

EVOLVING ROLE AND PERFORMANCE OF SCIENCE AND TECHNOLOGY PARKS IN INNOVATION SYSTEMS: A QUINTUPLE HELIX PERSPECTIVE

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Purpose: The purpose of the study was to identify various dimensions of change within science and technology parks over a ten-year period. This study identifies how science and technology parks have changed between 2012-2022 and whether they align with the Quintuple Helix system.

Design/methodology/approach: The primary research method employed is document analysis, supplemented by comparative analysis as the principal research technique. This study utilizes secondary data sourced from the International Association of Science and technology parks and Areas of Innovation (IASP).

Findings: The study illustrates that between 2012 and 2022, science and technology parks have experienced an increased presence of the private sector within their ownership structures. Furthermore, these parks have transitioned from facilities management organizations to entities that collect, process, and disseminate knowledge to their clients through value-added services. They have begun to provide support to non-resident companies, underscoring their expanded role within the innovation ecosystem. In alignment with the Quintuple Helix model, science and technology parks facilitate collaboration among academia, industry, government, civil society, and the natural environment. They are increasingly involved in community support and sustainability initiatives. These developments highlight the parks' pivotal role in orchestrating regional innovation systems and enhancing regional competitiveness.

Research limitations/implications: One limitation of this study is the reliance on secondary data, coupled with the limited availability of data regarding the number of parks and the geographical distribution of the sample. This may result in a sample that is not representative of each region. Future research should aim to explore additional variables and strive for a more balanced sample distribution across all geographical regions.

Practical implications: The findings suggest that science and technology parks should enhance investment strategies to attract private sector involvement, diversify their service offerings to include more knowledge-based and value-added services, and develop tools to support non-resident companies. Policymakers can use these insights to craft policies that encourage private sector investment in science and technology parks, fostering a more dynamic and diverse ownership structure.

Social implications: Increased community engagement can amplify the social impact of science and technology parks. The emphasis on community engagement and sustainability initiatives can enhance the quality of life for local residents, promote social cohesion, and encourage environmentally responsible practices. Parks can also serve as hubs for

education and social services, further integrating themselves into the fabric of the community and contributing to overall social well-being.

Originality/value: The paper presents novel insights regarding the evolving ownership structures of science and technology parks and provides empirical evidence supporting the shift from their traditional role in property management to a focus on knowledge creation. This knowledge is disseminated through various value-added services to resident companies and a wider public which enhance the parks' role in the innovation ecosystem.

Keywords: science and technology parks, Quintuple Helix, innovation systems, value-added services.

Category of the paper: research paper.

1. Introduction

To Innovation plays a crucial role in regional economic growth, a topic widely discussed from both economic and political perspectives (Maradana, 2017; Shpak, Ruduyk, 2023). Science and technology parks in contemporary knowledge-based economies align well with both economic and political objectives. These entities attract early-stage entrepreneurs, researchers, investors, and other institutions, catalyzing multidirectional knowledge transfer, innovation collaboration, and co-creation, leading to the development of regional innovation ecosystems based on cooperation. Besides providing space for business development, including research, experiments, tests, and prototypes, the value-added of such spaces lies in offering a wide range of services, opportunities for interaction and networking. As a consequence of interactions within science and technology parks, resident companies accrue benefits from their geographical proximity to other innovative entities, access to specialized knowledge and support systems, availability of funding opportunities, and enhanced reputational standing (Sanz et al., 2023).

Science and technology parks offer various types of value-added support, primarily targeting nascent, innovative enterprises engaged in the development of new products or services, market entry, or business acceleration. The concept of science and technology parks initiated the development of innovation support spaces and initiatives of various kind. The inception of innovation support spaces. While these parks continue to play a pivotal role as innovation support entities, the innovation ecosystem has expanded to include other key institutions within the helix system, such as clusters, business incubators, accelerators, innovation districts, industrial campuses, areas of innovation and living labs. These spaces differ conceptually but share the primary goal of supporting innovation to enhance regional competitiveness. This article focuses on 'science and technology parks', also known in literature and practice as 'science and technology parks', 'technology parks', 'technopoles' and research parks (Waligóra, 2015). All these entities fit the definition of science and technology parks. They provide space and value-added services which support innovation development and

consequently contribute to local and national economies. The scope of activities and ownership structures of these entities vary depending on the specific contexts and economic conditions of the region in which the science park and technology park operates. Diversity in ownership structures and stakeholder influence often leads to different priorities and management strategies, affecting the dynamics of relationships developed at each level of Quintuple Helix.

Science and technology parks play a crucial role in developing innovative regional environments. Davies (2013) suggests that parks ‘orchestrate’ collaboration within regional innovation systems. These are places where businesses, the public sector, and research and development institutions collaborate to create and implement new ideas and technologies. Relationships within such parks are vital as they facilitate the organization and exchange of knowledge, resources, and experiences among various entities (private sector, public sector, and academia), which are the fundamental building blocks of innovation systems based on the triple helix concept (Etzkowitz, 2008). In 2009, Carayannis and Campbell added the civil society as the fourth element of the helix, and in 2012, they included the natural environment as the fifth dimension. Nordberg (2015) critically addressed this extension of the helix structure, indicating that society and citizens are merely the backdrop against which innovation processes occur. However, for science and technology parks it is important to support and enhance the creation of innovations for and with civil society or for the benefit of the natural environment. By engaging in a wide variety of activities and with various stakeholders, science and technology parks play an important role as ‘orchestrators’ of relationships among different stakeholders that fit into the Quintuple Helix (Sousa, Silva, Celani, 2023).

2. Methodology

The purpose of the study was to identify various dimensions of change within science and technology parks over a ten-year period. This study identifies how science and technology parks have changed between 2012-2022 and whether they align with the Quintuple Helix system. The research questions have been designed as follows:

- Has the ownership model of science and technology parks changed over a ten-year period?
- How have the key activities and functions of science and technology parks changed over a ten-year period?
- Do science and technology parks’ activities align with Quintuple Helix model, which encompasses interactions among academia, industry, government, civil society, and the natural environment

The primary research method employed is document analysis, supplemented by comparative analysis as the principal research technique. This study utilizes secondary data sourced from the International Association of Science and technology parks and Areas of Innovation (IASP) Global Surveys conducted in 2012 (based on the research sample of 119 science and technology parks from 38 countries) and 2022 (based on the research sample of 113 science and technology parks from 47 countries). IASP, established in 1984, is a globally recognized organization headquartered in Malaga, Spain. It comprises nearly 400 members (science and technology parks and areas of innovation), including science and technology parks and areas of innovation, spanning 80 countries across all continents¹. This extensive global presence facilitates a diverse exchange of knowledge and best practice among science and technology parks and innovation districts worldwide.

3. Results

The concept of science and technology parks has undergone significant evolution over the past five decades. As these institutions have developed, the stakeholders involved and the dynamics of forces and influences within science and technology parks have shifted, leading to the emergence of diverse business models. The initial park initiatives in the 1950s were experimental in nature, rather than being well-defined instruments of innovation policy (Charles, Uyarra, 2010). The first science park was established by Stanford University in 1951, followed by the creation of Research Triangle Park in 1959 in the United States. This concept rapidly gained global traction. In Europe, the first science park, Sophia Antipolis, was established in France in 1969, followed by the Cambridge Science Park in the United Kingdom. During the 1980s and 1990s, science and technology parks began to be recognized as vital tools for fostering economic and technological growth. In Europe, the science park movement gained prominence in the mid-1980s, with the majority of existing parks being established in the 1990s and beyond.

Over a decade, several trends have emerged within science and technology parks, particularly concerning ownership models. Initially, the majority of science and technology parks were publicly owned. Although public ownership remains predominant globally, the private sector has become increasingly prominent within ownership structures. In 2022, 50.4% of science and technology parks reported being fully owned by the public sector, a slight decrease from 54.6% in 2012. Conversely, 22.1% of science and technology parks globally were privately owned in 2022, up from 16% in 2012. Additionally, mixed ownership models were reported by 27.4% of science and technology parks in 2022, compared to 29.4% in 2012.

¹ Source: <https://www.iasp.ws/our-members/directory>: 13.10.2024.

While many science and technology parks globally are publicly owned and retain their ownership structure throughout their life cycle, there are numerous instances of parks that have altered their ownership model. Several mature science and technology parks have transitioned to private ownership, including Cambridge Science Park and Manchester Science Park in the UK, and Sophia Antipolis in France. These changes in ownership structures frequently modify the relationships and dynamics among stakeholders.

Furthermore, significant variations of ownership models exist across different geographical regions. Mixed ownership models are predominant in Africa, North America, and Europe. In contrast, privately owned science and technology parks are most prevalent in the Asia-Pacific and Latin America regions. The model of full public sector ownership remains the most common in Eurasia, as well as in West Asia and North Africa.

Also, public involvement in science and technology parks can be achieved through various channels beyond ownership models. Governments and public institutions can provide critical support by offering access to funding and financing specific projects within the parks. Additionally, public sector representatives can play influential roles by serving as members of the board of directors or advisory boards, thereby contributing to strategic decision-making and governance. These forms of engagement ensure that public interests are represented and that science and technology parks benefit from a diverse range of expertise and resources, fostering an environment conducive to innovation and growth.

Another discernible trend within the science park concept is the evolving role of management teams in service provision. Management teams at science and technology parks are increasingly shifting their focus away from facilities management. In 2022, 67.3% of science and technology parks were engaged in facilities management, compared to 71.4% in 2012. Some science and technology parks outsourced their property management activities (e.g. Mjardevi Science Park in Sweden, Z-Park in China or 22@Barcelona in Spain). Instead of being preoccupied with facilities management, there is a growing emphasis on the provision of 'value-added' services by managers of science and technology parks. These knowledge-based services encompass a wide range of support designed to foster interaction and establish relationships with various stakeholders within the innovation ecosystem. These services included in 2022 for instance: incubation and acceleration (79.6% of science and technology parks globally in 2022), events for residents (78.8%) and open public (57.5%), community building (77.9%), financial planning (57.5%), technology transfer (57.5%), investor relations (54%), talent acquisition (54%), strategic and business planning (66.4%), etc. It is noteworthy that access to knowledge-based services provided by science and technology parks extends to external companies. In 2022, a mere 15.9% of IASP science and technology parks restricted their knowledge-based services exclusively to resident companies. Conversely, a significantly larger proportion of respondents (46.9% and 37.2%) offered these services to non-resident companies, either under varying or identical conditions.

Although it has been observed that between 2012 and 2022 science and technology parks have developed more specialized support services, there has been a noticeable decline in their focus on providing international support. In 2022, 77% of science and technology parks globally offered support related to international relations building and networking, compared to 86.6% in 2012. Instead, there has been more pressure for science park management to enhance activities also for the benefit of local communities and natural environment. Consequently, an increasing number of science and technology parks have undertaken initiatives aimed at promoting sustainable development and eco-friendly solutions. These efforts often extend to active engagement with civil society, including the organization of events for educational institutions, charitable organizations, and unemployed individuals. There has been a notable increase in the provision of health, education, and social services within science and technology parks, available both to resident companies and the general public. In 2022, 57.3% of science and technology parks globally reported having these elements on their sites. In the 2022 IASP Global Survey, data pertaining to ‘community’ building was gathered for the first time, indicating that this aspect had previously been a minor focus within science and technology parks.”

The above examples underscore the commitment of science and technology parks to fostering community engagement and contributing to the well-being of local populations.

4. Discussion

The study illustrates that between 2012 and 2022, science and technology parks have witnessed a significant increase in private sector involvement within their ownership structures. This trend indicates that these parks have evolved into viable and profitable entities for private sector investment. The concept has gained credibility, and the private sector recognizes the advantages of investing in and supporting such developments. The findings indicate that science and technology parks should meticulously evaluate their investment strategies to attract private sector involvement, ensuring that this does not compromise their primary objectives. It is crucial to maintain a balance, as the overarching goals of the parks may shift if the private sector assumes a dominant role.

The study highlights the science and technology park transformation, moving from property management to organizations focused on provision of sophisticated knowledge-based services. In addition to implementing green solutions and spaces, workshops and events promoting sustainable development and eco-friendly practices are organized for resident companies and the local community. Firms are encouraged to use renewable energy sources, reduce waste, and implement sustainable solutions. Collective efforts towards environmental

protection foster a culture of ecological responsibility, benefiting both the local community and the entire region.

The transition from property management organizations to more advanced entities is also evident in the evolving definitions of science and technology provided by science park associations: United Kingdom Association of Science and technology parks, Association of University Research Parks (US) and International Association of Science and technology parks (Table 1).

Table 1.
Definitions of science and technology parks

Organization	Definition (Early)	Definition (Current)
United Kingdom Science Park Association	1990s-2000s: A property-based initiative linked to universities, aimed at fostering collaboration between academia and industry, providing space and resources for R&D activities.	2020s: A science park is a business support and technology transfer initiative that: <ul style="list-style-type: none"> • encourages and supports start-up and incubation of innovation-led, high-growth knowledge-based businesses; • provides an environment where larger and international businesses can develop specific and close interactions with a particular centre of knowledge creation for their mutual benefit; • has formal and operational links with centres of knowledge creation such as universities, higher education institutes and research organisations.
Association Of University Research Park (US)	1990s-2000s: Developments affiliated with universities, focused on providing space for research and development activities.	2020s: Developments that foster innovation and commercialization of technology through the support of research and development. These parks are typically affiliated with universities and aim to create environments that support the growth of technology-based companies.

Cont. table 1.

International Association Of Science And Technology Parks	<p>1990s-2000s: Organizations managed by professionals whose main aim is to increase the wealth of their community by promoting innovation and competitiveness among associated businesses and knowledge-based institutions. This includes managing the flow of knowledge and technology among universities, R&D institutions, companies, and markets, and facilitating innovation-based companies through incubation and spin-off processes; and provide other added-value services together with high-quality space and facilities.</p>	<p>2020s: Areas of innovation, of which science, technology and research parks are highly specialized type, play a key role in the economic development of their environment. Through a dynamic and innovation mix of policies, programs, quality space and facilities and high value-added services, they:</p> <ul style="list-style-type: none"> • stimulate and manage the flow of knowledge and technology between universities and companies, • facilitate the communication between companies, entrepreneurs and technicians, • provide environments that enhance a culture of innovation, creativity and quality, • focus on companies and research institutions as well as on people: the entrepreneurs and 'knowledge workers', • facilitate the creation of new businesses via incubation and spin-off mechanisms, and accelerate the growth of small and medium size companies • work in a global network that gathers many thousands of innovative companies and research institutions throughout the world, facilitating the internationalization of their resident companies.
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Source: own work.

The above definitions of a science and technology parks do no longer focus on the quality spaces and facility management but on stakeholders' interaction and provision of value-added services based on knowledge.

Modern science and technology parks organizations focus on knowledge creation i.e. they collect, process, and disseminate information to their clients, which is one of the key characteristics of knowledge-based organizations. Moreover, the provision of specialized knowledge-based services extends beyond resident companies to include non-resident companies, indicating the broader impact and recognition of SPs as crucial players in regional innovation systems.

Davies (2013) names that evolution a "shift from third generation science and technology parks to areas of innovation" (p.3) where innovation support is available beyond physical boundaries and is not only available to businesses but also local communities benefit from their presence in the innovation ecosystem. The value-added services make science and technology parks quite unique on the market (Lecluyse, Knockaert, Spithoven, 2019).

Ratinho and Henriques (2010) elaborate that the knowledge possessed by park management is multidisciplinary, integrating scientific, technical, business, and political knowledge. This multidisciplinary approach enables managers to produce high-quality services tailored to the specific needs of client companies. The knowledge production within modern science and technology parks is a blend of tacit knowledge (skills, know-how, and personal attributes) and explicit knowledge (experience and facts that can be easily transmitted).

The process of knowledge creation within science and technology parks involves both individual and collective efforts. Managers draw on their personal experiences to generate new knowledge, which they then process and disseminate to client companies (Campanella, Peruta, Giudice, 2014). Science and technology management teams often work independently, in teams, or in collaboration with other professionals to create new knowledge or enhance the value of existing knowledge for their clients.

The implications of this shift are profound. The transformation of science and technology parks from property management organizations to knowledge-based organizations represents a significant development in the landscape of regional innovation systems. They are considered to be 'knowledge territories' (Sousa, Silva, Celani, 2023). This shift underscores the importance of knowledge creation and dissemination in driving economic growth and innovation, highlighting the evolving role of science and technology parks as key facilitators of knowledge-based economies.

Moreover, the emphasis on knowledge creation and dissemination fosters a culture of continuous learning and improvement within science and technology parks. This culture is vital for sustaining long-term growth and ensuring that parks remain at the forefront of technological and business advancements. By leveraging both tacit and explicit knowledge, park managers can create a dynamic environment that encourages collaboration, creativity, and the exchange of ideas. This environment not only benefits the resident companies but also attracts new businesses and talent to the region, further strengthening the regional innovation system.

To summarize, the park transformation underscores the critical role of knowledge creation and dissemination in driving sustainable development and economic growth. By providing a wide range of value-added services science and technology parks make innovations and business adventures more probable boosting the overall competitiveness and resilience of the regions they serve. This holistic approach ensures that innovation support transcends physical boundaries, benefiting businesses, local communities, and the environment. Consequently, science and technology parks reinforce the Quintuple Helix framework's emphasis on sustainability and societal impact, fostering a dynamic and inclusive innovation landscape.

5. Summary

This study investigated the evolution of science and technology parks over the past decade, focusing on changes in ownership models, key activities, functions and alignment with the Quintuple Helix model. Over the past decade, the ownership models of science and technology parks have shifted significantly. Initially, most science and technology parks were publicly owned. However, there has been a noticeable increase in private sector involvement. The proportion of privately owned parks has risen, while public ownership has slightly decreased. Mixed ownership models have also seen a minor decline, indicating a trend towards more diverse and dynamic ownership structures. This shift reflects the growing role of the private sector in the management and strategic direction of science and technology parks.

The key activities and functions of science and technology parks have evolved from a primary focus on facilities management to the provision of knowledge-based services. There has been a significant increase in services such as incubation and acceleration, community building, and technology transfer. Additionally, science and technology parks have expanded their support to non-resident companies, highlighting their broader role in the innovation ecosystem. This shift underscores the transition of science and technology parks from property management entities to knowledge-based organizations.

The activities of science and technology parks increasingly align with the Quintuple Helix model, which includes interactions among academia, industry, government, civil society, and the natural environment. Science and technology parks act as orchestrators of these relationships, fostering collaboration and innovation. They have enhanced their focus on community engagement and environmental sustainability, with many parks providing health, education, and social services. This alignment underscores the role of science and technology parks in driving sustainable development and regional competitiveness.

To summarize, the study highlights the dynamic changes in ownership models, the evolution of key activities, and the alignment of science and technology parks with the Quintuple Helix model over a ten-year period. These transformations reflect the adaptation of science and technology parks to the demands of knowledge-based economies, emphasizing their importance in fostering innovation and regional growth.

While the study provides valuable insights, it also has limitations, such as its reliance on secondary data and the limited availability of information on the number and geographical distribution of parks, which may lead to a non-representative sample. Future research should consider additional variables and strive for a more balanced sample distribution. On a practical level, the findings suggest that science and technology parks should improve their investment strategies to attract private sector involvement, diversify their service offerings to include more knowledge-based and value-added services, and develop tools to support non-resident companies.

References

1. Campanella, F., Peruta, M., Giudice, M. (2014). Creating conditions for innovative performance of science and technology parks in Europe. How manage the intellectual capital for converting knowledge into organizational action. *Journal of Intellectual Capital*.
2. Carayannis, E.G., Campbell, D.F.J. (2009). 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, 46(3/4), 201-234.
3. Charles, D., Uyarra, E. (2010). *Practical Benefits of Innovation-related Instruments at Regional and Local Level*. Report for the EU-oecd Innovation Project. A New Innovation Strategy for Regions. Paris: OECD.
4. Davies, J. (2013). *From Third Generation Science and technology parks to Areas of Innovation*. 30th IASP World Conference on Science and Technology Parks, Recife, Brazil.
5. Etzkowitz, H. (2008). *The Triple Helix: University-Industry-Government Innovation in Action*. Routledge.
6. IASP (2012). International Association of Science and technology parks 2012 Global Survey, IASP.
7. IASP (2022) International Association of Science and technology parks 2012 Global Survey, IASP.
8. Lecluyse, L., Knockaert, M., Spithoven, A. (2019). The contribution of science and technology parks: a literature review and future research agenda. *The Journal of Technology Transfer*, 44, 559-595.
9. Maradana, R.P., Pradhan, R.P., Dash, S. (2017). Does innovation promote economic growth? Evidence from European countries. *J. Innov. Entrep.*, 6, 1.
10. Nordberg, D. (2015). *Corporate governance: Principles and issues*. SAGE Publications.
11. Ratinho, T., Henriques, E. (2010) The role of science and technology parks and business incubators in converging countries: Evidence from Portugal. *Technovation*, 30, pp. 278-290.
12. Sanz, L., Klofsten, M., Van Dinteren, J., Jansen, P. (2023). *A Taxonomy of Organised Innovation Spaces*. Battiston, A., Fazio, A. (eds.). Luxembourg: Publications Office of the European Union.
13. Shpak, Y., Ruduyk, Y. (2023). *The role and impact of innovative development on the economic growth of countries*. Economic Scope.
14. Sousa, M., Silva, R., Celani, G. (2023). Placemaking in the Design of Knowledge-Based Urban Developments. *Joelho Revista de Cultura Arquitectonica*.
15. Waligóra, K. (2015). Parki naukowe, technologiczne i przemysłowe jako narzędzie wspierające potencjał innowacyjny polskiej gospodarki. In: E. Gruszewska (ed.), *Współczesne wyzwania rozwoju gospodarczego: polityka i kreacja potencjału: kreacja, innowacyjność, handel zagraniczny, Cz. 1* (pp. 171-186). Białystok: Wydawnictwo Uniwersytetu w Białymstoku.