreover, we have identified political initiatives in the Nordic countries, including specific strategies for setting up and structuring test and demonstration facilities</i>	EU and EEA	Test and demonstration facilities; Collaboration effects; Support Instruments; Qualitative	• <i>the Nordic test and demonstration facilities appear to be used by and are relevant for the companies.</i> • <i>The economic setup makes the focus of test and demonstration facilities largely market driven. This is positive for the companies, but in relation to the national (or Nordic) competitiveness, it could be advantageous to connect the innovation infrastructure more closely to the national strategies.</i>
Jakobsen, L. H. (2020). <i>Building a Nordic innovation ecosystem around technology infrastructures and testbeds A feasibility</i>	The report examines the feasibility of cross-border collaboration between Nordic testbeds and re-	EU and EEA	Collaborative platforms; Technology infrastructures;	• Cross-border collaboration is increasingly necessary because technologies are more complex, specialized, and global, making

<i>study of Nordic testbeds collaborations</i> . Danish Technological Institute.	search organisations (RTOs), asking how joint models can improve access to advanced technology infrastructures and support industrial innovation.		Testbeds; Support instruments; Qualitative	national testbed systems insufficient. There is clear potential for Nordic collaboration, but progress is limited by organizational barriers, lack of experience, and uncertainty about governance, costs, and shared control.
Kreiling, L., Robinson, D. K., & Winickoff, D. (2020). Collaborative platforms for innovation in advanced materials. <i>OECD Science, Technology and Industry Policy Papers</i> .	examines how collaborative platforms (shared infrastructures and networks) can support innovation in advanced materials, focusing on their governance, design, and the conditions under which they create scientific, economic, and societal value.	EU and EEA; Non-EU	Collaborative platforms; Support instruments; Qualitative	- Collaborative platforms accelerate innovation and reduce costs/time-to-market by pooling infrastructure, data, and expertise and coordinating value chains. - Their effectiveness depends on well-designed governance models (funding, access, and IP), which shape participation and long-term sustainability.
Malmer, T., Grande, S. & Andersdotter, C. (2018). <i>Workshop on good practices on increased accessibility of research/innovation infrastructure to industry for testing, demonstration and co-creation: Test beds as drivers for EU growth and innovation</i> . JRC Publications	Examines how test beds and innovation infrastructures can be made more accessible and coordinated in Europe to support industry, accelerate innovation, and inform an EU-level strategy for growth and competitiveness.	EU and EEA	Testbeds; Innovation effects	- Test beds are essential for transforming research into marketable solutions, enabling testing in real conditions, reducing risk, and speeding up innovation and competitiveness. - Europe needs a coordinated “Test Bed Europe” strategy that improves access, harmonizes practices, and strengthens collaboration across industry, research, and public actors - Effective use of test beds requires better accessibility (especially for SMEs), strong collaboration and

				trust (e.g., IPR handling), and sustainable funding/business models to scale innovation ecosystems.
Moore, D., Bulatovic, V., MacIntyre, P., Woock, K., Woon, L., & Barton, B. (2021). <i>Analysis of Access to Innovation Facilities</i> . Sappere	Analyzes how accessible innovation facilities are in New Zealand, identifying barriers, stakeholder experiences, and gaps across sectors (food, manufacturing, forestry) to inform policy and improve innovation outcomes.	Non-EU	Innovation facilities; Innovation effects; Qualitative	- Access to innovation facilities is uneven and constrained, particularly by costs, slow processes, limited awareness, and gaps between pilot and scale-up stages - Improving access requires policy action: clearer IP practices, better signposting/visibility, stronger funding support, and incentives aligned with faster, commercially focused innovation
Rambøll (2022). <i>Danmark som Testland - Barrierer og muligheder</i> .	The report maps Denmark's test, demonstration and development facilities and analyzes why SMEs in particular experience a lack of access to testing and scaling. The study is based on an initial review of written sources about available TDU facilities, reports and studies, as well as 15 interviews with central key players within basic research, applied research, business promotion and social partners within Life Science and welfare technology.	EU and EEA	Test-, demonstration- and development facilities; Economic effects; Innovation effects; Collaboration effects; Support instruments; Qualitative	- Danish companies' access to test, demonstration and development facilities is crucial to ensure growth and Danish companies the best possible position in international competition. - The primary reasons for the lack of facilities in the Danish test, demonstration and development infrastructure within Life Science and welfare technology are capacity and access, financing, legislation and technological development. - The interviewees say that larger companies (>1,000 employees) generally do not experience challenges when accessing and using TDU facilities. According to the interviewees, smaller companies, e.g. startups, experience being

				more dependent on contact with the universities or cooperation with larger companies to gain access to the TDU facilities.
Uddannelses- og forskningsministeriet (2016). <i>Metoderapport: Evalueringsramme-for-innovationsinfrastruktur</i> . Styrelsen for Forskning og Innovation.	The report describes a joint evaluation framework which must ensure better documentation, impact measurement and learning across Denmark's innovation infrastructure, which consists of GTS institutes, innovation networks and innovation environments. The framework is based on an effect chain approach, where the connection between inputs, activities, outputs and effects for companies and knowledge institutions is systematically assessed - both in the short and long term.	EU and EEA	Innovation facilities; Innovation effects; Collaboration effects; Support instruments	- The 22 innovation networks must ensure companies' access to a network of other companies as well as relevant knowledge institutions and authorities within the same industry and help to open the door for collaborations across traditional industry divides - Intervention is defined as a public intervention with a target group (companies or knowledge institutions) in the form of the innovation infrastructure's three types of institutions, which are designed to address various market failures and raise the level of innovation in Danish business life.
Viscido, Sophie., Taucer, Fabio., Grande, Sergio., Jenet, Andreas. (2022). <i>Towards the Implementation of an EU Strategy for Technology Infrastructures</i> . Publications Office of the European Union.	The purpose of the rapport is to provide policy recommendations from TI managers and users, as well as policy makers, to support the implementation of the ERA Policy Agenda towards an integrated European landscape for TIs in the next three years.	EU and EEA	Technology infrastructures; Economic effects; Innovation effects; Support instruments	- Industry's productivity and international competitiveness heavily depend on possibilities to test, validate and upscale new technological solutions with new levels of speed. For this, TIs are critical enablers in European RD&I ecosystems. - TIs fosters and leverages RD&I investments by industry, most of which would not take place if these companies did not have access to TIs.

				Public support is essential to enable access to TIs from a wide range of users including SMEs and academia who cannot afford the sometimes-high operational costs of TIs .
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Note: Direct quotations are italicized