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Doctoral School of Management and Organizational Sciences

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Structural and operational characteristics of Science and Technology Parks

Dissertation - Thesis booklet

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Introduction

Science and technology parks are special, geographically concentrated innovation ecosystems that contribute to the economic development of a region, so the development of the methodology of their management is an important area of research. Since these types of parks are usually multi-stakeholder systems with a wide range of activities and a wide range of operational elements, it is worth examining them from a complex point of view, along several aspects at the same time.

One of the aims of the research is to investigate the possible connections between complex systems and science and technology parks. By processing a wide range of literature sources and keyword analysis, the author established that there is a significant relationship between the topics. Empirical research based on data from 113 international science and technology parks has also confirmed that parks carry the characteristics of complexity.

A further aim of the research is to develop a novel approach in the field of typological analysis of science and technology parks, focusing on a comparative method based on the structural characteristics of parks. Typing along the ownership, the orientation of the park, the actors of the park and the sectoral focus offer an opportunity to demonstrate the similarities and differences of parks. By applying the developed typing method, based on empirical research, the author showed that similar parks evaluate challenges in a similar way, while different parks evaluate them differently. In addition, four different park groups can be distinguished based on the classification criteria of science and technology parks. The third part of the research pointed out the possible correlations of eight success criteria, the success factors and the root causes of the revealed relationships. In addition to the success factors, the examination of possible park endowment areas and their relationship was in the research focus in connection with the various success criteria. These can serve as a guide for the decision-making processes of science and technology parks. The findings highlight the need for balanced development to achieve a high level of performance in successful parks.

The final phase of the third part of the research provides a comprehensive picture of the operation and operational characteristics of science and technology parks based on the developed park typing method, through the case examples of four representative parks, compared to the patterns of other parks. In addition, the research also pointed out that the business model approach can be interpreted during the examination of the park-level value creation system, providing a general framework model proposal.

Research objectives and research questions

Three distinct but logically connected areas of research (KT1-3) provide the conceptual arc of the research topic. The complexity, types, patterns, systematization, success and operational-strategic issues of the scientific and technological park determine the narrowed areas of research as separate research criteria. The sub-areas of the research are parallel to the hypotheses and research questions (Table 1).

I associated five hypotheses with five research questions covering the three main research areas. The first research area is associated with one research question, and the second and third research areas are associated with two each. In the case of the third research area, one research question is the one that deals with the indicators of the success of parks, and the other research question appears in the thought model as a kind of comprehensive summative research question as a practical application of the previous ones. The research questions can be considered independent of each other, and the final element of the research (K5-H5) builds on the experiences and results of previous research areas.

1. Table Structure of research questions and hypotheses

Research objectives	Research Questions	Hypotheses
C1 **- Investigation of whether innovation ecosystems can be described by the characteristics of complexity theory.**	*Q1* – What characteristics of science and technology parks show the relevance of complexity theory?	*H1* - Complexity theory is suitable for the characterization of science and technology parks.
C2 **- Exploring the characteristics of the innovation ecosystem and defining its types.**	*Q2* – What are the systematically exploreable characteristics of the different science and technology parks?	*H2* – With the help of a targeted method, the typical characteristics of the science and technology park can be examined.
	Q3 – What types of parks and different characteristics can be detected?	*H3* – A correlation can be established between the types of parks and the challenges and typical park groups can be identified.
C3 **- Analysis of the factors influencing the success of innovation ecosystems, analysis of value creation and business approach.**	*Q4* – What success criteria and success factors can be identified during the operation of science and technology parks? What is the relationship between the success criteria of the parks and their endowments?	*H4a* - The correlations between the success criteria and success factors related to park-level operation can be established. *H4b* - The correlations between the success criteria and endowments related to park-level operation can be determined.
	Q5 – Can successful science and technology parks as complex systems have a generalizable operational framework?	*H5* – By examining parks from a business model approach, the basic elements and framework of value creation can be defined.

Literature review and research assumptions

During the comprehensive examination of the science and technology parks, research gaps appeared in several thematic areas, so I will take into account their importance and timeliness, on the basis of which I formulated my hypotheses. These are the basis of my research, italicized in the next section.

The growing role of parks. In order to focus the research, narrowing the range of innovation ecosystems to science and technology parks; this area is the main subject of my thesis. Since the 2000s, activity to create such parks has roughly doubled worldwide (Lecluyse et al., 2019), with more than 400 parks in Europe (Rowe, 2014) and around 300 parks in North America (Battelle Technology Partnership Practice, 2013). Rodríguez-Pose and Hardy (2014) reported on more than 1,500 parks operating in China and India, with a growing number of similar programs in emerging economies in South America, Asia, and Africa. It is clear that the topic is becoming increasingly important and timely to deal with it, but in the way that the present research examines, the analysis of parks has not yet been addressed.

Complex effects. Many studies deal with a specific aspect of the topic, but it is rare to find a treatment that offers a holistic view. The dissertation **aims to contribute to the systemic examination of science and technology parks**, as the problems and challenges of the parks are becoming more and more complex. The interaction of different factors, soft factors, and often changing effects over time play an increasing role, so it is justified to examine the topic from the perspective of the whole system. In the wake of the increasingly complex system conditions, the question arises whether it is possible and expedient to interpret innovation ecosystems, including science and technology parks, from the point of view of the theory of complex systems. The complex system approach is quite scarce in the literature, but there are some approximate results, such as the concept of CAS (complex adaptive systems), where complexity is already spilling over, drawing parallels with innovation ecosystems, see, for example, Carmichael and Hadzikadic (2019), and Lao et al. (2008). Its role may be to manage the emerging challenges more effectively and efficiently.

Significant publication activity. The field of research on science and technology parks is extremely broad, with about a hundred relevant publications published on the topic every year. Empirical research mainly analyses the various problems at the level of the actors in the parks. The type of research that examines the entire park as an ecosystem, i.e. at the level of a system, is rarer, and this is also one of the main goals of the research as a research niche. On the one hand, this is one of the inspirations of my research, i.e. the exploitation of the opportunities

inherent in the examination of the characteristics of the entire system. On the other hand, as the changes taking place in the world make management challenges more and more complex and "complex", the examination of the relationships between park-level processes and phenomena also requires other methods.

Parks are a diverse field of research. A fairly extensive and comprehensive literature analysis has been carried out on the subject by a large number of authors, so research on science and technology parks provides diverse challenges.

Research gaps in the system-side approach

The timeliness of the subject of my research is indicated by the significant number of publications related to innovation ecosystems, science and technology parks, and complex systems. Searching for the keywords "complex system(s)", "innovation ecosystem(s)" and "science park(s)" (in abstracts, for the period 2006-2023 in Management and Business, in the WoS database), an increasing trend in scientific publications can be observed, and after 2017, a significant jump was observed in relation to the topics listed.

System-side research on innovation ecosystems appears in the literature as a result of organic development, but the authors identified a turning point around 2006: the transition from a business ecosystem to an innovation ecosystem. Some studies (Peltoniemi, 2006; Roundy et al., 2018; Scaringella and Radziwon, 2018) have already followed a broader, complex systems approach, but they remain in the minority within the broader scope of ecosystem research. In contrast to innovation ecosystems, the complexity-sided, system-based approach of science and technology parks is already quite rare in the literature. Among the research on certain aspects of the complexity of parks, the article by Chertow and Ehrenfeld (2012) can be mentioned as a real systemic example . This is why the subject of my research is relevant, as the examined problems aim at novel findings on the systemic management of science and technology parks, and can help park management to interpret the challenges and develop appropriate strategies and operational responses.

Based on all this, I made the following assumption:

H1 - Complexity theory is suitable for the characterization of science and technology parks.

During the operation of science and technology parks, many factors influence the development of internal and external processes, which affects the entire operation. Therefore, my assumption is that science and technology parks can be described by characteristics characteristic of complexity.

Research gaps in the field of structural issues in science and technology parks

There are few systematic approaches to the typification of parks in the literature, touching on all essential aspects, and the research related to the topic concerns more of a single point of view or does not deal with the examination of a large number of park parameters in a structured way.

During the examinations of the ownership, the Triple Helix approach has been dealt with by many, but it was Dabrowska et al. (2020) who systematically evaluated the different ownership combinations of the model. Based on his approach, my research aims to provide a systematic, improved, novel method for typifying parks. Examining the orientation of parks, the existence of the duality of research and development and market approach cannot be considered a scientific novelty. Research and development and some level of start-up or incubation activity are present in almost all science and technology parks (this also follows from the definition of parks). Building on these foundations, however, the approach of the research can be considered novel, according to which I determine orientation on the basis of proximity to the market economy. Separately, several authors have examined the characteristics of the group of park settlers (e.g. the influence of universities), but it is rare along several dimensions at the same time. My research also analyses parks from the dual perspective of the presence of universities and the nature of enterprises (SMEs vs. large companies). In connection with the sectoral focus, many people have reached the point of connecting to the collaborative environment within the park, but at the same time, it is still rare to systematically examine this at the park level. Liberati et al. (2015) gave a good example of this, and I developed the related part of the typing method further developing it.

The method I developed can handle the combined viewpoint of several aspects. Such a multi-aspect, park-level methodical approach cannot be found in the literature. The methods of examining these aspects are novel in themselves. The novelty of the method is that the similarity or difference can be made clear through the typification classes. The significance of the application of the developed method is that, according to my expectations, different types of parks face different management challenges and thus require different management responses.

I have associated the following hypotheses with the above:

H2 – With the help of a targeted method, the typical characteristics of the science and technology park can be examined.

Science and technology parks have different characteristics, differing due to differences in how they operate. My assumption is that a method can be developed for classifying parks based on the defined criteria.

H3 - A correlation can be established between the types of parks and the challenges and typical park groups can be identified.

Science and technology parks show a different operating system in terms of their owners, based on their settled operators, orientation and sectoral focus. My assumption is that several park types can be distinguished based on the characteristics, and the correlations and differences between them can be examined.

Research gaps in the field of research on the operation of parks.

A lot of research deals with the comparison of operations inside and outside the parks, and the examination of the operation from the point of view of the actors settled in the parks. Many people touch on some elements of park operation (the role of universities, incubation activities, collaborations, etc.), but the scope of research examining parks as a whole at a systemic level is a research gap. This is also true for the analysis of the performance of parks, there are several publications on the factors of the success of parks, but an analysis examining their entirety is rare. This is the main contribution of my research to the research in the field, examining the structure and operational success of parks together with the influencing features, and I intended to make findings at the level of the park as a system.

Related assumptions:

H4a - The correlations between the success criteria and success factors related to park-level operation can be established.

During the operation of science and technology parks, several factors can be determined that influence the path to success, either positively or negatively. My assumption is that a correlation can be established between the characteristics of success (success criteria) and the areas influencing them (success factors).

H4b - The correlations between the success criteria and endowments related to park-level operation can be determined.

My assumption is that a correlation can be established between the success criteria related to the operation of science and technology parks and the facilities present in the parks.

Since the concept of the business model is very important in the management of organizations, the scope of related research is very diverse. There is not much research on this topic among science and technology parks, namely in the subject of park management with a business model approach. In line with this research niche, this part of my research also tries to contribute by

building the analysis of the operation of parks on certain elements of the business model approach. The business model framework used for the analyses carried out in connection with the operation of science and technology parks uses my previous research results in the field.

Related hypothesis:

H5 – By examining parks from a business model approach, the basic elements and framework for value creation can be defined.

My assumption is that based on the previous results, a general operating model can be developed that characterizes and reflects the business character of the value creation system operating in science and technology parks.

The hypotheses have been formulated in parallel with the research questions, they follow their structure and content, which is summarized in Figure 2.

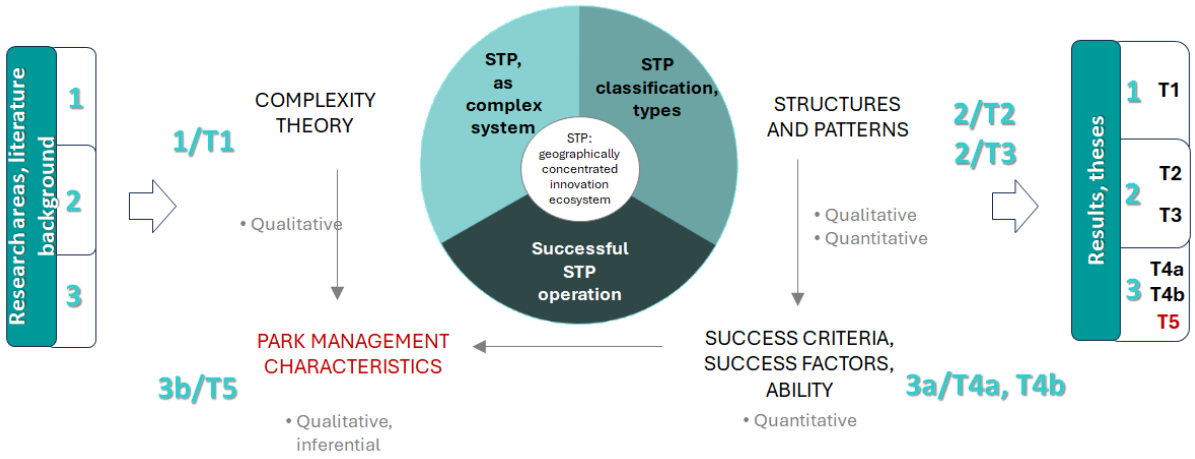

Figure 2 Structure of the research

Research results and theses

First research sub-field (KT1-K1-T1)

A significant part of the common keywords examined in the first part of the research were found in the abstracts of the examined publications. The results prove that the features of complexity theory are present to a significant extent in the topic of innovation ecosystems, and vice versa. The same is true for the topic of science and technology parks. The keywords of complex systems appear to a lesser extent in the abstracts of science and technology parks, which

suggests that publications with such content occur in an even smaller number. The high-level perspective of the comparison is illustrated in Figure 3.

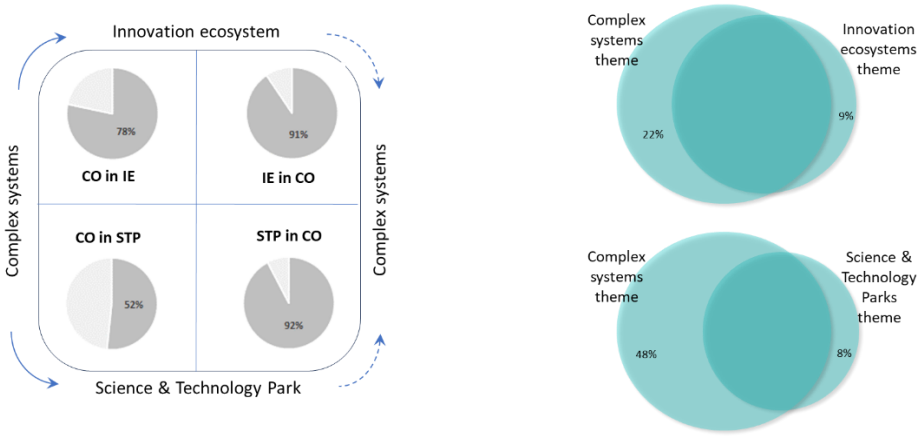

Figure 3 Relationship between the examined topics

To examine the complexity of science and technology parks, I carried out an empirical survey in two steps. On the one hand, I analyzed the existence of complexity characteristics determined on the basis of the literature among the 113 parks (basic survey), and on the other hand, I conducted a control survey among 33 parks based on a broader and systematically structured set of criteria.

Based on Figure 4, each park can be said to fall into the highest or the second highest complexity class along at least one complexity aspect. This was confirmed by both the basic survey and the control survey. In other words, it can be stated that almost all of the parks examined can be considered complex in some way.

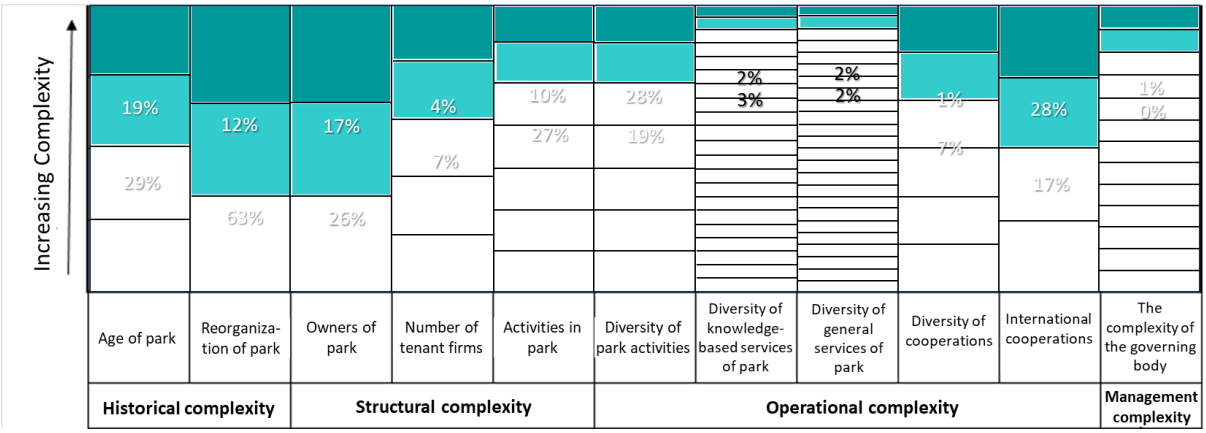

Figure 4 Assessment of the complexity of parks (basic survey)

T1 thesis

Based on the literature review of the topics, I concluded that there is a substantive relationship between complexity theory and the topic of innovation ecosystems, as well as between complexity theory and the topic of science and technology parks .

With the help of empirical research, I pointed out that each of the examined parks can be considered complex at some point of view **at a high level**. However, the analysis also showed that **there is no single type of complexity**, and that there are several forms of complexity among science and technology parks.

Second research subfield (KT2--K2-T2)

Based on the literature review, I developed a method for classifying science and technology parks based on four categories. According to the four criteria, a total of 18 types of science and technology parks can be defined, the processing of which is illustrated in Figure 5. It can be seen that the first aspect is a Triple Helix viewpoint, the second is a one-dimensional classification, and the third and fourth are two-dimensional classifications.

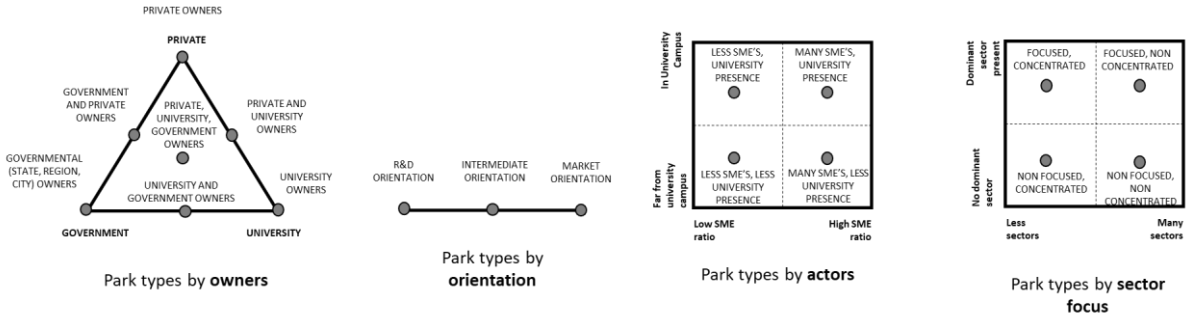

Figure 5 Typology of science and technology parks (own editing)

With the help of this method, I conducted an empirical survey among 113 international science and technology parks, identifying the different types of parks.

T2 thesis

Based on the similarity theory, based on the examination of specific ecosystem characteristics, I developed a method for comparing science and technology parks. With the help of the developed method, typical ecosystem patterns can be identified in terms of the owners, orientation, actors and sectoral focus of the parks.

The **developed methodology** is suitable for describing parks, exploring special characteristics, and demonstrating the **similarities and differences between parks**. The role of this is that the application of the methodology can help to develop the appropriate park development strategy.

Third research sub-field (KT2-K3-T3)

In addition to the development of the detailed park classification method presented above, my aim was to define aggregate park groups. To this end, I performed a hierarchical cluster analysis by examining the main parameters of international parks along four aspects of the developed method. Figure 6 shows the resulting dendogram, based on which four main park groups are given, with a fifth, underrepresented group.

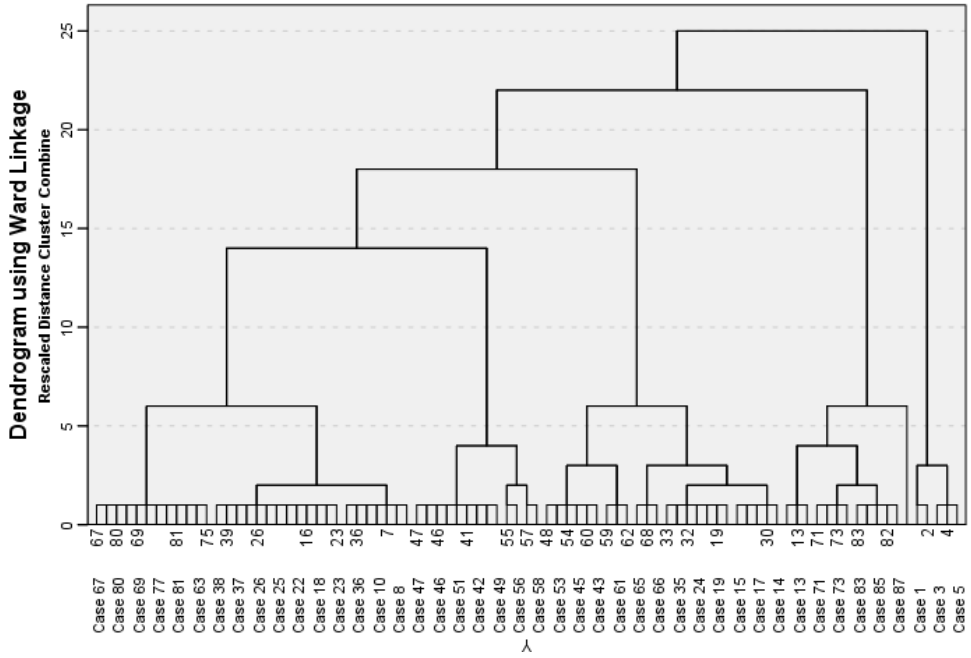

Figure 6 Dendogram obtained by hierarchical cluster analysis

Cluster 1

This is a small park group to be treated separately, underrepresented in the sample, possibly an outlier group formed due to a data error/lack of data, so it will not be included in the evaluation.

Cluster 2

A group of mixed and market-oriented parks (62.5% mixed), the SME ratio is above average, there are usually fewer players from fewer sectors and the number of residents is also rather low (4-260). **BUSINESS PARK**

Cluster 3

It is similar to group 2 in many ways, but this group typically includes larger parks. In terms of orientation, it is rather mixed, but there are also R+D parks here (7.7%). The proportion of SMEs is average, but the number of sectors and the number of settlers is typically higher (260-1000). **TECHNOLOGY PARK**

Cluster 4

In terms of orientation, 50% is mixed, but 37.5% of the participants are R+D in nature. The SME ratio is above average. The sectoral diversity is high, but rather has a small number of settlers, an average of 81 (the average in the whole sample is 170). In these parks, there is usually no sectoral focus, due to the proportion of mixed SMEs. **INNOVATION PARK**

Cluster 5

The group containing only R+D-oriented parks shows the highest proportion of SMEs. It is characterized by greater focus, as it has the fewest sectors. It is a heterogeneous group in terms of the number of participants (15-413). **UNIVERSITY PARK**

T3 thesis

Based on the developed methodology, it is possible to analyze the characteristics of the given park, as well as the relevant management challenges, and the characteristics of the given park type can be determined. Based on the classification criteria of the parks, I separated different groups of science and technology parks and showed the correlations between the different ecosystem types and the relevant management challenges.

The four test parameter groups are suitable for describing science and technology parks. By statistical clustering, I defined four **typical groups of science and technology parks**.

Fourth research subfield (KT3-K4a/K4b-T4a/T4b)

First, I examined the relationships between the eight success criteria of science and technology parks identified on the basis of literature research. As a result of the analysis, Figure 7 illustrates the relationships where the study showed the strongest positive statistical relationship (1-p>0.4) divided into three groups (0.4-0.5; 0.5-0.6; >0.6). From the point of view of the aim of the research, the data are favourable, as a very strong relationship (close to p=1) would show that the success criteria are coherent, i.e. there is no need for so many indicators.

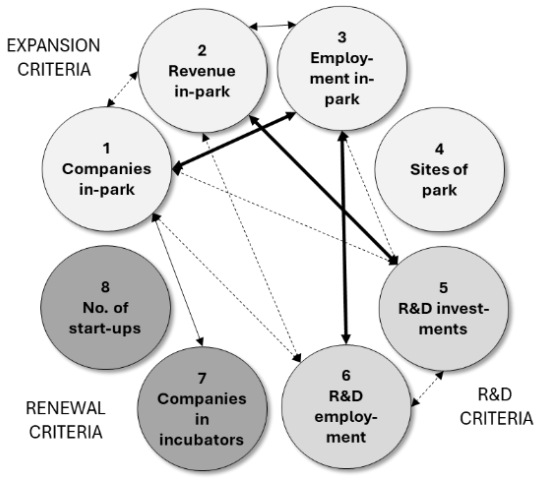

Figure 7 The strongest correlations between the success criteria

The figure illustrates the results of the analysis and reflects the essence of science and technology parks, i.e. the role of the synergistic effect of R&D and innovation in addition to the competitive environment necessary for business growth. The start-up and incubation areas that help renewal are important, but only supporting elements in this system.

Then I examined the relationships between the success criteria and the success factors influencing success. The results (1-p>0.85 value) are summarized in Figure 8, the three different strength levels are indicated by *, **, *** (levels 0.85; 0.9; 0.95).

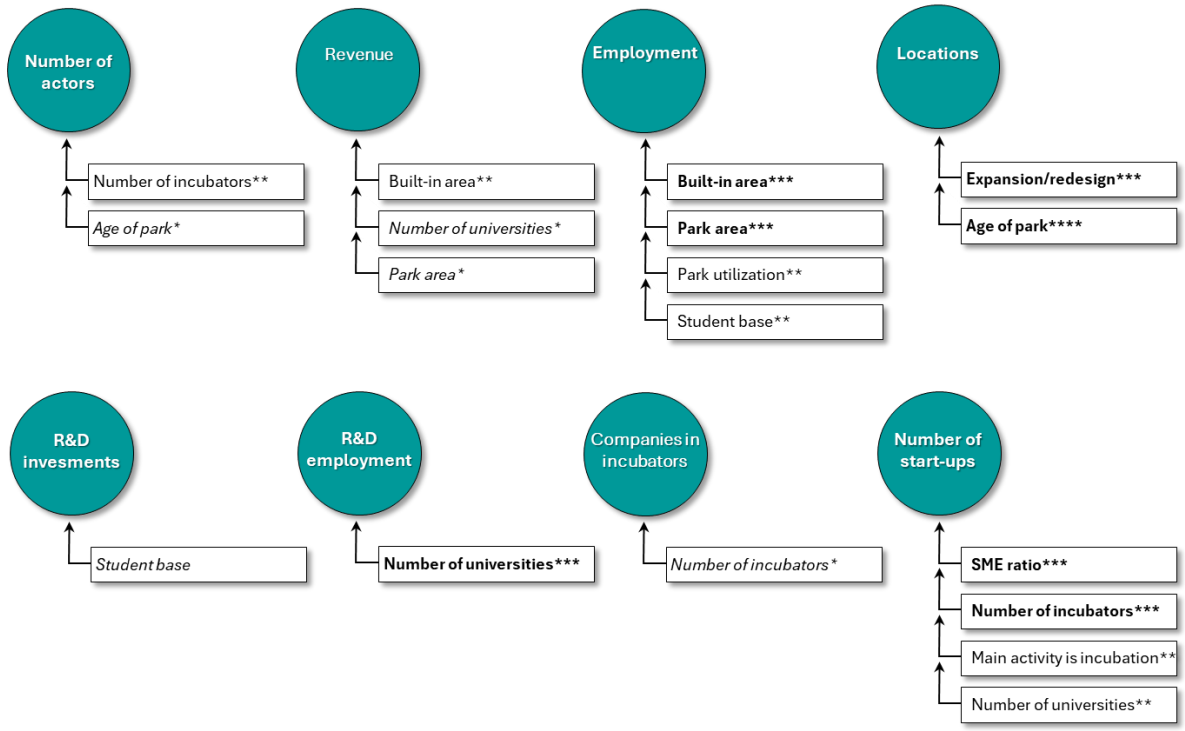

Figure 8 Relationship between success criteria and success factors

I examined the relationship between success criteria and the characteristics related to success in the following. First, I analyzed the internal relationships of the eight endowment areas using the ARM (Association Rule Mining) method, based on the data of 113 parks. After that, I highlighted the characteristic pairs with the strongest correlations, and finally I examined the relationship between the highlighted, most closely related characteristics and the success criteria related to the research questions with a Fisher exact test. Indicating the strongest relationships found, the conclusion of the analysis is given in Figure 9, where I highlighted the statistically significant (1-p>0.95) relationships with a thick line.

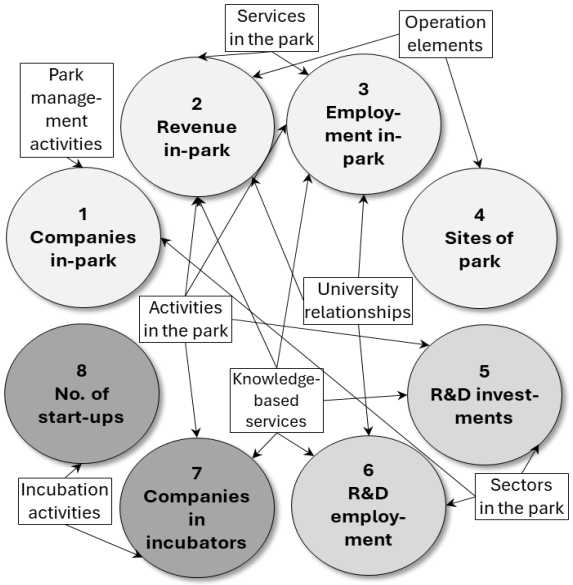

Figure 9 Results of the relationship analysis (based on the values of the Fisher-exact test 'p')

T4a thesis

There are demonstrable relationships between the success criteria of **science and technology parks** , based on which I have verified the correlations between the development, R&D and renewal criteria.

Based on the relationships between the success criteria and success factors **of science and technology parks** , I also determined the relationships between these factors. Along the closest connections, I have shown the most important influencing factors for the success of parks.

T4b thesis

There are demonstrable associations and relationships among the endowments influencing the success **of science and technology parks** , based on which I have demonstrated **the intensity and characteristics of the presence of typical endowment elements**.

Based on the relationships between the success criteria and the capabilities **of the science and technology parks** , I determined the relationship between these factors. Along the closest relationships, I have shown the **specific patterns of** influencing factors.

Fifth research subfield (KT3-K5-T5)

The last part of the research builds on the previous results, as a kind of summary research. Based on the empirical data of the parks under investigation and a detailed survey of the operation of four typical science and technology parks, I demonstrated that the developed methodological elements are suitable for describing and comparing the case of a specific park with other parks:

- assessing the characteristics of the complexity of the park,
- description based on the type characteristics of the parks along four groups of criteria,
- analysis of management challenges taking into account the type of park,
- Analysis of the performance of the park (success criteria, success factors, endowments).

As a result of the research, I pointed out that with the help of a business model-based approach, the main units of understanding operation can be outlined based on the case examples of the examined science and technology parks:

- the conditions of its creation, the mission funds, the essence and basic value proposition of the park,
- the principles and operation of the value creation system: services and management,
- the financial and operational model;
- knowledge background, embeddedness and internationality, development directions.

Based on all this, I prepared the main elements of a general science and technology park development framework model. The purpose of establishing a park usually determines the resettlement strategy and establishes the catalyst effect of the park. The R+D activities in the park and the eventual presence of the university are closely related to the companies that have settled in, and this dual is the basis of the park's development. The knowledge and competence within the park is partly based on the park's university connections. Start-up and incubation activities are important sources for expanding the circle of internal actors in parks. Parks are important elements of regional economic development, so it is essential to connect and cooperate with their environment. Internationality contributes to regional development goals in addition to the development of the actors who have settled in the park.

The final summary of my findings is shown in the following figure, which shows the essence of the general framework model.

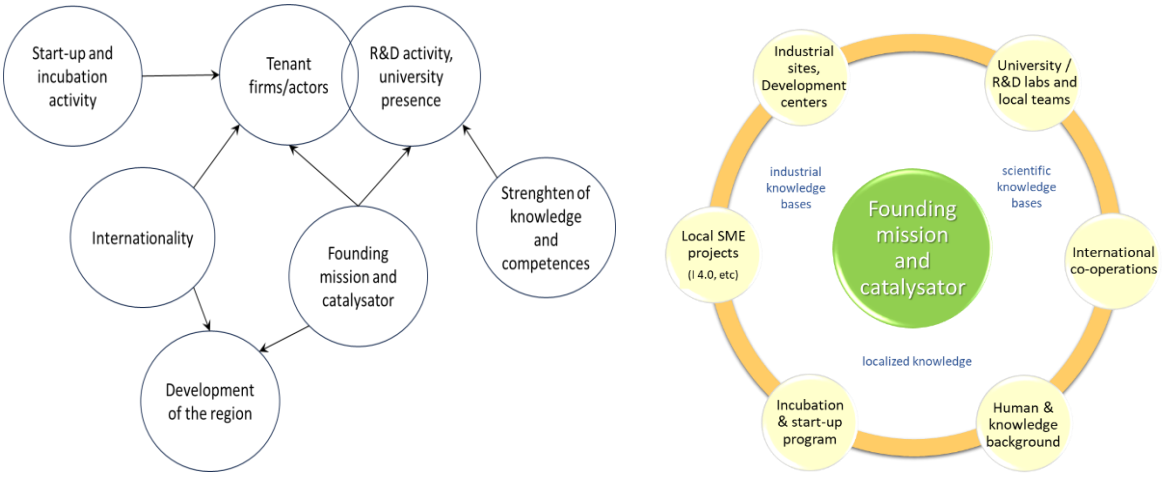

Figure 10 General development framework model for science and technology parks

T5 thesis

The thesis **is based on the developed park investigation methodology**, which allows the evaluation of the level of complexity of science and technology parks, classification according to owners, orientation, park actors and sectoral focus, assessment of park challenges, and evaluation of success metrics through success criteria, success factors and endowments. The developed methodology and the conclusions it can draw **are suitable for describing the case of a specific science and technology park** and comparing it **with other parks**.

Based on the example of the parks examined, I pointed out that the **business model approach can be interpreted** at the level of science and technology **parks**, helping to understand the operational success of the park.

Based on the findings from the cases of the parks examined and from the research as a whole, I outlined a **general framework model to help the development of** science and technology parks.

Summary

The object of my research was the research of the theoretical background, structural and classification issues, operational and development characteristics of science and technology parks, basically from the point of view of complex systems. Due to the complex approach, the choice of research areas and research questions, as well as the construction of the entire research methodology, were based on a multi-faceted approach with a diverse set of research tools. The

research follows a framework structure, the first thesis that establishes the subject of the research and the summary thesis based on the results of the research frame the thesis. The framework model developed in the last thesis is of paramount importance for practical application, as it reflects the multi-faceted approach needed to understand science and technology parks.

The complexity perspective studied within the first research area occurs to some extent in the literature of innovation ecosystems. However, the approach from the side of complex adaptive systems is also particularly relevant for my research (e.g. Jucevicius and Grumadaite (2014), Phillips and Ritala (2019)), as the interpretation of this to the area of science and technology parks is limited. The research results contribute to this, which can be further investigated from both theoretical and practical aspects along new complexity aspects.

Within the second research area, the typification and classification of innovation ecosystems is widely researched, while that of science and technology parks is less so. The work of Albahari et al. (2016) is still relevant today, but the work of Oh et al. (2016), Katri (2015), Jacobides et al. (2018) and Lecluyse et al. (2019) can also be mentioned. Aggregate park typing methodology with several aspects at the same time appears less in the literature. This is suggested by my related research results, which have further developed the single-aspect-based methods of Dabrowska-deFaria (2020) and Liberati et al. (2015), among others. The developed methodology can be expanded according to further criteria and sub-aspects, and a particularly interesting future research area is the quantification of the orientation of parks and the evaluation of university presence.

My research related to the topic examined in the third research area, the evaluation of the performance of science and technology parks (e.g. Ng et al. (2021), Albahari et al. (2022), Bigliardi et al. (2016) and Berbegal-Mirabent (2019)), explore previously unexplored correlations between the success criteria, success factors and endowments of parks. In the course of future research, the range of examined data can be broadened, the range of parks involved can be expanded, and further correlations can be sought.

An important conclusion of the research is that knowledge-based aspects have appeared relatively limited among the parks examined, which may be the first step of an interesting future development. There are few research results in the interpretation, examination and practical implementation of the topic of knowledge management at the level of the park as a system, and even fewer concrete and well-functioning practical examples. With this aspect, the developed framework model can be further expanded.

Practical significance and limitations of research

Practical significance. The research results can be used primarily for park management organizations. The approach on the complexity theory side helps to find answers to short- and long-term challenges. With the help of the developed method, park managers can place their parks based on the defined groupings, which require different development strategies. With the help of the success criteria and success factors, as well as the elaborated correlations of the endowments, the performance management methodology of the park can be developed. The general development framework model is suitable for managing the entire development environment of a park. Improving the methodical nature of park management contributes to the development of services provided to the settled companies. The system of success factors and endowments makes it possible to develop and introduce answers to the needs of the settlers. The four-aspect-based methodology helps to approach the regional and spill-over effect of the science and technology park in a systemic approach and to develop the cooperation program between the park and the region based on this. Through the management of the success criteria, the impact of the park on the region can also be modeled. The results of my research may also be useful for innovation policy decision-makers, as the four-criteria evaluation methodology and the system of success criteria are very finely suited for comparing different parks, yet they also provide the opportunity to develop programs tailored to the unique environment of the park.

Applicability in the development of domestic parks. The results of my research showed that science and technology parks appear in many forms on the international scene. There is no single recipe that leads to "sure success", it comes from the diversity of the parks' formation, environment, development path and internal functioning. As complex "complex" social systems, the role of individuals, groups, collaborations as soft factors is also significant. As the research shows, certain patterns and characteristics can still be detected, helping the park management to develop and manage the development strategy.

UNIVERSITY PARK

The fact that the park is initiated, owned and operated exclusively by a single university or a majority university entity, also results in the culture and community character of the ecosystem in general. In addition to education and research as basic elements, market-based activities can also contribute to the maintenance of the park, bearing in mind that this is not the primary competitiveness factor. Based on international examples, a park structure that is independent of

the central organization and partly slightly closer to market conditions can contribute to the university's entrepreneurial attitude and relationships. In its service portfolio, the range of knowledge-based services can be decisive, exploiting the university background. In Hungary, the university-centred innovation ecosystem initiatives that have been launched fit well into this line. However, it is important that the park structure is clearly separated from the university's organizational operation, but the synergistic relationship between the two is still maintained. It should also be kept in mind that an organization with a university background will be less able to carry out competitive market activities independently, therefore, in addition to the necessary real estate portfolio, special emphasis should be placed on community projects and goals, as well as on having a positive impact on the local economic and social environment. The success of this type of park can be measured, for example, in the positive effects on the university (external R+D projects, investments, etc.), an important condition for this is cooperation with the established industrial players and the region.

INNOVATION PARK

The focus of these parks is on activities that promote innovation, and the creation and promotion of a culture related to it. In terms of its activities, it is strong in catalyzing innovation processes, initiating cooperation, and implementing programs and projects that support them. It can be owned or operated by a city, a non-profit actor or a private company that wants to do something for the region (based on international experience, there are several examples of the latter). This type of well-functioning innovation ecosystem is relatively rare in Hungary, otherwise this model could be built on innovation or incubation centers. In terms of innovation, the SME circle is important, either independently or dynamised by a large local company. At the same time, developing businesses, intensive start-up activities and creative solutions could be the tools that can have a positive impact on the economic development of a region. Building on the experience of a small number of previous positive examples, a sustainably functioning infrastructure implemented with targeted tender support and a balanced service environment can help the development of these. The success of this type of park can be measured, for example, in innovation performance (number of patents, number of start-ups, etc.), an important external condition for this is an inclusive entrepreneurial environment.

BUSINESS PARK

This type aims to attract high value-added activities with a high-quality, attractive built environment that promotes competitive operation. The utilization of infrastructure (real estate) and related services are in the foreground, which often have a private investor background. Its

relationship with the regional environment is primarily realized through external business cooperation. There are several parks of this kind in Hungary, usually in a service environment, where industrial and manufacturing activities are less typical. Its creation assumes an attractive location, so it is more typical for the capital or other frequented places. The R&D and innovation that characterizes science and technology parks is more of a business consequence than a founding mission in these ecosystems. The success of this type of park can be measured, for example, in the value of the services provided to the settlers, and an important condition for success is the appropriate attractiveness.

TECHNOLOGY PARK

Compared to industrial parks, it is a structure positioned at a higher level of research, development and innovation along the principles of science and technology parks, often tied to some sectoral focus. Based on international experience, the background of the creator, operator and owner may be different, from a governmental-local government or private investor circle, or with different combinations of these. The presence and connection of university and research and development capacities is of paramount importance in these parks, in line with industrial needs. In terms of size, the circle of settlers and the development path, it is one of the most diverse forms of parking. Its successful operation cannot do without cooperation with the narrower or wider region. Several successful industrial parks have been established in Hungary in recent decades and several large-scale industrial park developments are currently underway. A zone that has been positioned as an industrial park from the beginning rarely becomes a classic technology park environment, and this must already be reflected in the conditions of its creation. A typical example of the technological park form is the ZalaZONE Technology Park, which was established in the vicinity of the automotive test track in Zalaegerszeg. Each of the Triple Helix stakeholders is involved in the development of the ecosystem from the very beginning, through investments, projects or collaborations. The balance between the industrial-market settlers and the research and development activities is ensured by the cooperation and complementary activities of the established and cooperating universities and engineering activities. The success of this type of park can be measured, for example, in the joint performance of research and development and industry (projects, employees, etc.), and an important condition for success is a balanced park development implemented in harmony with the region.

Of course, the four types of models are not sharply distinguishable types, in practice transitions and overlaps appear between them. The main message of my research is that although there are

typical park models, in fact each science and technology park initiative must follow a development strategy that fits into the specifics of the given region, culture and industry.

The limits of research. The limitations of the research stem primarily from the delimitation of the field of research. The limitations of the developed method were detailed in Chapter 4.2.4, and by expanding the examined aspects and aspects, the methodology can also be improved. An empirical database is always a limitation, although the 113 parks provided a sufficiently deep and detailed data set for the purposes of the research. As I pointed out in the literature review, the possibilities of success measures are wide-ranging, but the aim of my research was to develop the foundations of a coherent causal system. The interview partners for understanding the operation were selected on a sample basis, which is a natural limitation, but the basic operating principles were still outlined.

Future research opportunities. Deeper and broader examination of complexity aspects, expansion of the criteria of the evaluation method, further diversification of the identified park grouping, further examination of success criteria, success factors and endowments, further analysis of operational model elements, evaluation of the experiences of the developed framework model. Further cooperation with the IASP will provide an opportunity for further, even longitudinal studies.

Publications

https://m2.mtmt.hu/gui2/?type=authors&mode=browse&sel=authors10078546

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