

THE ROLE OF SCIENCE PARKS IN POLAND IN THE INTERNATIONALIZATION OF TENANT BUSINESSES

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Purpose: The aim of the article is to characterize the internationalization of science parks (STP) from a micro perspective, while the main aim of the research was to diagnose the support for the internationalization process of tenant businesses located in Polish STP in the context of the development phases of these enterprises.

Design/methodology/approach: To achieve the theoretical goal, a critical analysis of the literature was carried out. In the empirical layer, own research was carried out using the diagnostic survey method, in which a research technique in the form of an interview was used according to the author's questionnaire. The study was conducted in the second half of 2022 with the participation of management staff from 18 STPs in Poland (55%). The study was complemented by direct interviews with directors of selected STPs conducted in September 2023. The diagnosis of the internationalization status of science parks was made at one of the four possible levels of analysis, i.e. micro, which was analyzed in the following areas: the size of the population of international companies operating in the STP and the scope of support for the internationalization of the STP for companies. For the purposes of the study, four phases of development of STP tenant enterprises were defined and operationalized based on the criteria indicated in the literature on the subject: pre-incubation, incubation, post-incubation and maturity, and their age and size were also taken into account.

Findings: The intensity of services provided by the surveyed STPs in supporting the internationalization of enterprises varied. The research results indicated that parks with the highest share of entities in the maturity phase were, on average, characterized by the highest percentage of entities with foreign capital. However, statistical analysis using linear correlation coefficients and rank correlations did not indicate the existence of significant differences between the share of enterprises active abroad and the development phase of enterprises tenants of parks. However, it was confirmed that the activities undertaken by the park were positively and statistically significantly correlated with the share of enterprises active abroad.

Originality/value: The result of the study is an understanding of the phenomenon of STP internationalization in Poland at the micro level in the context of the development phases of tenant enterprises, which is an original approach to this issue and the first study of this type conducted in Poland. Although the research confirmed some of the assumed relationships,

some of them were confirmed on the basis of statistical analysis, however, further research should undoubtedly be conducted to take into account other parks operating in Poland, but also to take into account other factors that may determine the process of STP internationalization from a micro perspective.

Keywords: internationalization, phase of development, science park, tenant businesses.

Category of the paper: Research paper.

1. Introduction

Considering the concept of science parks¹ and their organization, contemporary science parks are the most developed type of centres of innovation and entrepreneurship (Allen, 2007; Albahari et al., 2017; Amoroso, Hervàs Soriano, 2019; EARTO, 2015; Lai, Shyu, 2005; Martínez-Vela, 2016; Mażewska, Tórz, 2012; Squicciarini, 2008; Unlü, 2022). The basic mission of science parks is to stimulate the economic development of the region in which they are situated (Luger, Goldstein, 1991). However, in order to pursue their principal mission, they have to incorporate into their classical roles and activities some completely new initiatives, and to create a portfolio of innovative services so as to support the development of tenant businesses (Edler, 2008; ESCAP, 2019; Henriques et al., 2018; Lizińska, 2015; Zacharewicz et al., 2017). A considerable percentage of businesses residing in science parks are knowledge-based companies, which typically implicates a higher degree of innovativeness and technology use than demonstrated by traditional businesses. At the same time, such enterprises are strongly exposed to globalization and its consequences, and somehow ‘forced’ to undergo internationalization in the early years of their existence (Cahen et al., 2017; Zacharewicz et al., 2017).

Tenant businesses who are stakeholders of a science park go through different stages of development, and therefore present different limitations and needs, also in the scope of support to internationalization. It is significant to strengthen the international presence of a science park’s residents (Błaszczyk et al., 2023) because ‘the 21st century science park is a gateway and not a destination’ (Allen, 2007, p. 10). Yet, the number of research papers dedicated to this question is limited (Albahari et al., 2019; Błaszczyk et al., 2018; Sobol, 2018b).

¹ Parks are given different names around the world, like ‘technology park, technopole, research park or science park’ (Link, Scott, 2018). For the sake of this article, we follow the definition by the International Association of Science Parks and Areas of Innovation (IASP), which refers to all of the mentioned organizations, and the STP acronym is used with regard to all of these designations.

The above considerations encouraged us to undertake a study on internationalization² of Polish science parks on a micro-level, in the context of phases in the development of tenant businesses, which is an original approach to the research problem.

The purpose of this study has been to explore the issue of support given to the process of internationalization of tenant businesses in Polish science parks, taking into consideration development phases of these businesses. To reach this goal, a review of the subject literature was made, while the empirical part of the research consisted of own quantitative and qualitative studies aimed at obtaining original data.

The article is designed as follows. The next chapter contains a brief review of the literature dealing with the essence of internationalization of science parks on the micro-level, including a discussion of the specific character of tenant businesses. Afterwards, the methods used in the relevant research were presented. In the subsequent chapter, the results of the research were discussed. Finally, conclusions are drawn and the limitations encountered by the authors are mentioned. In addition, some valuable observations regarding future studies are given.

2. Literature review

The essence of internationalization of STPs on the micro-level

Although internationalization is not the goal of all parks (Bengtsson, Löwegren, 2001; Lizińska, Sobol, 2023; Zacharewicz et al., 2017), nowadays it is almost impossible for a science park to be exclusively 'national', and to completely ignore the international dimension in its strategies and actions (Lund, 2019). It also needs to be stressed that the strategic decision to go international and consequently to undertake actions for the sake of internationalization, including their effectiveness, depends on various external and internal factors, such as the phase in the lifecycle of a park, specific character of tenant businesses, the park management model, as well as the quality of support provided by business environment institutions (Bigliardi et al., 2006; Cruz-Castro et al., 2015; Guadix et al., 2016; Tomelin et al., 2018). These factors either directly and indirectly shape the type, range and dynamics of activities in a given science park.

M. Wright and P. Westhead (2019) emphasize the need to consider three context-related levels of analysis regarding the operation of a science park: macro- (city, region, country), meso- (science park, incubator, accelerator) and micro-level (a tenant business, a businessman). More precisely, internationalization of a science park on the micro-level can be considered as

² For the purpose of this article, the definition of internationalization is borrowed from concept applied to Public Research Organizations (RTOs), including the internationalization of science parks, which is explained as 'a process of increasing involvement in international (non-nationally based) operations and actions by the PRO, its sub-units or its employees and an increasing openness of the PRO to 'non-national' influences, with the effect of transforming the attributes of the organization and of modifying its resource dependence features' (Castro et al., 2015, p. 4).

some support in the sphere of internationalization of the operation of a science park's tenant companies (cf. Błaszczuk et al., 2018; Phan et al., 2005). The organizational framework of analysis, as described thus far, reflects the heterogeneity of parks. It is highlighted that internationalization of science parks does not equate to the internationalization of its tenant enterprises.

As regards internationalization on the micro-level, managers of a science park can adopt one of the following strategies for implementation: defensive (attracting companies with foreign capital, which creates opportunities to start cooperative relationships with tenant companies) or offensive (activization and support of tenant companies in internationalization efforts). In practice, managers of science parks usually choose to implement both strategies, but with different intensity or focus (Błaszczuk et al., 2018; Lund, 2019), and the choice of a strategy brings about significant implications, affecting for example the portfolio of innovative services which a science park offers.

Questions pertaining to the internationalization of these organizations on the micro-level can be analyzed in the following areas: size of the population of international companies seated in a science park and the range of support to the internationalization of these companies on behalf of the park³. It is common practice for science parks to monitor the internationalization of their tenant businesses (IASP, 2022).

Support to the process of internationalization of companies is an example of innovative services found in portfolios of science parks (IASP, 2017; Laspia et al., 2021; Lecluyse et al., 2019). Manifestation of science parks being active in this area is the assistance given to a company in its preparation for internationalization, such as market research, presentation of opportunities on international markets, advisory services and mentoring (e.g. development of a strategy, preparation of documentation, conducting negotiations, regulations concerning the international transfer of technology and foreign trade, marketing) as well as international programmes (Albahari et al., 2019; Engelman et al., 2015; Franco et al., 2020; IASP, 2022; İmer in., 2021). A science park can actively support resident companies by developing and adjusting the following services:

- international commercialization: organizing conferences, visits and meetings with foreign entities, foreign missions (Guadix et al., 2016; IASP, 2022; İmer in., 2021; UNIDO, 2021);
- partnership in international projects: assistance in finding foreign partners or creating own international network, in which companies should be able to gain access to knowledge and technology and to attract new ventures and customers (Albahari et al., 2019; Engelman et al., 2015; Franco et al., 2020; Lund, 2019; IASP, 2022; Ng et al., 2021; UNIDO, 2021);

³ The mentioned areas of analysis of internationalization were presented in the only report so far issued by IASP under the title *Strategigram Analytical Report 2010* as cited in: Błaszczuk et al., 2018.

- international joint venture companies: assistance in the selection and choice of suitable partners for such undertakings (Albahari et al., 2019; IASP, 2022; Tomelin et al., 2018);
- international workforce: development of programmes for attracting talented foreign students, and organizing the selection and training of professional workforce (Zacharewicz et al., 2017).

It is worth underlining that these innovative services offered by science parks in the area of support to internationalization of businesses can be addressed to both domestic and foreign residents. Some parks also offer support of internationalization processes to non-residents of a given park.

Enterprises – science park tenants

Science parks serve a wide range of companies (Lecluyse et al., 2018; Tomelin et al., 2018). According to their organizational characteristics, such as capital origin, size, age, development phase, prevalent branch, etc., tenant businesses can be submitted to basic classification. Among the companies operating in science and technology parks, it is possible to distinguish a group of enterprises with foreign capital (ca 13% of the population). However, the dominant share is composed of local companies (41.4%), regional and national companies (19% and 26.4%, respectively), which reflects the role of science parks as local actors of innovation (IASP, 2022; Theeranattapong et al., 2021). Nearly 85% of businesses situated in science parks are micro- and small companies, while the presence of large companies is rather incidental. There is also a considerable share of young businesses, that is less than 3 years old, in the total number of tenant companies (IASP, 2022). This means that science parks still focus on their main goal, such as supporting start-ups from their onset, for example by providing entrepreneurship incubation and business acceleration, in addition implementing spin-off programmes. Nonetheless, it is possible now to observe a group of science parks that concentrate on supporting and improving the competitiveness of companies with a stable market position, including international ones (Lund, 2019).

Companies based in science parks represent quite a large variety of branches, although the following sectors seem to dominate: ICT, biotechnology, software engineering, energy generation, and artificial intelligence (IASP, 2022). The focus among science parks on specific sectors stems from the criteria adopted for the selection of potential tenant companies (Ng et al., 2017; Ng et al., 2019a), which could be dictated by the following reasons: strengths of the local business community and promoting synergy, the need to develop specific technologies, or certain bonds with specialized higher education institutions (IASP, 2022; Van Winden, Carvalho, 2015). Another important consideration could be the limited area of a park, which means that the park's strategic decision-makers are inclined to prefer companies with the highest growth potential (Chen, Huang, 2004).

An overview of the sectors and specializations seated in science parks demonstrates that a considerable percentage of park residents are companies based on specialized and advanced technologies, including new technology-based firms (NTBF). This class of companies is important and interesting for a number of reasons (cf. Sobol, 2021). NTBFs excel in flexibility and rapid response to a change in the environment (Sobol, 2018a); they also demonstrate strongly innovative and pro-active approaches (Lee et al., 2013; Onetti et al., 2012), and their business offer is characterized by innovativeness and a significant added value (Bell et al., 2003; Knight, Kim, 2009). This means that such companies have the potential to develop their business also outside the home country, but - on the other hand - they are somehow 'forced' to undergo early internationalization in order to become profitable and to develop (Bruneel et al., 2006; Cahen et al., 2017; Coeurderoy, Murray, 2008; Zacharewicz et al., 2017). The indisputable role that these companies play in the development of regions is worth emphasizing (Asc et al., 2003; Audretsh, Keilbach, 2007; Verheul et al., 2009; Hessels, Van Stel, 2011), in addition to their contribution to the promotion of technological change and innovation in many countries (Autio et al., 2000). Companies developing their business around a new technology platform will most probably have influence on globalization, on both the rate of innovation and competitive pressure (Onetti et al., 2012).

Regardless of the dominant branch and specialization, science park residents go through different phases of development, which can also serve as a basis for their classification, that is: entities with business ideas which have not been developed yet (the pre-incubation stage), companies at an early stage of development (incubation stage), and well-established companies (Albahari et al., 2019). Particular stages in the development of a business are distinguished by having a different set of limitations and needs (Chan, Lau, 2005; Ferguson, Olofsson, 2004; Ng et al., 2019b; Ng et al., 2021), and internationalization is a component of post-incubation, understood as the phase of acceleration of a business project, which comprises the activities carried out when a company has achieved operational and financial independence, and is capable of continuing its business activities without external support (FEDER, 2014 as cited in: Franco et al., 2020).

For the management of science parks, it is therefore important to meet the actual needs of tenant companies, including those related to internationalization, and taking into account the specific character of each company (Albahari et al., 2019; Cadorin et al., 2020).

3. Methodology

Objective and scope of the study

The main objective of this study has been to make a diagnosis of the support given to the internationalization of tenant businesses in Polish science parks, in the context of the development phases these companies are in. The following research questions were put forth, to express the research objective more accurately:

1. What activities in the scope of supporting the internationalization of tenant companies do science parks undertake?
2. What is the structure of tenant companies in Polish science parks related to the phase of their development and some characteristics (age, size)?
3. Are there dependences between the internationalization of science parks on the micro-level and a phase in the development of tenant companies?
4. What changes are expected within the next three years regarding the intensification of the internationalization of tenant companies, and the support they obtain from science parks?

The following research hypotheses were put to test:

H1: The share of companies active on foreign markets increases with the increase in the share of tenant companies in science parks in the consecutive phases of development in a company's life cycle.

H2: The activities undertaken for the internationalization of tenant companies in science parks translate into a higher percentage of tenant companies in a given park active on foreign markets.

The research subject consisted of all 33 active science parks in Poland, as of 1 June 2022. The number of these parks was determined according to the database of centres of innovation and entrepreneurship in Poland maintained by the Polish Business and Innovation Centers Association in Poland (PBICA)⁴. The names of these science parks were not revealed so as to ensure the research respondents' complete anonymity in order to reduce the range of error in responses (Konrad, Linnehan, 1995). The management staff from 18 science parks in Poland (55%) took part in the survey. There was also one reply submitted to the researchers informing that the science park in question could not take part in the survey due to some organizational matters.

⁴ *Stowarzyszenie Organizatorów Ośrodków Innowacji i Przedsiębiorczości w Polsce (SOOiPP)*. Retrieved from: <https://www.sooipp.org.pl/baza-osrodkow>, 1.06.2022.

Research methods

To achieve the research goal, a review of the subject literature was conducted, while the empirical part consisted of own study aiming at the acquisition of primary data. The authors' intention was to gain a comprehensive insight into the internationalization of science parks on the micro-level, which is why a decision was made to conduct the study in two stages and to employ both quantitative and qualitative research methods.

The first stage of the empirical study was completed in the first half of year 2022. A survey method was used, involving a research technique in the form of a questionnaire developed by the research authors. The aim of the questionnaire was to obtain two categories of information: activities in the area of support to internationalization of tenant businesses in science parks, and the characteristics of science park residents according to these criteria: age, size, development phase, branch or branches represented and the level of internationalization. The analysis included: start-ups and enterprises - stationary tenants of individual PNTs, i.e. excluding companies using a virtual office.

The study results enabled us to express the analyzed problem in figures. The preliminary analysis of the data also shed light on some important aspects which required in-depth studies. It was therefore justified to conduct a qualitative analysis as the second step of the research. Based on the questionnaire, face-to-face conversations were carried out with directors of four selected science parks in Poland. This part of the study took place in September 2023, at the premises of these parks. The results of those interviews provided a valuable supplement to the results of our analysis of the quantitative data, and made a significant contribution to the reliable and professional interpretation of the whole research that followed.

In turn, our diagnosis of mutual dependences between the selected dominant characteristics of tenant companies in parks versus the continuous variables describing the share of companies with foreign capital and the share of companies active on foreign markets was conducted on the basis of an analysis of relationships between the variables and an attempt to determine statistically significant differences between the identified groups of companies.

Due to the small number of observations, the unequal numbers of observations within particular groups of objects, and the lack of a possibility to confirm a normal distribution of the analyzed variables with the use of the Shapiro-Wilk test, it was decided to employ non-parametric versions of tests, identifying the differentiated level of the intensity of the analyzed parameters among the groups. In addition, beside the results of these non-parametric tests, means and medians within particular groups were provided, which facilitated the interpretation of the results. The following levels of significance of the non-parametric tests, i.e. (i) nonparametric equality-of-medians test, verifying if the analyzed populations have the same medians, (ii) Kruskal-Wallis test, which is generalization over a larger number of groups, (iii) two-sample Wilcoxon (Mann-Whitney) rank-sum test, also verifying the distribution of medians between groups (Mann-Whitney, 1947; Wilcoxon, 1945), are given under table 5.

Additionally, as an element of the analysis of the stability of results, verification was conducted using parametric versions of these tests, including *inter alia* differences in means between the groups, using, for example, one-factor ANOVA.

4. Results

Activity of science parks depends on the strategy each park has developed and implemented as well as on the number and characteristics of tenant businesses. The data gathered in this study demonstrate that the science parks in Poland vary in terms of the structure of companies they host, including the age and size of these enterprises. Most science parks have a large share of companies operating there for over 3 years. The data do not manifest a large degree of concentration (over 75%) in terms of the size of companies (tab. 1).

Table 1.

Number of parks in terms of tenant structure by age and size of enterprises

Enterprises' age	Number of parks by tenant structure			
	up to 25%	26-50%	51-75%	above 75%
up to 3 years	8	5		2
above 3 years		1	6	8
Enterprises' size	up to 25%	26-50%	51-75%	above 75%
micro-enterprise	4	1	3	5
small enterprise	8	3	3	
medium enterprise	9	1	2	

Source: own study based on research.

The duration of a company's operating in a science park has influence on both the activities undertaken by the park and on the level of development of these companies as the park's tenants. As demonstrated by data achieved in this research, the companies hosted by the science parks in question are in different phases of development. The share of companies in the first and second development phases does not usually exceed 25%. The share of companies in the third and fourth development phases is more varied, but parks where such companies make up no more than 25% of all tenant businesses are still dominant (tab. 2). A larger share of companies in the phase of stabilization and maturity was typically indicated in parks situated in large urban agglomerations, while a large percentage of companies in the incubation and acceleration phases was indicated in science parks from smaller urban centres.

Table 2.

Number of parks in terms of tenant structure by phase of their development

Enterprises' phase of development	Number of parks by tenant structure			
	up to 25%	26-50%	51-75%	above 75%
phase 1: incubation (using the services and infrastructure of the Business Incubator under the agreement with the park)	10	1	1	2
phase 2: acceleration (using the park's services and infrastructure on the basis of de minimis aid/scaling programs for start-ups)	10			1
phase 3: stabilization (strengthening market position/cooperation network/customer portfolio)	6	4	3	
phase 4: maturity (ready to function outside the park)	8	3	1	3

Source: own study based on research.

The diverse level of development of companies which are tenants in science parks is quite natural as science parks usually host a variety of companies, from start-ups, including new technology-based firms up to international companies (Albahari et al., 2019; Bengtsson, Löwegren, 2001; Franco et al., 2020; Ng et al., 2021; Tomelin et al., 2018). This, however, gives rise to certain implications for the park's policy. The activities pursued by a park will be equally diverse and adjusted to the possibilities and needs of its tenant businesses.

As the research results implicate, the intensity of advisory services provided by science parks in the field of internationalization of companies varied (fig. 1). Some parks did not offer such services at all, others did so occasionally, and in five parks such support was a permanent component of the offer addressed to businesses (also outside the park).

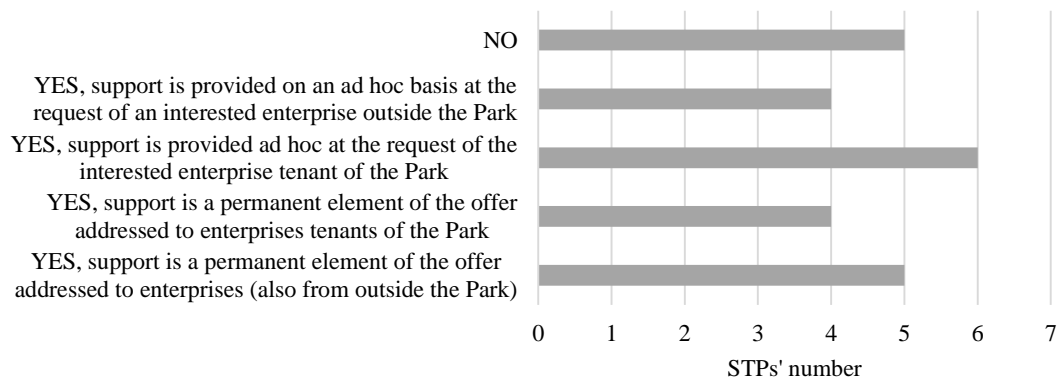


Figure 1. Consulting services offered by STPs in the field of internationalization of enterprises.

Source: own study based on research.

Considering the time perspective, many activities are yet in the sphere of planning (including the support to financing internationalization of companies, making an analysis of a foreign market or providing professional translation of documents). Among the activities which were carried out in the past but then discontinued, the following were indicated most often: assistance in starting cooperation with foreign entities (suppliers, buyers, distributors), legal support (including tax law, intellectual property protection) and help in organizing trips

to trade fairs abroad, study visits, networking sessions. At present, the parks carry out mainly such activities that aim to help companies to embark on cooperation with foreign enterprises in technology, research, business support (e.g. creating a business model), and to organize trade fairs, study visits and networking sessions with foreign businesses in the park (fig. 2).

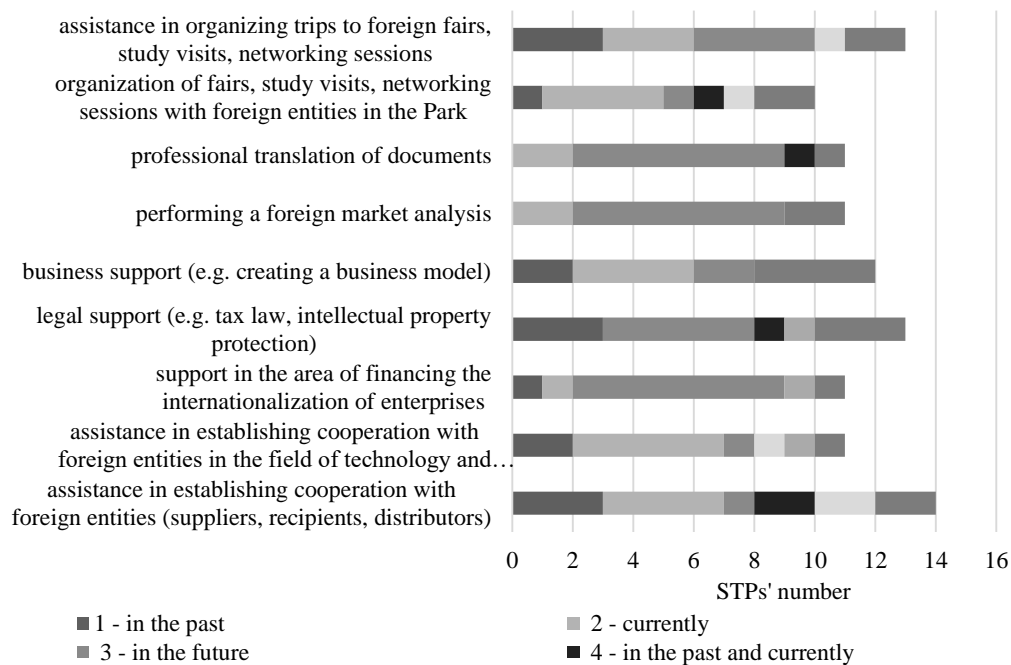


Figure 2. Activities carried out by STPs in the area of supporting the internationalization of enterprises. Source: own study based on research.

A compilation of various factors can determine, to various degrees, the specific character of a given park regarding the level of forms of internationalization of tenant businesses.

As the subject literature implicates (Bengtsson, Löwegren, 2001; Lizińska, Sobol, 2023; Zacharewicz et al., 2017), not all parks define it as their aim to promote and achieve internationalization (of a park or its tenants), even though – as underlined by Lund (2019) – internationalization is essential in the current economic conditions. This may also result from the different phase of a lifecycle that is characteristic for parks in Poland (Lizińska, Sobol, 2023).

As the results of this study implicate, there are two groups of businesses to distinguish: companies with foreign capital and companies active abroad, which differed in both their absolute number, a finding also reported by others (Błaszczyk et al., 2018; Lund, 2019), and in their share relative to the entire set of companies established in a science park (fig. 3). Companies with foreign capital, owing to their specific character, will definitely find it easier to establish international contacts and gain access to foreign markets. Such diverse shares of the above-mentioned groups of companies among tenant businesses in science parks can be dictated by actions taken by science park managers that may stimulate the process of internationalization, but they can also depend on the specific character of each park, and on the level of development of both tenant companies and the park itself.

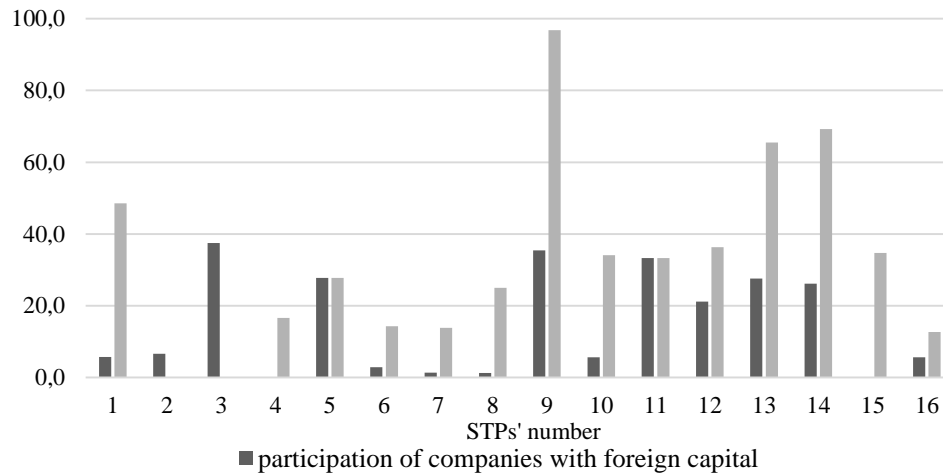


Figure 3. Share of companies with foreign capital and companies active abroad in the surveyed STPs.

Source: own study based on research.

Science park managers attribute a more intensive internationalization process of tenant businesses to large companies with longer history. However, the survey respondents admitted it was difficult to identify the direction and intensity of changes, particularly with respect to small companies with shorter history of operating in a science park (fig. 4).

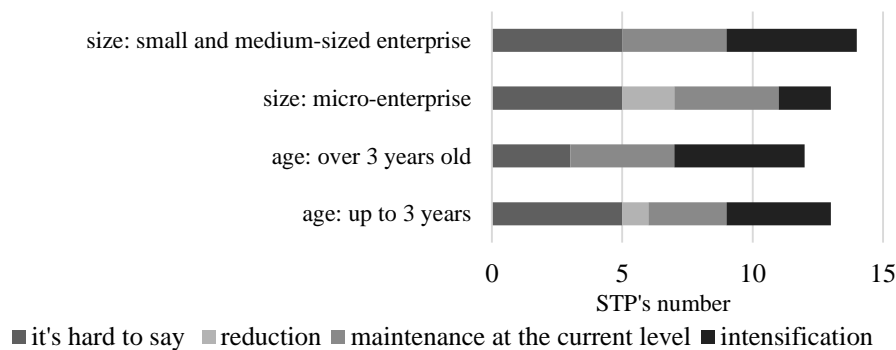


Figure 4. Assessment of the intensity of changes in the level of internationalization of tenant enterprises according to specific features over the next 3 years in the opinion of STPs' representatives.

Source: own study based on research.

The respondents pointed to some characteristics of tenant companies, indicating the frequency of their occurrence on a quantile scale (cf. column 1, tab. 3). Only the indications given by science park managers that described the companies most numerous among their park's tenant businesses were submitted to further analysis. This approach enabled us to classify the parks into one of the several groups of parks, separately for each of the characteristics considered (phase in the development of a company, the company's age and its size). Data contained in table 3 give a synthetic description of the research sample.

Table 3.*Distribution of the enterprises operating in scientific parks by their main characteristics*

Enterprises' phase of development			Enterprises' age			Enterprises' size		
Category	%	N	Category	%	N	Category	%	N
1 - incubation	25.0	4	< 3 years	18.75	3	micro	43.75	7
2 - acceleration	12.5	2	>= 3 years	81.25	13	small	31.25	5
3 - stabilization	37.5	6				medium	25	4
4 - maturity	25.0	4						
Total	100.0	16	Total	100.0	16	Total	100.0	16

Source: own study based on research.

Science parks with a larger share of companies operating on the market for a longer time (i.e. more than 3 years) more frequently hosted companies in the third and fourth phase of development. On the other hand, science parks distinguished by a larger percentage of younger business entities more often hosted companies in the first and second phase of development.

The distribution of replies from the science park managers regarding the share of companies with foreign capital (left-hand panel) and the share of companies active abroad (right-hand panel) is displayed in figure 5. In this box plot, the mean value was denoted by a circle, the median by a horizontal line in a rectangle, and the maximum and minimum values by horizontal lines located in the uppermost or lowermost positions (so-called whiskers). In turn, outliers were marked with shaded dots. The highest variation in answers relative to the above groups was observed in the right-hand panel for the maturity phase, and the lowest one was noted for the acceleration phase. An evident outlier in the stabilization phase located also in the right-hand panel is worth noticing.

Analysis of data illustrated in fig. 5 reveals the highest average level of internationalization of science park tenant companies in the maturity phase, followed by those in the stabilization phase, and finally in the incubation and acceleration phases. Likewise, parks distinguished by the highest percentage of companies in the maturity phase were characterized by the highest average percentage of companies with foreign capital share, although – same as in the aforementioned case – this change did not follow a linear course.

Analysis of data obtained from non-parametric tests (tab. 4) does not provide the ground for verifying the occurrence of significant differences in the values of medians illustrating: (1) the share of companies with foreign capital, and (ii) share of companies active abroad, versus the developmental phase that the tenant companies were in. However, the verification of the results from non-parametric tests with the outcome of the one-factor ANOVA test applied to analyze means between the groups proved the lack of statistically significant differences.

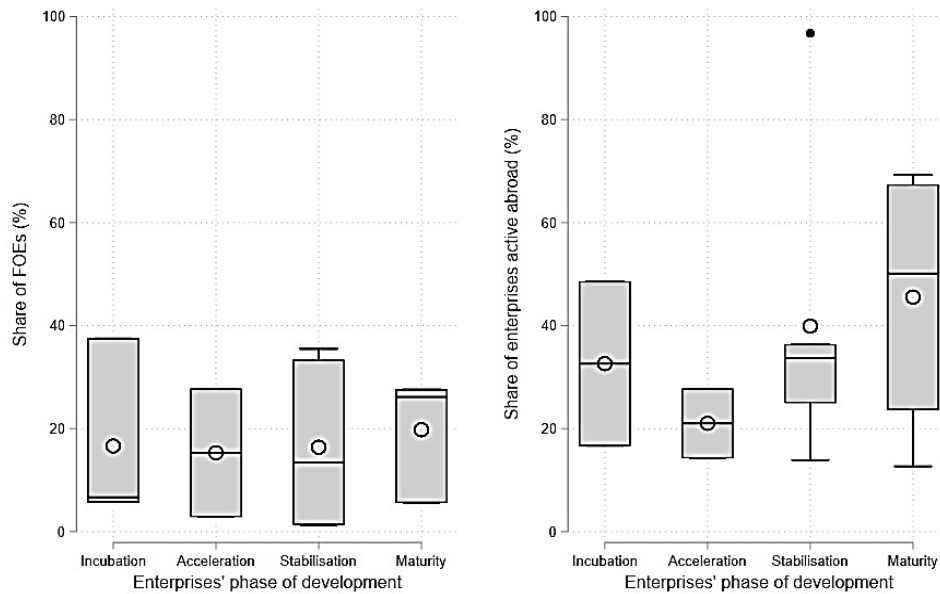


Figure 5. Distribution of variables of interest by phases of enterprises' development.

Source: own study based on research.

Table 4.

Share of FOEs and share of enterprises active abroad by the phase of enterprises' development

Phase	Share of FOEs (%)			Share of enterprises active abroad (%)		
	Mean	Median	N	Mean	Median	N
1 - incubation	16.63	6.67	3	32.62	32.62	2
2 - acceleration	15.32	15.32	2	21.03	21.03	2
3 - stabilization	16.39	13.45	6	39.91	33.71	6
4 - maturity	19.79	26.15	3	45.53	50.11	4
Total	17.02	13.94	14	37.78	33.71	14
Median test p-val		0.881			0.392	
Kruskal–Wallis test p-val		0.903			0.707	

Note. p-val values below 0.1 indicate significant differences in the distribution of the analyzed variables between the identified groups of enterprises. Otherwise, these tests indicate statistically insignificant differences in the level of medians (equality of distribution function) between the above-mentioned. identified groups. The Kruskal–Wallis test is considered a nonparametric alternative to one-way ANOVA.

Source: own study based on research.

The identification of correlations between the level of internationalization of tenant companies and the dominant phase in their development was verified with the help of correlation coefficients, and linear regression models were constructed to further visualize the tested dependences (fig. 6). Levels of the linear correlations and rank correlations (which do not require a normal distribution of variables) are given in table 6. Their results (especially the coefficients of the Spearman and Kendall correlations) do not allow us to determine any statistically significant correlation between the selected measures of the internationalization of companies (here, the share of companies) and the dominant development phase. In the case of all measures shown in this study, the achieved correlation coefficients were not significant statistically. Thus, the results do not attest to the validity of hypothesis 1.

This outcome might have been influenced by a number of factors illustrating both the background conditions in which the companies in particular science parks operate, the extent and success of the actions that these parks' managers undertake to support their tenant businesses' internationalization, the branches in which these companies operate, or the willingness to take risks by the managerial personnel of these companies.

Table 5.

Correlations between internationalisation measures and enterprises' phase of development

Correlation measure	Share of FOEs vs. enterprises' phase of development		Share of enterprises active abroad vs. enterprises' phase of development	
	Coefficient	p-val	Coefficient	p-val
Pearson's	0.072	0.808	0.259	0.371
Spearman's	-0.106	0.717	0.228	0.434
Kandall's tau-a	-0.076	0.727	0.153	0.449
Kandall's tau-b	-0.088	0.727	0.178	0.449

Source: own study based on research.

The estimated linear regressions (fig. 6) confirmed a small fit of the curve equations and the data (R^2).

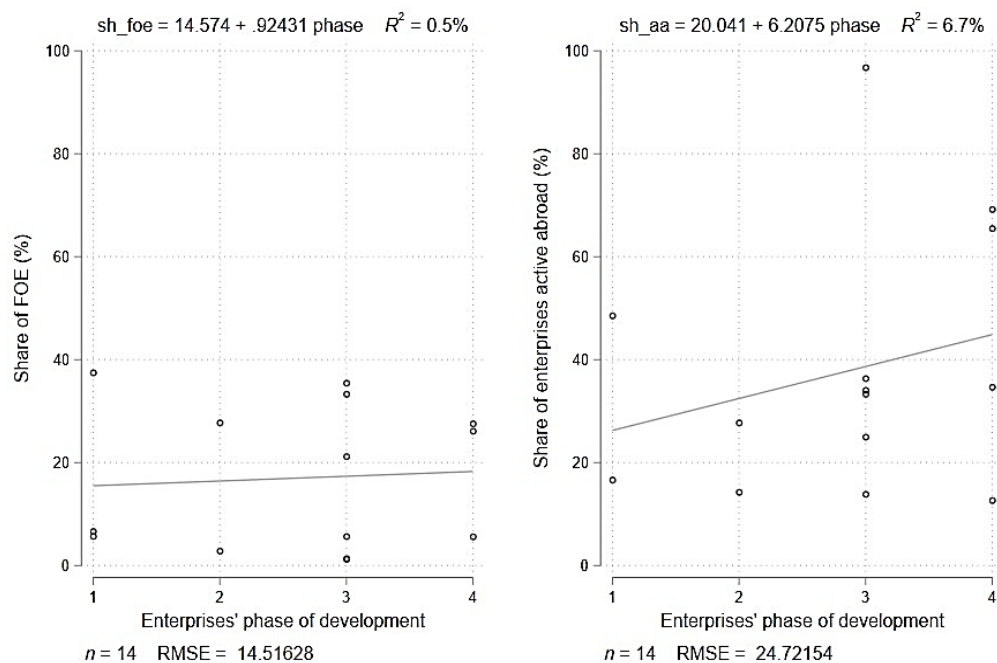


Figure 6. Visualization of the relationship between the dominant enterprises' phase of development and the level of enterprise internationalization.

Source: own study based on research.

Furthermore, the fit for companies active abroad (the right-hand panel) was higher than that of companies with foreign capital (the left-hand panel). Also in this case, the coefficient standing at the phase of development of companies was higher, which means that as the share of companies in a higher development phases increases, an average percentage of companies active abroad increases too. The relationship between the share of companies with foreign capital and the development phase is less obvious, and the collected data do not provide

evidence to fully identify this relationship. Nevertheless, in both cases, a higher number of observations might allow one to determine more precisely the course of relationships between the categories submitted to analysis.

The results obtained in our study could be connected to the diverse pathways set by the internationalization processes that companies go through. Companies with a share of foreign capital have greater opportunities to enter higher phases of internationalization right from the start of their existence. As for other companies, launching different actions on a foreign market can more often occur in a sequence, characteristic for the Uppsala model. This may often require some support from the host park, but it could also be conditioned by the development phase in which a given company is.

The search for characteristics differentiating the level of internationalization of companies encouraged us to verify dependences between the variables describing companies, i.e. age of a company, its size, and actions taken by the science park in the realm of corporate internationalization. Among the analyzed categories, only the actions undertaken by the park were positively and statistically significantly correlated with the percentage of companies active abroad, which means that the parks offering services in the field of business internationalization had a higher share of companies active abroad (tab. 6).

Table 6.

Spearman's correlations between selected enterprises' characteristics

Category	Share of FOEs		Share of enterprises active abroad	
	Coefficient	p-val	Coefficient	p-val
Enterprises' age	-0.065	0.826	0.310	0.281
Enterprises' size	0.295	0.305	0.284	0.325
Does the park offer consulting services in the field of enterprise internationalization (yes/no)?	0.194	0.506	0.628	0.016

Note. The table presents Spearman's rank correlation coefficients due to the specificity of the analyzed data.

Source: own study based on research.

This was a factor that unambiguously differentiated the share of companies active on foreign markets between science parks, which can implicate positive effects of measures implemented for the sake of supporting internationalization of tenant companies in science parks (in view of the positive correlation coefficient). The research outcome allows us to confirm the second research hypothesis, claiming that actions undertaken by science parks to support internationalization of tenant businesses translate into a higher average percentage of companies residing in science parks that are active on foreign markets. Due to the small size of the research sample, an attempt to deepen the above analysis, for example by focusing on particular type of actions (i.e. which actions most contribute to greater internationalization) was impossible and would call for further survey studies. Also, an attempt to determine the causality and direction of this causality for the analyzed phenomenon would necessitate obtaining more data from companies, which should cover several years of their operation on the market.

5. Summary

The conducted research made it possible to characterize the parks in terms of the characteristics of the tenant enterprises operating there. The research results indicated that the structure of these enterprises varies in terms of age and size of enterprises. This situation is undoubtedly related not only to the development of enterprises, but also to the creation and development of the parks themselves. There are enterprises in various stages of development in the studied parks. A greater share of enterprises in the stabilization and maturity phase was most often characteristic of parks located in large urban agglomerations, while a greater share of enterprises in the incubation and acceleration phases was more often indicated in parks located in smaller urban centers.

The factor that may determine the development of tenant enterprises, not only on the domestic market, but also internationally, is support from parks. The intensity of advisory services provided by the surveyed parks in the field of enterprise internationalization varied. Unfortunately, some parks did not offer such services in general, some did so on an ad hoc basis, while only in a few parks support is a permanent element of the offer addressed to enterprises. At the same time, many activities are still in the planning stage.

The two groups of entities identified in the research (companies with foreign capital and companies active abroad) were characterized not only by their absolute number, but also by their share in relation to all park companies. The research results indicated that parks with the highest share of entities in the maturity phase had, on average, the highest percentage of entities with foreign capital. However, the statistical analysis did not indicate any significant differences between the share of enterprises active abroad and the stage of development of enterprises tenants of parks. This situation may have many causes. These include the varied conditions in which enterprises operate in parks, the activity of parks, and the specificity of the enterprises themselves. In the case of the share of enterprises active abroad, their share increased with the increase in the share of enterprises at a higher stage of development, but this relationship was not at a statistically significant level. However, it was confirmed that the activities undertaken by the park were positively and statistically significantly correlated with the share of enterprises active abroad. The research and its results confirmed some of the assumed relationships, some of them were confirmed on the basis of statistical analysis, but further research should undoubtedly be conducted to take into account other parks operating in Poland, but also to take into account other factors that may determine the internationalization process.

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