

FUNCTIONING OF BUSINESS INCUBATORS AND TECHNOLOGY PARKS IN POLAND IN THE CONTEXT OF INDUSTRY 4.0

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Purpose: The aim of this article is to identify and evaluate the research infrastructure and the scope of services offered by business incubators and technology parks in Poland. This evaluation specifically focuses on the development of technology start-ups operating in Industry 4.0.

Design/methodology/approach: This study employed a netnographic survey method, encompassing the entire population of incubators and technology parks in Poland, including the start-ups operating within them. The analysis addressed three questions: Do parks and incubators specialize in supporting high-tech industries? How many companies are associated with a given park? Do the parks have facilities for conducting R&D services? The netnographic study reviewed the current state of services and laboratories, drawing on publicly accessible data from the websites of Polish technology parks and business incubators. Additionally, the article illustrates the importance of support from incubators and technology parks by presenting the development trajectories of the top startups in Poland in 2023, as recognized in the CEE Startup Challenge competition.

Findings: Business incubators and technology parks are fundamental to the innovation ecosystem, contributing to technology transfer, creating innovative solutions, and supporting new enterprises. This article highlights the role of 73 technology parks and business incubators as foundational for the operation of startups, with particular emphasis on the space industry. It presents the number of laboratories dedicated to high-tech industries, categorized by voivodeships, and includes a brief discussion on the details of the technologies used. The industry specialization of technology parks and incubators, particularly in high-tech and space industries, is also explored. The analysis of the development trajectories of the best startups in Poland revealed that three out of six winning startups used the services of technology parks, two received support from the National Center for Research and Development, and one did not use any public support.

Research limitations/implications: This article assesses technology parks and business incubators in the context of Industry 4.0 and examines how they support the entrepreneurship of technology startups. Future research should investigate startups in terms of diagnosing needs and assessing support received from these entities. It should also propose improvements in the operations of parks and incubators, with particular focus on the space industry. Suggestions for

enterprises on adapting to Industry 4.0 requirements would be beneficial. Additionally, the potential influence of park and incubator analyses on investments in modern technologies in Poland, and whether these institutions contribute to economic growth by supporting innovative ventures, is worth exploring.

Practical and Social implications: Knowledge about the role of technology parks and business incubators in Industry 4.0 can change societal attitudes towards entrepreneurship, innovation, and technology, fostering a positive approach to digital transformation. The research findings can inform public policy by highlighting the effectiveness of enterprise support in the Industry 4.0 era, potentially leading to more tailored government programs. The business and technology sector might adapt its standards and practices in light of these findings, thereby offering more effective support to start-ups and technology companies. The article is intended for scientists and researchers, business practitioners, entrepreneurs, and managers, providing valuable information, practical conclusions, and improvement tips in the context of Industry 4.0. It is also significant for policymakers responsible for shaping regulations and support programs for entrepreneurship.

Originality/value: The article conducts a literature review to define the boundaries of high-tech industries fundamental to Industry 4.0. The analysis of services and laboratories offered in parks and incubators in this context provides insight into how these institutions adapt to the evolving business environment. This comprehensive study of parks and incubators is the first of its kind in Poland.

Keywords: business incubator, technology park, start-up, seed capital, venture capital.

Category of the paper: research paper.

1. Introduction

In Poland, despite the dynamic development of the innovation sector, there is a noticeable research gap in the area of support for business incubators and technology parks for high-tech industries. The limited number of published scientific works on this topic presents a challenge for researchers, practitioners, and decision-makers who strive to fully understand and optimally shape the incubation ecosystem. The scarcity of publications hinders the identification of best practices, the analysis of the effectiveness of existing support models, and the prediction of potential development directions for high-tech incubators in Poland. Notable publications in English include: Butchart, R.L. (1987) "A New Definition of High Technology Industries", *Economic Review*, 400, pp. 82-88; Ghobakhloo, M. (2020) "Industry 4.0, Digitization, and Opportunities for Sustainability", University of Hormozgan, Iran; Glasson, J. (1992) "An Introduction to Regional Planning", 3rd edition, London: UCL Press; and Mason, C., Brown, R. (2014) "Entrepreneurial Ecosystems and Growth Oriented Entrepreneurship", OECD, Paris.

Industry 4.0 (Lasi, Kemper, Fettke, Feld, Hoffmann, 2014) marks a new stage in the evolution of the industry, based on advanced digital technologies, data integration, and automation. It is characterized by three main directions: automation and mechanization, miniaturization, and digitalization and networking. Industry 4.0 sets the trend towards more individualized, service-oriented, and socially responsible production.

The fourth industrial revolution is a dynamic process of digital transformation that significantly affects the functioning of society and enterprises. Industry 4.0 is developing exponentially, contributing to the digital revolution. It involves connecting intelligent machines and computers that communicate with each other, integrate with the environment, and can make decisions with minimal human involvement. Automation, in this context, means the use of advanced robots, control systems, and production management systems, which increases flexibility, efficiency, and quality of production (Ghobakhloo, 2022).

The technology sector is closely related to the research, development, or distribution of technology-based goods and services. It includes enterprises related to software development, electronics production, computers, and services and products related to information technology. The term "technology sector" is often used interchangeably with "technology industry" (Frankenfield, 2022).

A technology startup is an enterprise that operates to bring technology services and products to the market. They modify existing solutions by implementing modern technological innovations or introducing innovative services. Examples of technology startups include IoT (Internet of Things), FinTech (finance), BioTech (biotechnology), PropTech (real estate), MedTech (medicine), BigData, Blockchain (data), and Smart City (cities) (Blank, 2020).

This direction of development is significant worldwide, and understanding how Poland is adapting to this trend is important both nationally and internationally. Technology parks and business incubators play a crucial role in supporting innovative ventures in the technology sector. Recognizing the benefits and challenges of Industry 4.0 for these institutions will enable effective support for innovation and entrepreneurship development in Poland. Industry 4.0 may also significantly influence Poland's international competitiveness. Examining the functioning of business incubators and technology parks can reveal strategies for creating competitive advantages and maximizing benefits. Additionally, Poland benefits from EU funds that support Industry 4.0. Observing the functioning of technology parks and business incubators will allow for adapting activities to market needs and assessing the effectiveness of investments. The aim of this article is to identify and evaluate the infrastructure and scope of services offered by business incubators and technology parks in Poland, focusing on the development of technology start-ups operating in sectors related to Industry 4.0. This article may contribute to increasing interest in the importance of the role of business incubators, technology parks, and Industry 4.0.

2. Literature review

The classic approach to identifying "high-tech" companies is based on a sectoral approach, where "high-tech" industries are identified by specific characteristics. This approach originated in the UK with Butchart (1987). Using the four-digit level of the 1980 Standard Industrial Classification (SIC), it identified high-tech industries as those exhibiting higher-than-average research and development expenditures, as a percentage of sales, or employing a higher proportion of "skilled scientists and engineers" compared to other sectors (Butchart, 1987).

This definition was later updated in a study of the high technology industry in Oxfordshire using SIC 2003 by Glasson et al. (2006). They argued that this definition must consider the local or regional industrial structure. Consequently, Glasson et al.'s definition (2006) was adapted to account for local and regional economic conditions in Oxfordshire. This combination of precise criteria with an element of subjectivity, considering local conditions, is particularly compelling. Therefore, to incorporate the influential oil and gas sector, a significant part of Scotland's industrial strength, Glasson et al.'s definition was modified (Glasson, Chadwick, Lawton-Smith, 2006).

However, a weakness of this approach is that not every company within these sectors is necessarily "high-tech". Additionally, this approach excludes high-tech companies in industries not defined as high-tech (Mason, Brown, 2014).

The high-tech industry encompasses various branches and industries (Słowiński, 2023; GUS, 2002):

- chemical industry, related to the production of plastics, synthetic materials, and inorganic chemicals. This industry also includes the pharmaceutical industry, specializing in biotechnology-based medicine production.
- arms industry,
- aerospace and rocket industry, focusing on the production of flight and space research equipment, rockets, spacecraft, and aircraft,
- precision industry, concentrating on producing medical and optical equipment (telescopes, lenses, microscopes) and measuring devices. This industry is often located near scientific centers due to qualified staff requirements,
- transport industry, including car, ship, and aviation production,
- industrial electronics industry, producing integrated circuits, transistors, microprocessors, semiconductors, printing and measuring devices, medical and telecommunications equipment, as well as research and office equipment.

High-tech areas and products are characterized by significant R&D intensity. The high-tech industry is also defined by technologies included in licenses and patents, a high level of scientific and technical staff employment, significant technical equipment turnover, long-term cooperation with research centers and other high-tech enterprises, and the need for high capital

expenditure. Examples include astronautics, biotechnology, pharmacy, nuclear physics, computer science, quantum and materials engineering, aviation, medicine, robotics, and telecommunications (Wojnicka, 2006).

The development of high-tech industries is highly beneficial for the economy. The concept of a learning region (Florida, 1995) suggests that regions become central points for knowledge creation and acquisition. Regions are viewed as key economic units in the global economy, where globalization and regionalization are interconnected. According to this concept, regions are natural economic zones whose importance escalates in the era of globalization. Regions become focal points for knowledge creation and acquisition, taking on the characteristics of "learning regions". These regions act as collectors and repositories of knowledge and ideas, providing infrastructure that enables the flow of knowledge, ideas, and learning. The infrastructure supporting the knowledge-based economy includes:

- production infrastructure, i.e. a network of production companies,
- human infrastructure, i.e. the labor market from which companies draw employees,
- technical infrastructure (physical and communication) enabling the global flow of information, goods and services,
- a capital allocation system and a financial market that supports knowledge-based organizations,
- mechanisms of industrial governance, including formal and informal rules and norms that regulate relationships between companies, as well as between companies and government institutions.

The transition from a mass production economy to a knowledge-based economy represents a fundamental shift in how goods are produced and how the economy is organized (Romanowski, 2011, 2015). In the knowledge-based era, value and economic growth are primarily derived from the human mind rather than physical labor. The author notes that globalization does not signify the end of the role of regions; rather, regions are emerging as key economic units. The globalization process unfolds through complex systems of regional interdependence and integration. The future is moving towards strategies and policies focused on sustainable advantage at regional and national levels, rather than just national competitiveness. Sustainable advantage involves shifting focus from short-term economic performance to creating, maintaining, and sustaining conditions conducive to global leadership through continuous technology improvement, human resource development, clean production technologies, waste elimination, and a commitment to ongoing environmental improvement. The concept of a learning region suggests that regions are integral to the knowledge economy, providing the necessary infrastructure for the growth of knowledge-based organizations. Business incubators and technology parks, integral to the business environment infrastructure, play a pivotal role in developing the learning region.

A business incubator is an entity, an economic complex of various legal forms, designed to support entrepreneurship. Their offerings include real estate with premises and services to aid small and medium-sized enterprises. Incubators focus on supporting enterprise development, improving operational conditions, and aiding in the implementation of new technologies. Incubator services include (Brol, 2009, p.330): promoting entrepreneurship, consulting in finance, law, economics, organization, and patents; access to local business networks; support in acquiring funding; access to service and technical infrastructure; creating an environment conducive to starting a business, primarily for innovative projects; training; support in establishing contacts with scientific institutions for project evaluation; office and administrative services; and enabling enterprises to use premises on favorable rental terms, which increase as the company develops and participates in the incubator.

Depending on the target group, business incubators can be categorized into (Brol, 2009, p.331):

- incubators supporting young entrepreneurs from the small and medium-sized enterprises sector who are starting or are just about to start a business,
- incubators supporting the ideas of young people and students,
- incubators that provide assistance to social economy entities.

The scope of incubator activities can be broad, yet they are always well-conceived, adapted, and specialized to specific situations. The primary focus is on aiding innovative enterprises, especially in the early stages. The duration of cooperation, depending on the form of cooperation, rules, statute, and characteristics of the venture established in the incubator, can range from several months to several years. For entrepreneurs, the appropriate selection of incubator residents who can provide mutual assistance is also crucial. The operation of incubators is primarily supported by EU funds (Świeszczak, 2016, p. 67).

The types of business incubators include academic, social, technological, and scientific and research (Świeszczak, 2016). Academic incubators, established by universities under the provisions of the Act on Higher Education, aim to optimally utilize the technical and intellectual potential of a university and to transfer and apply research results in the economy. They also support the economic activities of the academic community, including students and university staff who are entrepreneurs. Academic incubators encompass pre-incubation, supporting individuals who want to start a business, as well as those supporting existing market incubation principles (Świeszczak, 2016, p. 68).

Social incubators, initiated by non-governmental organizations or local governments, offer training, advisory, and infrastructural assistance to social economy entities. They support people at risk of social exclusion, labor market integration, social assistance entities, and those interested in social economy entities (Pikuła-Małachowska, 2016, p. 94).

Technology incubators, often structured as technology or science and technology parks, facilitate improved technology and information flow between entrepreneurs and scientific entities. They focus on supporting small and medium-sized enterprises introducing new

technologies to the market. Scientific incubators concentrate on implementing and promoting competitive and innovative ventures (Pikuła-Małachowska, 2016, p. 95).

In Polish legislation, the concept of a technology park was defined in 2002 in the Act on Financial Support for Investments. A technology park is a complex of separate properties with technical infrastructure, designed to facilitate the flow of technology and knowledge between entrepreneurs and scientific entities. Technology incubators are often located in these areas (Act of March 20, 2002). The term "technology park" is synonymous with various names used interchangeably around the world, such as technopoly, research park, science and technology park, or science park. The International Association of Science Parks (IASP) has defined a technology park as an institution managed by experts whose main goal is to enhance the competitiveness and innovative culture of companies and scientific and research institutes associated with the park. The park oversees the processes of technology and knowledge flow between enterprises, universities, and research institutions. It also facilitates the development and establishment of innovative enterprises by offering incubation opportunities and assistance in creating spin-off companies. A science park performs similar functions to a technology park, but the production there is limited only to prototype production (Act of March 20, 2002).

Industrial or industrial-technology parks also operate alongside technology park institutions. These concepts vary depending on specialization or business profile. An industrial park is a group of separate properties with technical infrastructure that enables running a business under special conditions. The industrial-technology park is a hybrid between a technology park and an industrial park. It may take the form of a complex of buildings conducting activities that enable the flow of scientific information between entrepreneurs and scientific entities, serving as an infrastructure. There are also business and functional connections between technology and science parks. These parks are created by local authorities to provide favorable conditions for conducting business, especially for small and medium-sized enterprises (Matusiak, 2011, p. 186).

3. Method

The article employs the netnographic method. Netnography is a method of examining virtual communities through content analysis, observation, and other methods of analyzing content from the Internet (Kozinets, 2012).

The netnographic study aimed to review the current state of services and laboratories based on publicly available data from the websites of technology parks and business incubators in Poland, the towns where these institutions operate, and the Polish Investment and Trade Agency S.A. It was a comprehensive examination. To conduct the study properly, three research questions were posed:

1. Do they specialize in high-tech industries?
2. How many companies are associated with a given park?
3. Do they have the resources to conduct R&D services?

The collected information (Table 2) indicated that there are technology parks in Poland specializing in high-tech industries. These include Wrocław Industrial Park, Lublin Science and Technology Park, Lifescience Park Cracow, Mielec Industrial Park, Podkarpacki Science and Technology Park AEROPOLIS, Torun Technology Park, Łomża Industrial Park, Euro-Centrum Industrial Park, Technopark Pomerania, IT LOFT Park in Tychy, YouNick Technology Park, Kutnowski Agro-Industrial Park, Puławy Science and Technology Park, Branice Science and Technology Park, Industrial and Technology Park "Ekopark" in Piekary Śląskie, Lower Silesian Technology Park "T-Park", Bukowice Industrial Park, Lubuski Industrial Park Technology, Science and Technology Park "Świerk", Płock Industrial and Technology Park, Tarnobrzeg Industrial and Technology Park, Science and Technology Park Polska-Wschód in Suwałki, Gdańsk Science and Technology Park, Pomeranian Science and Technology Park Gdynia, Sosnowiec Science and Technology Park, Regional Science and Technology Center, Poznań Science and Technology Park of the University Foundation. A. Mickiewicza, the Science and Technology Park of the Koszalin University of Technology and the Bielsko-Biała Aviation, Entrepreneurship and Innovation Technology Park. Each technology park is characterized by an individual approach to the company seeking its services. In addition to basic services, support also includes providing specialized laboratories or prototyping facilities and expert knowledge.

The study involved analyzing the websites of all technology parks and business incubators in Poland. If an institution lacked a website or the data was incomplete, information was sourced from the websites of the towns where the incubator or park was located. An important source of information was the official website of the Polish Investment and Trade Agency, which contained crucial information on the functioning of technology parks and business incubators. Each park and incubator was evaluated based on the research questions.

Due to the extensive factual material, it was decided to describe the startups that were awarded in the EEC Startup Challenge 2023, i.e., the 15th edition of the European Economic Congress in Katowice, and then present their path to success.

4. Results

Despite sharing many comparable features, industrial and technology parks are entities of great diversity. Each technology park is distinguished by its unique character, shaped by regional cultural, economic, and social conditions, as well as local growth factors. It is not feasible to isolate a single practical park model or organizational template that guarantees

success. Specific initiatives reflect the local science and business ecosystem, industrial traditions, type of economy, and cultural aspects of entrepreneurship. In Poland, each voivodeship hosts several technology parks (Table 1) (www.paih.gov.pl, 2023).

In Poland, across sixteen voivodeships, there are 73 institutions referred to as technology parks or business incubators. The highest concentration of these institutions is in the Silesian Voivodeship (16), while the fewest are found in the Lubuskie Voivodeship (1).

Table 1.

List of technology parks in Poland divided into voivodeships, along with hi-tech laboratories

Voivodeship	Name of the park (number of enterprises in brackets)	Number of laboratories for hi-tech industries
Dolnośląskie	<ul style="list-style-type: none"> • Lower Silesian Technology Park "T-Park" (22), • Noworudzki Industrial Park (25), • Bukowice Industrial Park (no data), • Wrocław Industrial Park (45), • Wrocław Technology Park S.A. (141), 	14
Kujawsko-Pomorskie	<ul style="list-style-type: none"> • Bydgoszcz Industrial and Technology Park (73), • Grudziądz Industrial Park (11), • Industrial Park in Solec Kujawski (13), • Płużnicki Investment Park (no data), • Toruń Technology Park (70), • Vistula Park I and II (7), • Włocławek Economic Development Zone - Industrial and Technology Park (no data), 	1
Lubelskie	<ul style="list-style-type: none"> • Lublin Science and Technology Park (10), • Puławy Science and Technology Park (146), 	5
Lubuskie	<ul style="list-style-type: none"> • Lubuski Industrial and Technology Park (84), 	6
Łódzkie	<ul style="list-style-type: none"> • Bełchatowsko Kleszczowski Industrial and Technological Park (no data), • Bionanopark (35), • Kutno Agro-Industrial Park (43), • Boruta Zgierz Industrial Park (11), 	1
Małopolskie	<ul style="list-style-type: none"> • CracowTechnology Park (63), • Lifescience Park Cracow (no data), • Branice Science and Technology Park (98), 	8
Mazowieckie	<ul style="list-style-type: none"> • Science and Technology Park "Świerk" (13), • Płock Industrial and Technology Park (29), 	8
Opolskie	<ul style="list-style-type: none"> • Kędzierzyńsko-Koźle Industrial Park (no data), • Science and Technology Park in Opole Sp. z o. o. (26), 	1
Podkarpackie	<ul style="list-style-type: none"> • Mielec Industrial Park (52), • Industrial Park of the Leżajsk Commune (10), • Podkarpackie Science and Technology Park AEROPOLIS (91), • Tarnobrzeg Industrial and Technology Park (37), 	1
Podlaskie	<ul style="list-style-type: none"> • Białystok Science and Technology Park (35), • Science and Technology Park Poland-Wschód in Suwałki (74), • Łomża Industrial Park (101), 	8

Cont. table 1.

Pomorskie	<ul style="list-style-type: none"> • Gdańsk Science and Technology Park (30), • Kwidzyn Industrial and Technology Park (19), • Pomeranian Science and Technology Park Gdynia (189), • Słupsk Technology Incubator (24), 	12
Śląskie	<ul style="list-style-type: none"> • AURO Business Park Gliwice (no data), • Bielsko Aviation, Entrepreneurship and Innovation Technology Park (6), • Bytom Industrial Park (5), • Częstochowa Industrial and Technology Park (no data), • Euro-Centrum Science and Technology Park (no data), • Euro-Centrum Industrial Park (no data), • GPP Business Park (no data), • IT LOFT Park in Tychy (no data), • Science and Technology Park "Technopark Gliwice" (21), • Industrial and Technological Park "Ekopark" in Piekary Śląskie (8), • Sosnowiec Science and Technology Park (9), • Synergy Park (12), • Silesian Business Incubator (53), • Silesian Industrial and Technology Park (no data), • Zawiercie Industrial and Technology Park (6), • Żory Industrial Park (31), 	6
Świętokrzyskie	<ul style="list-style-type: none"> • Kielce Technology Park (111), • Regional Science and Technology Center (no data), 	7
Warmińsko-Mazurskie	<ul style="list-style-type: none"> • Elbląg Technology Park (27), • Olsztyn Science and Technology Park (48), • Science and Technology Park in Ełk (20), 	10
Wielkopolskie	<ul style="list-style-type: none"> • Eureka Technology Park (10), • Kalisz Business Incubator (no data), • Poznań Science and Technology Park of the University Foundation. A. Mickiewicza (88), • Poznań Technology and Industrial Park (no data), • Turkish Business Incubator (24), • YouNick Technology Park (9), 	2
Zachodniopomorskie	<ul style="list-style-type: none"> • Białogard Investment Park INVEST-PARK (6), • Goleniowski Industrial Park (45), • Science and Technology Park of the Koszalin University of Technology (21), • Industrial Park of Modern Technologies in Stargard (15), • Regional Park in Gryfino (no data), • Szczecin Shipyard "Wulkan" Sp. z o. o. (no data), • Technopark Pomerania (51). 	Brak danych

Source: www.paih.gov.pl, 2023.

A comprehensive analysis of technology parks and incubators revealed the range of services offered to young entrepreneurs. It's notable that the scope of services in these institutions is similar. Most technology parks or business incubators (60 out of 72) provide workspace, including offices, conference rooms, and laboratories for companies requiring specialized equipment. They offer business consulting in strategy, financial planning, marketing, and product development, and organize training and workshops, such as in business management. They assist in obtaining financing by providing information about grants and investment funds, facilitate building business relationships by enabling entrepreneurs to meet

potential partners, clients, investors, or mentors, and provide mentorship to help develop businesses through guidance and experience. They offer access to specialized equipment and technological infrastructure, collaborate with research centers, allowing companies to leverage the latest science and technology achievements, support legal and regulatory issues related to running a business, help companies establish international contacts with partners and customers, and foster cooperation with universities and research centers, giving entrepreneurs access to the latest technologies and research.

Technology parks and business incubators often tailor their services to the local market's specificity and the dominant industry profile in a region. Some institutions focus solely on selling or leasing space, totaling 12, including Płużnicki Investment Park, Vistula Park I and II, Włocławek Economic Development Zone - Industrial and Technology Park, Kutnowski Agro-Industrial Park, Leżajsk Commune Industrial Park, Tarnobrzeg Industrial and Technology Park, AURO Business Park Gliwice, Częstochowa Industrial and Technology Park, Industrial and Technological Park "Ekopark" in Piekary Śląskie, Białogard Investment Park INVEST-PARK, Goleniowski Industrial Park, and Regional Park in Gryfino.

In Poland, 23 technology parks and business incubators possess research and development (R&D) facilities. These include Wrocławski Park Technologiczny S.A., Bydgoszcz Industrial and Technology Park, Puławy Science and Technology Park, Lubusz Industrial and Technology Park, Bionanopark, Krakowski Park Technologiczny, Lifescience Park Kraków, Science and Technology Park "Świerk", Płock Industrial and Technology Park, Science and Technology Park in Opole, Podkarpacki Science and Technology Park AEROPOLIS, Białystok Science and Technology Park, Gdansk Science and Technology Park, Pomeranian Science and Technology Park Gdynia, Słupki Technology Incubator, Euro-Centrum Science and Technology Park, IT LOFT Park in Tychy, Kielce Technology Park, Elbląg Technology Park, Olsztyn Science and Technology Park, Science and Technology Park in Elk, Poznań Science and Technology Park of the University Foundation A. Mickiewicza, and YouNick Technology Park. R&D resources are a crucial part of their infrastructure that supports the innovation and technological development of enterprises. These resources may include advanced laboratories for research, prototype development, and new technology testing. The mentioned technology parks collaborate with R&D centers, universities, or other scientific institutions, allowing entrepreneurs to utilize their resources and expertise. They provide companies with access to specialized tools, equipment, and technology, often too costly for individual businesses. Employees at these parks are experts in various fields, providing substantive support to entrepreneurs in developing innovative solutions. They support companies in implementing R&D projects by offering financing, mentoring, and access to specialist knowledge.

R&D facilities in technology parks and business incubators are vital components of the innovation ecosystem, supporting the development of modern technologies and aiding companies in commercializing their ideas. Cooperation with research institutions and providing

specialized resources fosters favorable conditions for the growth of enterprises in technology and innovation.

In Wrocław Technology Park S.A., there are 14 modern laboratories and prototype rooms equipped with world-class equipment. This technologically advanced infrastructure enables research to transform innovative ideas into products. The park offers support in implementing research and development projects, and training in chemistry, biotechnology, molecular biology, and pharmacy. Enterprises focusing on areas such as cryogenics, catalyst production, innovative energy, generic pharmacy, or testing the physical properties of various products are prevalent. The park facilitates the creation of R&D consortia and establishes contacts between the scientific and business communities, both nationally and internationally. Technological facilities include laboratories and machine rooms equipped with, among others, a supercritical extractor, electropasteurizer, or spray dryer. The Bydgoszcz Industrial and Technology Park offers rental halls that can be used as warehouse space, workshops, showrooms, demonstration centers, and laboratories.

The Puławy Science and Technology Park hosts several laboratories: the Metal Injection Molding Laboratory (MIM), JG Machine and Tools Laboratory, Biodegradable Plastics Laboratory, Biologically Active Compounds Laboratory, Bioprocesses Laboratory, Technology and Development Division, Grupa Azoty Zakłady Azotowe Puławy S.A.

Lubuski Industrial and Technology Park offers CNC machine rental and coordinate measuring machine rental. The park also houses various laboratories: the Energy Generation Laboratory, the Sustainable Construction Laboratory, the Renewable Electricity Sources Laboratory, the Electromagnetic Compatibility Laboratory, the Acoustics and Electrostatics Laboratory, and the Acoustic Insulation Laboratory.

Bionanopark (Łódź Voivodeship) provides a wide array of research services: surface testing, biological and chemical analysis, pharmaceutical testing, cosmetic testing, biochemistry and cell culture, molecular biology and bioinformatics, industrial biotechnology, wine authentication, food testing, textile testing, 3D printing and scanning, medical implants, personalized medicine, organic electronics, computing resource sharing, and computational chemistry.

Cracow Technology Park features the KPT Community Cloud IT platform, a data center for server collocation and other IT devices, film post-production studios, and LivingLab for product research and UX consultations. Lifescience Park Cracow offers facilities like diagnostic imaging, clinical trials, Biological Analysis Laboratory, Chromatography and Mass Spectrometry Laboratory, Quality Control Laboratory, Microbiology Laboratory, NMR Spectroscopy Laboratory, and an Imaging Laboratory.

The "Świerk" Science and Technology Park, part of the National Center for Nuclear Research (NCBJ), includes the Advanced 3D Printing Laboratory, a 3D Scanner Laboratory, a Clean Room, and a Climatic Chamber Laboratory. The Institute operates the Świerk IT Center, HITEC (electron accelerators, particularly for oncological therapy), POLATOM

Radioisotope Center, and the Materials Research Laboratory. In the Płock Industrial and Technology Park, the largest chemical analytical laboratory in Poland and one of the leading industry laboratories in Europe enables the analysis of fuels, petroleum products, water, sewage, soil, and air.

Science and Technology Park in Opole Sp. z o.o. offers services in reverse engineering, CAD design, testing and measurement, and computer simulations. Podkarpacki Science and Technology Park AEROPOLIS houses the Aeropolis Materials Science and Prototyping Laboratory, which includes the Aging Research Laboratory, Rapid Prototyping Laboratory, Metallographic Laboratory, and Materials Characterization Laboratory.

The Białystok Science and Technology Park features a range of facilities in its laboratory: a PET/MR bio-scanner - Monocular Imaging Laboratory, Computer Graphics and Interactive Art Laboratory, 3D Prototyping Laboratory, Electromagnetic Compatibility Testing Laboratory, Biomedical Laboratory, Physicochemical Laboratory, Innovative Metallurgical Laboratory, Cisco Academy at BPN-T, and BaseLAB.

The Gdańsk Science and Technology Park boasts three laboratories: a small wind energy module, a module for testing the dynamics of microturbines and mini cogeneration plants, and a module for testing solar collectors, heat pumps, and hybrid heating systems. This park also offers specialized drone services. The Pomeranian Science and Technology Park Gdynia provides research services in its bio laboratory, specializing in chemical analysis, microbiology, molecular biology, and in vitro plant breeding. Gdynia Park's facilities also include a 3D printing laboratory, 3D measurement laboratory, measurement laboratory, biotechnology laboratory, destructive and non-destructive testing laboratory, measuring instrument calibration laboratory, and wood and metal processing laboratory. The Słupsk Technology Incubator's 3D Center offers services in 3D printing, 3D scanning, GD&T measurements, and reverse engineering.

Euro-Center Science and Technology Park features a Solar Systems Testing Center, Laboratory for Testing Thermal Properties of Buildings, Laboratory of Processes in Energy-Saving Construction, Photovoltaic Cells Laboratory, Climate and Meteorological Station, and Intelligent Energy Networks Laboratory. IT LOFT Park in Tychy caters to companies in the technology, IT, design, financial, and marketing industries with its laboratories. The Kielce Technology Park includes a LabDesign studio, CNC Center, ICT Center, Energy Science Center, 3D Printing Center, Technology Center, and a Complex of Technology Incubators.

The Elbląg Technology Park has Research and Development Centers: Environmental Quality Center, Metal Science Center, Wood and Furniture Technology Center, and Information Technology Transfer Center. The Olsztyn Science and Technology Park features technological, molecular, and chemical laboratories, along with the Center for Geomatics and Modern Satellite Technologies and the Center for the Propagation of Radio Waves in the Ionosphere. The Science and Technology Park in Elk houses a Food and Production Environment Research Laboratory.

Poznań Science and Technology Park of the University A. Mickiewicz Foundation provides a broad range of research and analysis services, including ion chromatography for ionic liquids analysis, supercritical carbon dioxide for quantitative and qualitative analysis, elemental analysis of solid and liquid samples, surface analysis with a scanning electron microscope (SEM), fatty acid profile analysis, rheological analysis, chromatographic analysis, thermal analysis, microbiological testing of cosmetics, asbestos fiber testing in water, sewage, and soil, microorganism growth testing, consulting, excavation and expert opinions, solvent extraction, carbon dioxide extraction, tangential filtration of liquids up to 10 liters, cultures in bioreactors, asbestos fiber identification in building materials, freeze-drying, fluorescence microscope imaging, organic remain aging using the accelerator method (AMS), chemical and technological processes, separation, purification and recovery of solvents, spectrophotometry and UV-Vis spectroscopy, supercritical carbon dioxide drying, and synthesis and production of chemical compounds and preparations.

Turek Business Incubator operates the Building Energy Consumption Assessment Laboratory and the Spatial Measurements and Non-Destructive Testing Laboratory. YouNick Technology Park offers modern laboratory and office spaces to companies from the Life Science, medical, pharmaceutical, biotechnology, and related industries, with areas adapted to SANEPID, GMP, GLP, HACAP, etc., requirements.

Table 2.

Specialization of technology parks and business incubators divided into specializations

Industry	Technology park/business incubator
Construction	Wrocław Industrial Park Podkarpackie Science and Technology Park AEROPOLIS, GPP Business Park,
Electromachines, electrical engineering, electronics, optoelectronics, electromobility	Wrocław Industrial Park, Lublin Science and Technology Park, Lifescience Park Cracow, Mielec Industrial Park, Podkarpacki Science and Technology Park AEROPOLIS,
Environmental Protection	Lublin Science and Technology Park,
IT, ICT, IoT, telecommunications, ICT, software	Wrocław Industrial Park, Toruń Technology Park, Lublin Science and Technology Park, Lifescience Park Cracow, Łomża Industrial Park, Euro-Centrum Industrial Park, Technopark Pomerania, IT LOFT Park in Tychy, YouNick Technology Park
Metallurgical industry	Wrocław Industrial Park, Lifescience Park Cracow
Logistics, transport, distribution	Bukowice Industrial Park, Wrocław Industrial Park, Kutno Agro-Industrial Park,
Biotechnology, Organic Chemistry, Pharmaceuticals, Chemistry, Life Sciences, Life Science, waste management,	Lublin Science and Technology Park, Puławy Science and Technology Park, Kutno Agro-Industrial Park, Lifescience Park Cracow, Branice Science and Technology Park, Podkarpacki Science and Technology Park AEROPOLIS, Industrial and Technology Park "Ekopark" in Piekary Śląskie, YouNick Technology Park

Cont. table 2.

High-tech	Lower Silesian Technology Park "T-Park" Bukowice Industrial Park Toruń Technology Park, Lubuski Industrial and Technology Park Bionanopark Łomża Industrial Park Science and Technology Park "Świerk", Płock Industrial and Technology Park Mielec Industrial Park, Tarnobrzeg Industrial and Technology Park Science and Technology Park Poland-Wschód in Suwałki, Gdańsk Science and Technology Park, Pomeranian Science and Technology Park Gdynia, Sosnowiec Science and Technology Park, Regional Science and Technology Center Poznań Science and Technology Park of the University Foundation. A. Mickiewicz, Science and Technology Park of the Koszalin University of Technology,
Sustainable energy, energy, energy-saving technologies, renewable energy	Lifescience Park Cracow, Mielec Industrial Park, Euro-Centrum Science and Technology Park, Euro-Centrum Industrial Park,
Food industry	Kutno Agro-Industrial Park,
Plastics industry	Kutno Agro-Industrial Park, Podkarpackie Science and Technology Park AEROPOLIS,
Machinery	Kutno Agro-Industrial Park, Lifescience Park Cracow
Railway industry, mining, heating	Mielec Industrial Park,
Multimedia, marketing	IT LOFT Park in Tychy,
Space, aviation,	Mielec Industrial Park, Podkarpackie Science and Technology Park AEROPOLIS, Bielsko Aviation, Entrepreneurship and Innovation Technology Park,

Source: Own work based on the websites of the mentioned institutions.

According to the classification of high-tech industries in Poland, technology parks and business incubators can specialize in particular industries (Table 2). To fulfill the purpose of this article and given the extensiveness of the factual material, the study focused on examining the development paths of the best technology start-ups in Poland, awarded in the EEC Startup Challenge.

The EEC Startup Challenge 2023, the 15th edition of the European Economic Congress in Katowice, took place in Poland from April 24-26, 2023, where awards were presented to the best startups in various categories. A total of 213 projects were submitted to this year's edition of the competition. The prize for the winners included a voucher sponsored by OVHcloud, granting participation in the special OVHcloud Startup Program acceleration program for startups, along with a promotional campaign in industry media (Koc, 2023).

In the environmental protection category, focusing on smart energy, raw material use, waste processing, climate technologies, and ecological crops, the winner was Biostra from Katowice. The company offers solutions to modify bio-waste into solid organic fertilizer SOILREN, addressing composting plant issues. During their presentation, the team showcased an innovative concept related to waste processing, which the jury appreciated. The judges also

valued the startup's current financing round and its solution to a critical environmental issue. However, SOILEREN does not maintain records of business support (dlahnadlu.pl, 2023).

In the category of automation, industry, robotics, energy, construction, telecommunications, and transport, the winner was ParkCash from Rzeszów. The startup adapts non-urbanized office parking lots for hybrid work by launching a system for booking and sharing parking spaces, as well as providing mobile access to barriers and gates. ParkCash's application allows employees to reserve parking spaces before leaving for work, reducing stress associated with finding parking and helping to decrease carbon footprints. The jury noted the idea's ease of implementation, potential for widespread adoption, and relevance in the modern economy (Koc, 2023).

ParkCash startup is located in the Podkarpackie Science and Technology Park AEROPOLIS, particularly in the Technology Incubator in Jesionka. As part of the "Expansion of the Podkarpackie Science and Technology Park (PPNT) - stage II" project, an agreement was signed in 2010 with the Polish Agency for Enterprise Development and the Rzeszów Regional Development Agency S.A. under the Operational Program Development of Eastern Poland 2007-2013. This project established four research and development laboratories: three within the Research Laboratory facility for the Rzeszów University of Technology (including the Laboratory of Composite and Polymer Materials for Aviation, the Laboratory for the Application of Information Systems in Diagnostics, and the Laboratory for Computer-Aided Research and Design of Aviation Structures and Alternative Renewable Energy Sources), and one within the scope of the Biotechnology Laboratory for the University of Technology. The project also entailed constructing a Technology Incubator complex with a PPNT Service Center. The project's third stage aimed to strengthen and supplement the research base for enterprise development and increased competitiveness based on innovation ideas by creating the Aeropolis Laboratory, equipped with high-end equipment to provide specialized research services for the industry (AEROPOLIS, 2023).

The best company in the business process category related to management, HR, analytics, logistics, ICT, and cybersecurity was Zonifero. This Białystok-based company boasts its own office management program, transforming spaces to allow employees to choose a convenient work style. The platform interacts with IoT sensors that control building activity in real time, monitoring employee presence, light intensity, humidity, and temperature. Sensors developed by the startup significantly reduce building operation costs and improve communication. The platform also aims to reduce the carbon footprint in office buildings. The jury appreciated the project for the company's knowledge and competence, scalability, and technology, which influence the comprehensiveness and maturity of the solution (www.portalsamorzadowy.pl, 2023). Zonifero was developed within TenderHut, a company specializing in the IT industry and developing modern technologies in areas such as solutions for laboratories, workplaces, and telemedicine (TenderHut, 2023).

The competition also highlighted the best startup in the *client & lifestyle* category, encompassing industries like leisure, trade, sports, customer experience, gaming, e-commerce, edutech, and fintech. Startup Magly was recognized for its platform that creates modern and fully personalized hotel attractions through interactive educational games designed for families. Its innovative controller recognizes player movements and interacts with monitors throughout the facility and various objects. The game operates without VR glasses or phones, utilizing the emerging phi digital trend, which impacts the future of the gaming industry. The company was further rewarded with a trip to Expand North Star in Dubai, the world's largest startup event. Participants at this prestigious event can engage in mentoring sessions, the Supernova Challenge competition, and networking, meeting entrepreneurs and investors from around the world (wkatowicach.eu, 2023). Magly was part of a project by Unicorn Hub, aimed at supporting the development of innovative startups from Eastern Poland through a comprehensive incubation program preparing startups for market entry. Cracow Technology was one of the project partners (UnicornHub, 2023).

Diagendo was recognized as the best company in the *health & biotechnology* category, which includes industries related to medicine, biotechnology, health, pharmacy, and medical technologies. The startup presented an innovative medical device, EndoRNA, for analyzing endometriosis diagnostics using qRT-PCR, a technique popularized in Poland due to the COVID-19 pandemic. The team claims that results should be available within 48 hours of sample receipt, depending on laboratory availability. The jury considered the idea significant as it responds to current diagnostic needs for illnesses and diseases (PTWP, 2023). Diagendo collaborated with scientists from the Medical University of Warsaw, including Prof. Jacek Malejczyk and Dr. Ilona Kalaszczyska from the Department and Department of Histology and Embryology.

At this year's European Economic Congress in Katowice, the finalist of the InCredibles program, initiated by Sebastian Kulczyk, was also selected. The winner was startup Hydropolis, offering solutions and services for running and creating vertical farms anywhere in the world using its proprietary platform and Grow Wizard automation (Koc, 2023). Hydropolis collaborated with EQ Development Wojciech Krajewski and the University of Agriculture in Cracow. A team of scientists from three faculties contributed to the project: the Faculty of Agriculture and Economics, Ph.D. engineer Tomasz Zaleski; the Faculty of Biotechnology and Horticulture, Prof. UR, Ph.D. engineer Anna Kołton; and the Faculty of Production Engineering and Energy, Prof. UR, Ph.D. engineer Jarosław Knaga.

5. Discussion and Conclusion

It can be said that technology parks and business incubators, by creating an innovative environment for the development of companies and technologies, play an important role in shaping the future of entrepreneurship. Technology parks serve as centers for companies from the modern technology sector and are excellent places for cooperation, idea exchange, and synergy creation across various industries. They support the development of startup companies by providing not only workspace but also access to experts, mentors, and financing sources.

Conversely, business incubators offer crucial support to young companies at an early development stage, playing a significant role in reducing the risks associated with starting a business. They provide not just infrastructure, but also the knowledge and experience necessary for effective business management. Incubators are where innovative ideas transform into successful ventures, giving entrepreneurs the opportunity to build sustainable and competitive companies.

The common factor between technology parks and business incubators is the creation of a favorable ecosystem conducive to the growth and development of new enterprises. However, for this model to function effectively, involvement from entrepreneurs, government, educational, and business institutions is necessary. Only through collaboration among these diverse entities can a dynamic environment conducive to innovation, job creation, and enhanced economic competitiveness be established. It is noteworthy that the development of technology parks and business incubators contributes not only to economic growth but also plays a key role in building a society based on knowledge and innovation.

Tabela 3.

EEC Startup Challenge comparison table

EEC Startup Challenge edition	The winning startup	Support provided by selected institutions
EEC Startup Challenge 2021	Warmie (health & biotechnology)	Park LifeScience Cracow , diaMedica (medical store), MedInTech (medical store), Epruf (billing operator), Medigent Foundation, Aban Fund, Med App, ProPlus (telemedicine), Nordic Semiconductor (IoT)
	CUX (business process)	No data
	MAB Robotics (new industry)	Cracow Technology Park
	Wood Pack (tradition & modernity)	National Centre for Research and Development
	SunRoof Technology (environment)	National Centre for Research and Development
IDENTT (client & lifestyle)	Wroclaw Technology Park , National Centre for Research and Development	

Cont. table 3.

EEC Startup Challenge 2022	Doctor.One (health & biotechnology)	Movens Capital, VC Atlantic Labs
	Simpl.rent (client & lifestyle)	PZU, otodom, Olx, Black Pearls Venture Capital, KOGITO Ventures
	The True Green (environment)	Created as part of the Green Lanes holding
	ULTRAXIS (modern economy)	Space Research Center in Warsaw
	Omniaz (business process)	National Centre for Research and Development
EEC Startup Challenge 2023	Diagendo (health & biotechnology)	Warsaw Medical University
	Magly (client & lifestyle)	Unicorn Hub launch platform, Cracow Technology Park
	Zonifero (business process)	TenderHut company
	ParkCash (modern economy)	Podkarpacki Science and Technology Park Aeropolis
	Biostra (environment)	No data

Source: own work based on the websites of the mentioned start-ups.

A thorough analysis of the winners of the EEC Startup Challenge 2023 partially confirms the assumption that the infrastructure of technology parks and business incubators contributes to startup achievements. For comparison, the outcomes of the 15th edition of the competition are compared with those from 2021 and 2022 (Table 3).

One of the distinguished startups, ParkCash, operates within a technology park and business incubator. Startups Diagendo and Hydropolis collaborated with universities in Poland. Magly was part of a startup project, while there is no information about whether Biostra cooperated with any other institution in creating its idea. This suggests that startups or young enterprises often collaborate with institutions that can provide scientific, research facilities, or appropriate financing.

The infrastructure offered by technology parks, business incubators, and universities serves not only as a physical workplace but also as an essential environment conducive to creativity, experience exchange, and business network building. These elements create the conditions necessary for the effective development of startups, enabling them to utilize available resources efficiently.

Additionally, this infrastructure is not limited to office spaces. Access to advanced laboratories, specialized equipment, and experts in various fields is crucial for startups operating in the technology sector. Such resources enable effective research and development, translating into the innovation and market competitiveness of these companies.

Moreover, substantive support, mentoring, and acceleration programs offered by technology parks, business incubators, and universities significantly expedite startup development processes. Access to experienced mentors and business experts helps avoid many pitfalls, increasing the likelihood of success in a competitive market.

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