

STRATEGIC SHAPERS OF INNOVATION ZONES: THE EVOLVING ROLE OF STPS IN ECOSYSTEM DEVELOPMENT

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Purpose: This study explores how science and technology parks (STPs) have evolved over the past decade, focusing on their transition from infrastructure-based facilitators of innovation to strategic shapers of innovation zones. It examines changes in governance, strategic priorities, and sustainability orientation, assessing their alignment with the Quintuple Helix framework.

Design/methodology/approach: A longitudinal comparative document analysis was conducted using data from the IASP Global Surveys (2015 and 2024). The study applies thematic coding to identify structural and functional transformations of STPs and interprets them within the ecosystem and Quintuple Helix perspectives.

Findings: The results show that STPs have shifted from publicly managed institutions to hybrid and professionalised governance models. They have diversified funding, expanded services, and integrated sustainability and ESG principles into their strategies. STPs now function as orchestrators of innovation ecosystems, actively shaping governance, sustainability, and spatial development.

Research limitations/implications: Based on secondary IASP data, the study offers global insights but limited regional granularity. Future research should include case studies for deeper contextual understanding. The reliance on secondary survey data limits direct observation of organisational practices; therefore, future research should combine longitudinal survey analysis with qualitative case studies to further validate the causal mechanisms identified in this study.

Practical implications: The findings highlight the need for policymakers and innovation managers to recognise STPs as strategic partners in regional and urban development. Strengthening hybrid governance, expanding ecosystem-oriented services, and embedding sustainability frameworks can enhance the long-term impact of STPs on competitiveness and innovation-led growth.

Social implications: The study highlights the social added value of STPs as institutions that connect science, industry, government, and society. By promoting sustainable innovation, civic engagement, and knowledge diffusion, STPs contribute to more inclusive, responsible, and participatory models of economic and social development.

Originality/value: The study provides rare longitudinal evidence of STP evolution and demonstrates their emerging role as strategic shapers of innovation zones.

Keywords: STPs, science and technology parks, Quintuple Helix, innovation systems, innovation areas.

Category of the paper: research paper.

1. Introduction

The geography of innovation has undergone a profound transformation in recent decades. Science and technology parks (STPs), once designed primarily as physical infrastructures supporting research commercialization and technology transfer, have evolved into strategic shapers of innovation zones. These entities now actively structure and govern how innovation ecosystems emerge, connect, and sustain themselves. Their function has expanded from hosting technology-oriented enterprises to curating dynamic, knowledge-intensive environments where academia, industry, government, and society interact in real time (Etzkowitz, Leydesdorff, 2000; Dąbrowska, 2024). This transformation reflects the growing importance of integrated spaces that orchestrate innovation across technological, social, and environmental domains.

Historically, STPs were conceived as regional policy instruments aimed at enabling technology transfer, stimulating entrepreneurship, and fostering economic diversification. Over time, however, globalisation, digitalisation, and the growing importance of sustainability have significantly altered their mission and governance. The traditional Triple Helix model of university–industry–government collaboration has gradually evolved into the more comprehensive Quintuple Helix model, which also incorporates civil society and the natural environment as active contributors to innovation (Carayannis, Campbell, 2010). Within this expanded framework, STPs no longer simply facilitate innovation processes but also shape their direction and inclusivity, aligning technological advancement with societal well-being and ecological responsibility (Carayannis, Grigoroudis, Campbell, 2022).

Recent scholarship confirms this shift in the conceptual and functional identity of STPs. Dąbrowska (2024) argues that their performance must now be analysed through a Quintuple Helix lens, recognising their strategic capacity to balance economic competitiveness with social and environmental objectives. Her findings demonstrate that STPs have transformed into complex, self-organising ecosystems that co-create innovation outcomes with diverse stakeholders. In this capacity, they have become institutional orchestrators that influence urban development, regional policy, and global knowledge networks.

Despite the dynamic evolution of STPs, longitudinal analyses capturing the full scope of these transformations remain limited. Many existing studies focus on single aspects such as governance or clustering, without considering their systemic interactions (Ratinho, Henriques, 2020). Using a longitudinal comparative document analysis of the IASP surveys from 2015 and 2024, this article aims to identify the structural, functional, and conceptual transformations that redefine the role of STPs within global innovation ecosystems. By interpreting these changes through the Quintuple Helix perspective, the study contributes to a deeper understanding of how STPs evolve into organised innovation spaces that integrate technological excellence with sustainability and social value. In doing so, the article positions STPs not merely as participants in innovation systems but as strategic actors shaping the development and governance of contemporary innovation zones.

2. Methodology

The purpose of this study was to explore and interpret the multidimensional evolution of STPs over a ten-year period, focusing on their strategic, organizational, and spatial transformations. The research investigates how the role of STPs has changed between 2015 and 2024 and to what extent these changes reflect a broader transition from technology infrastructure toward ecosystem-oriented innovation zones. The study also examines whether contemporary STPs align with the principles of the **Quintuple Helix Model**, which encompasses the interactions among academia, industry, government, civil society, and the natural environment.

The research questions guiding this study were formulated as follows:

- How have the ownership and governance models of STPs evolved over the past decade?
- How have the strategic priorities, functions, and services of STPs evolved, and what emerging trends define their current development trajectories?
- To what extent do contemporary STPs align with the Quintuple Helix framework and its emphasis on sustainable, multi-actor innovation ecosystems?

The primary research method employed in this study is qualitative document analysis (Bowen, 2009), supported by comparative and longitudinal analysis (Yin, 2014; Bryman, 2016) as the main analytical techniques. This approach enables a structured investigation of changes over time and allows both quantitative and qualitative data to be interpreted in their institutional and conceptual context. The empirical foundation of the study consists of two comprehensive reports published by the International Association of STPs and Areas of Innovation (IASP): the *IASP General Survey Report (2015)* and the *IASP Global Survey Report (2024)*. The IASP, founded in 1984 and headquartered in Málaga, Spain, unites nearly 400 member parks and innovation districts across 80 countries, providing a rich global dataset that captures the diversity and evolution of innovation environments worldwide.

Both reports were systematically reviewed and coded to identify key categories of change, including ownership and governance structures, relationships with universities and cities, diversification of services, integration of sustainability and ESG principles, and internationalisation trends. The thematic coding process followed an iterative abductive approach combining theory-driven and data-driven category development. An initial coding framework was derived from innovation ecosystem and Quintuple Helix literature and subsequently refined through open coding to capture themes emerging directly from the empirical material. Codes identified in both reports were compared across time periods to construct a longitudinal comparative coding matrix, enabling the identification of recurring themes, discursive shifts, and emerging patterns of transformation. Analytical reliability was strengthened through repeated cross-reading, temporal comparison, and theoretical triangulation, enhancing conceptual consistency, transparency, and replicability.

This methodological approach integrates descriptive comparison with interpretive synthesis, enabling the identification of both structural and conceptual evolution within the global network of STPs. By combining empirical analysis with theoretical reflection, the study provides a comprehensive understanding of how STPs have evolved into strategic orchestrators of innovation ecosystems between 2015 and 2024.

3. Results

The presentation of results is guided by the theoretical framework of innovation ecosystems and the Quintuple Helix model introduced in the previous sections. The identified empirical categories are interpreted not only as organisational changes but also as indicators of systemic transformation reflecting evolving interactions between academia, industry, government, society, and the natural environment. This perspective enables the findings to be analysed as empirical manifestations of broader theoretical shifts in the governance and spatial organisation of innovation.

The comparative analysis of the IASP Global Surveys from 2015 and 2024 reveals a significant and multidimensional transformation in the global landscape of STPs. The following results are presented in accordance with the analytical criteria outlined in the comparative table: identity and scope, role in the ecosystem, spatial distribution, governance, university relations, services, funding, scale, internationalisation, sectoral focus, sustainability, management, tenant profile, and strategic orientation.

Table 1.
Analysis of changes within STPs over a ten-year period

Category	2015 Findings	2024 Findings	Analytical Comment / Strategic Implication
Identity and Scope	Defined mainly as <i>Science & Technology Parks</i> focused on research commercialization and technology transfer.	Broader concept of <i>Organised Innovation Spaces (OIS)</i> including STPs, Innovation Districts, and Areas of Innovation.	Conceptual shift from “park-based” to “ecosystem-based” innovation environments.
Role in the Ecosystem	Functioned as intermediaries between universities, industry, and government (triple helix).	Act as orchestrators of innovation ecosystems integrating business, academia, community, and sustainability agendas.	Transition from knowledge transfer units to strategic innovation platforms.
Location Pattern	Mostly located on university campuses or city peripheries.	87.9% situated in urban areas; increasing integration with city fabric.	Urbanisation of innovation: parks evolve into <i>city-embedded ecosystems</i> .
Ownership and Governance	Predominantly public ownership (universities, local or national governments).	50.8% public, 31% mixed (PPP), 18.3% private.	Rise of public-private partnerships and professionalized management, hybrid governance models dominate.

Cont. table 1.

University Relations	Strong but traditional cooperation (research transfer, spin-offs).	80.2% formal partnerships; 75.4% within 5 km of a university; 47.6% host research groups.	Collaboration shifts from institutional to co-locational and co-creative forms.
Service Portfolio	Focused on incubation, R&D infrastructure, and basic business support.	93.7% run incubators, 81.7% accelerators, 75.4% cluster programs; broader community and social services.	Expansion from infrastructure provision to holistic, value-added ecosystem services.
Funding Structure	Largely dependent on public grants and subsidies.	Diversified revenue streams: public grants, rent, service fees, and private investment.	Greater financial autonomy and sustainability; parks as self-financing organizations.
Scale and Expansion	Mostly single-site operations.	37.4% operate multiple sites (2-5); 87.3% plan further expansion.	Regionalisation and networked models of innovation zones.
Internationalisation	Limited, mainly through IASP membership and events.	70.7% have formal international MoUs; growing cross-border cooperation.	From local clusters to globally networked innovation nodes.
Sectoral Specialisation	Dominated by ICT, biotech, electronics, materials.	Narrower focus (3-5 key sectors per park); AI, ICT, biotech most prevalent.	Shift toward thematic and high-value specialisation strategies.
Sustainability / ESG	Rarely mentioned; limited to energy efficiency.	Majority implement formal ESG or SDG frameworks; 65.8% dedicate >15% land to green areas.	Sustainability becomes a core strategic and identity component.
Management Teams	Small administrative teams (≤ 10 staff).	Typically 11-25 employees with expertise in innovation, ESG, and partnership management.	Professionalisation of park management and strategic competencies.
Resident Companies Profile	Mostly SMEs and university spin-offs.	SMEs still dominant but with rising presence of international firms.	Diversification and globalisation of tenant profiles.
Strategic Orientation	Focused on regional economic development and tech transfer.	Oriented toward global connectivity, sustainability, and talent attraction.	From regional development instruments to <i>global ecosystem enablers</i> .

Source: own work.

Identity and Scope

In 2015, the concept of the STPs was largely synonymous with infrastructure-based technology transfer. STPs were defined as physical facilities supporting collaboration between universities and industry, focusing on commercialization of research outcomes and enterprise incubation. By 2024, this narrow definition had evolved substantially. The term *Organised Innovation Spaces (OIS)* now encompasses STPs, innovation districts, and areas of innovation (IASP, 2024). This reflects a paradigmatic shift in understanding - from *parks as physical enablers of technology transfer* to *strategic orchestrators of innovation ecosystems*. Contemporary STPs function as platforms that integrate economic, social, and environmental objectives, aligning with the Quintuple Helix framework (Carayannis, Campbell, 2010; Dąbrowska, 2024).

Role in the Ecosystem

The traditional role of STPs as mediators of the Triple Helix model, linking academia, government, and business, has expanded into a multi-stakeholder paradigm that includes civil society and the natural environment. In 2015, STPs were considered *facilitators* of innovation; by 2024, they are *strategic actors* that actively shape innovation networks and regional policy agendas (Carayannis, Grigoroudis, Campbell, 2022). They serve as intermediaries between different layers of innovation governance, influencing knowledge exchange, sustainability initiatives, and entrepreneurial ecosystems. This role expansion underscores the transition of STPs from support institutions to ecosystem orchestrators (Dąbrowska, 2024).

Location and Urbanisation

The 2015 data showed that most STPs were located on the peripheries of cities, often near universities or in industrial zones. By contrast, the 2024 survey indicates that 87.9% of parks are now urban, integrated into city structures as part of innovation districts or mixed-use developments (Lecluyse et al., 2021). This spatial transformation demonstrates the process of *urbanisation of innovation*. STPs are no longer isolated technological enclaves; they are embedded within metropolitan ecosystems, linking research and entrepreneurship with cultural, residential, and civic functions (Davies, 2023). The integration with urban infrastructure enhances collaboration, visibility, and social engagement.

Ownership and Governance

In 2015, public ownership dominated the STP sector, with most parks operated by universities, municipalities, or regional governments. By 2024, ownership patterns have become much more diverse: 50.8% of parks remain public, 31% operate under public–private partnerships, and 18.3% are privately owned (IASP, 2024). This diversification indicates a growing trend toward professionalisation and hybrid governance. Public–private collaboration has introduced more agile decision-making processes and greater financial sustainability, reflecting the global trend toward entrepreneurial governance models. The growing share of private stakeholders suggests a strategic shift from publicly subsidized operations to self-sustaining, investment-driven organisations.

Relations with Universities

University collaboration remains central but has evolved significantly. In 2015, cooperation was often transactional, focusing on technology transfer or student entrepreneurship. By 2024, 80.2% of parks have formal agreements with universities, and 47.6% host research groups within their facilities. Moreover, 75.4% are located within a 5-kilometre radius of academic institutions (IASP, 2024). This indicates a deepening of co-creation mechanisms. STPs and universities now share not only infrastructure but also

research agendas and innovation programs. This shift represents a move from *proximity-based cooperation* to *co-locational integration*, where academic and entrepreneurial ecosystems merge (Dąbrowska, 2024).

Service Portfolio

In 2015, the typical service portfolio of a STP included incubation, research facilities, and technology transfer assistance. By 2024, this range has expanded dramatically: 93.7% of parks operate incubators, 81.7% offer acceleration programs, and 75.4% manage cluster initiatives (IASP, 2024). Additionally, new value-added services such as mentoring, networking, training, and internationalisation support have become widespread. Modern parks act as ecosystem integrators, providing business support alongside community-building and sustainability programs. This expansion indicates a transition from infrastructure provision to knowledge brokerage and systemic innovation support (Ratinho, Henriques, 2020).

Funding Structure

The funding models of STPs have evolved from reliance on public subsidies to diversified revenue streams. In 2015, most parks operated with government grants and limited rental income. In 2024, income sources include a combination of public funding, private investment, rental fees, service charges, and international project participation. This shift reflects a trend toward financial autonomy and economic sustainability, consistent with broader movements toward self-financing innovation ecosystems (IASP, 2024). The hybrid funding approach enhances resilience and reduces dependence on cyclical public budgets.

Scale and Expansion

While in 2015 most STPs consisted of single-site operations, by 2024, 37.4% manage multi-site campuses with two to five locations (IASP, 2024). This expansion signifies the rise of distributed innovation ecosystems, where parks form networks across metropolitan or regional areas. Such scaling supports cross-sector collaboration and resource optimisation, aligning with the global trend toward *polycentric innovation systems*. Moreover, 87.3% of parks plan further expansion, confirming their increasing spatial and organisational relevance.

Internationalisation

The global connectivity of STPs has increased significantly. In 2015, international engagement was limited mainly to conferences and IASP membership. By 2024, 70.7% of parks have signed formal international cooperation agreements (MoUs), and many operate as global hubs within transnational innovation networks (IASP, 2024). This growing connectivity enhances knowledge exchange, cross-border collaboration, and participation in international

R&D programs. STPs are thus evolving into global innovation intermediaries, enabling firms and research institutions to access international markets and expertise (Dąbrowska, 2024).

Sectoral Focus

The sectoral composition of STPs has become more specialised. In 2015, most parks hosted companies from broad technology fields such as ICT, biotechnology, and electronics. By 2024, parks increasingly focus on three to five priority sectors, with strong representation in AI, ICT, biotechnology, clean technologies, and life sciences (IASP, 2024). This thematic concentration aligns with regional smart specialisation strategies and fosters synergies between research and industrial strengths. It represents a strategic move from general-purpose technology zones to knowledge-intensive, sector-driven innovation clusters.

Sustainability and ESG Integration

Sustainability has emerged as a defining dimension of modern STPs. In 2015, environmental considerations were marginal. By 2024, a majority of parks implement formal environmental, social, and governance (ESG) frameworks and sustainability strategies. Approximately 65.8% dedicate more than 15% of their total area to green spaces, while 19% allocate more than half. Sustainability is now embedded in governance, infrastructure design, and stakeholder engagement. STPs align their missions with the UN Sustainable Development Goals (SDGs) and the European Green Deal, establishing themselves as laboratories of sustainable innovation.

Management Teams

Management structures have professionalised. In 2015, park management teams were small and administratively oriented, often fewer than ten staff. By 2024, the average team size ranges from 11 to 25 professionals, including experts in innovation management, ESG, and internationalisation. This professionalisation strengthens strategic planning and global competitiveness. It also reflects a broader transformation of STPs from *administrative bodies* into *strategically managed organisations*.

Resident Companies Profile

The resident base of STPs remains dominated by micro and small enterprises, yet its composition has become more diversified. By 2024, an increasing share of international firms and research-intensive startups coexists with university spin-offs. This diversity enhances knowledge exchange, accelerates innovation, and connects local ecosystems to global value chains (IASP, 2024).

Strategic Orientation

Finally, the strategic orientation of STPs has shifted from a focus on regional economic development and technology transfer in 2015 to a broader mission emphasising global connectivity, sustainability, and talent attraction in 2024. STPs now operate as strategic orchestrators of innovation zones, managing not only infrastructure but also the social, cultural, and environmental dimensions of innovation. Their evolution exemplifies the transition from technology-driven growth to ecosystemic, sustainable, and globally networked innovation governance.

4. Discussion

The results of the longitudinal analysis presented in this study provide comprehensive answers to the three research questions and confirm that STPs have undergone a profound institutional and functional transformation over the past decade. They have evolved from being support infrastructures facilitating technology transfer to becoming strategically managed organisations that orchestrate innovation ecosystems at multiple scales. This transformation encompasses changes in governance, operational priorities, and conceptual alignment with sustainable and inclusive models of innovation. In this respect, the empirical findings provide interpretive support for the theoretical transition from Triple Helix coordination mechanisms toward Quintuple Helix ecosystem governance, demonstrating how organisational transformations of STPs reflect broader systemic changes in innovation theory.

The first research question addressed the evolution of ownership and governance models in STPs. The comparative data reveal a clear transition from public dominance to a more hybrid and diversified landscape. In 2015, most parks were publicly owned and managed by universities or regional authorities, operating within rigid administrative frameworks. By 2024, nearly one third of all parks had adopted public–private partnership models, and almost one fifth were privately owned (IASP, 2024). This diversification marks a fundamental shift toward professionalised and performance-driven governance. The emergence of hybrid structures has enabled STPs to balance public accountability with the efficiency, flexibility, and innovation capacity typical of private sector management. Germain et al. (2021) observe that hybrid governance enhances strategic responsiveness by allowing STPs to adapt to technological change, attract private capital, and integrate entrepreneurial management practices. Sandoval Hamón et al. (2024) similarly emphasise that diversified governance structures strengthen institutional resilience by spreading financial and operational risks.

This evolution represents a move from administrative coordination to strategic orchestration. STPs are no longer managed as extensions of public policy but operate as independent institutions capable of shaping their own development trajectories. Dąbrowska (2024) argues that this new institutional maturity allows parks to act as orchestrators of innovation ecosystems, managing multiple networks and stakeholders rather than simply providing physical space for firms. The shift in governance thus reflects a deeper transformation in the identity of STPs, from policy tools to autonomous strategic actors in the innovation landscape.

The second research question examined how the strategic priorities, functions, and services of STPs have evolved and what emerging trends define their development trajectories. The findings indicate a marked expansion of functions and strategic goals. In 2015, the role of most parks was confined to technology transfer, business incubation, and research infrastructure provision. By 2024, their activities had broadened to include acceleration, mentoring, sustainability consulting, and internationalisation. The diversification of services demonstrates that STPs have adopted the role of ecosystem intermediaries that facilitate co-creation and collaboration between academia, industry, government, and society. Ratinho and Henriques (2020) note that such intermediary organisations are critical in enabling multi-actor innovation, as they design and coordinate the interactions that lead to knowledge exchange and collective learning.

Another striking change is the spatial reconfiguration of innovation spaces. Almost 88 % of parks now operate in urban or metropolitan areas, confirming the trend described by Lecluyse et al. (2021) as the urbanisation of innovation. The movement from peripheral university campuses to integrated city environments reflects a rethinking of innovation geography. Urban-based parks are not isolated technological enclaves but dynamic components of metropolitan innovation ecosystems, where scientific research, entrepreneurship, cultural activity, and civic life intersect. Davies (2023) points out that the integration of innovation infrastructure into cities generates new synergies between technological development and urban transformation. This spatial shift enhances the visibility of innovation and strengthens the social dimension of STPs by connecting them directly with local communities, creative industries, and municipal sustainability agendas.

Parallel to these organisational and spatial developments is the diversification of financial models. In 2015, most STPs relied heavily on public subsidies and project-based funding. By 2024, they had adopted more balanced revenue structures based on rental income, service fees, private investment, and international partnerships. This evolution illustrates a growing focus on financial sustainability and autonomy, reducing dependence on government programmes and allowing for long-term strategic planning. This trend reflects the increasing economic maturity of STPs as self-sustaining institutions capable of reinvesting in innovation infrastructure. The combined effect of governance diversification, urban integration, and financial independence shows that STPs are becoming complex, adaptive organisations operating as orchestrators rather than facilitators within innovation ecosystems.

The third research question explored the extent to which contemporary STPs align with the Quintuple Helix framework and its emphasis on sustainable, multi-actor innovation ecosystems. The analysis strongly supports the argument that the Quintuple Helix perspective now underpins both the strategic orientation and operational models of STPs. The 2024 data indicate that most parks have integrated ESG principles into their strategies and reporting mechanisms. Many have adopted the United Nations Sustainable Development Goals and the European Green Deal as reference frameworks, dedicating significant portions of their physical space to green areas and implementing energy-efficient technologies (IASP, 2024). Environmental responsibility and social inclusion are viewed as competitive advantages of STPs rather than regulatory obligations.

The incorporation of the Quintuple Helix model signifies a shift from purely economic or technological objectives to a more holistic vision of innovation that includes civil society and the natural environment. Carayannis and Campbell (2010) describe this framework as an evolution of the Triple Helix model, recognising that innovation is shaped not only by universities, industry, and government but also by societal and ecological systems. Buday (2025) confirms that this perspective is increasingly visible in global innovation policy, where sustainability and resilience are treated as integral to competitiveness. By embedding these principles into their missions, STPs have become laboratories of sustainable innovation, translating theoretical frameworks into practical strategies that link technological advancement with ethical responsibility.

Internationalisation further reinforces this alignment. More than seventy percent of parks now participate in global innovation networks and maintain formal international partnerships (IASP, 2024). This engagement enables them to exchange knowledge, attract investment, and participate in cross-border research initiatives. Germain et al. (2021) argue that such international linkages are essential for building resilient innovation ecosystems, as they allow local actors to access global markets and expertise. Thematic specialisation is another dimension of this global alignment. Many parks have concentrated on specific sectors such as artificial intelligence, biotechnology, clean technologies, and life sciences, contributing to global sustainability challenges while enhancing regional smart specialisation. This combination of sustainability, specialisation, and global connectivity shows that STPs are increasingly positioned as strategic mediators between local assets and global innovation flows.

Based on the finding it can be confirmed that STPs have matured into institutional orchestrators of innovation ecosystems. The evolution of governance demonstrates their growing autonomy and professionalisation. The expansion of functions and services, together with trends of urbanisation, financial independence, and global integration, illustrates their transition into multidimensional organisations that manage, connect, and sustain innovation. The adoption of the Quintuple Helix model anchors this transformation in a conceptual framework that unites technological, social, and environmental objectives.

While the findings indicate increasing alignment of STPs with the Quintuple Helix framework, this transformation should not be viewed as linear or universally successful. Expanding stakeholder involvement and sustainability agendas introduce governance complexity and coordination challenges, potentially creating tensions between economic efficiency and broader social and environmental objectives. Hybrid governance models may enhance flexibility but can also generate institutional ambiguity and conflicting stakeholder expectations, while sustainability integration may involve trade-offs between long-term societal value and short-term financial performance. Moreover, the growing strategic role of STPs may reinforce uneven regional development, as better-resourced ecosystems are more capable of benefiting from orchestration processes. These considerations suggest that the Quintuple Helix transition represents not only an opportunity but also a space of organisational experimentation and potential failure, highlighting the need for future research examining both successful and unsuccessful transformation pathways.

The implications of these findings extend beyond the institutional boundaries of STPs. Theoretically, they validate the ecosystemic understanding of innovation as a distributed process requiring coordination and collaboration among diverse actors. Practically, they suggest that governments and universities should recognise STPs not merely as infrastructure projects but as key policy partners in shaping sustainable innovation strategies. As the decade between 2015 and 2024 demonstrates, STPs have become strategic shapers of innovation zones, integrating governance, sustainability, and collaboration into a unified model of ecosystem development that defines the future of innovation.

5. Summary

This study demonstrates that STPs have evolved from traditional facilitators of research commercialisation into strategic actors shaping contemporary innovation zones. Over the past decade, STPs have transitioned from infrastructure-oriented entities into dynamic organisations that orchestrate complex innovation ecosystems. This transformation reflects fundamental changes in governance, strategic direction, and conceptual alignment with sustainable and collaborative models of innovation.

The evolution of governance from public control toward hybrid and professionalised management has enhanced the autonomy, flexibility, and strategic capacity of STPs. They now function as institutional anchors balancing public purpose with private efficiency and entrepreneurial leadership. This organisational maturity confirms their growing influence in shaping innovation policy and managing ecosystem development at both regional and global levels.

At the same time, STPs have broadened their functions and adopted new trajectories of development. Their integration into urban environments, diversification of services, and pursuit of financial self-sufficiency illustrate a transition from passive enablers to active orchestrators of innovation processes. Their increasing commitment to sustainability and alignment with the Quintuple Helix framework demonstrate that innovation is becoming inseparable from environmental and social responsibility.

Taken together, the findings demonstrate the emergence of STPs as institutional orchestrators that actively design, connect, and govern innovation ecosystems rather than merely hosting them. Their evolution confirms that the governance of innovation and the governance of sustainability are increasingly intertwined processes. In this sense, the study demonstrates a simultaneous structural, functional, and conceptual transformation of STPs, completing their transition from technology infrastructures to ecosystem-oriented innovation institutions. From a theoretical perspective, the study reinforces the ecosystemic understanding of innovation as a co-evolving and multi-level system requiring institutional coordination. From a policy perspective, the findings suggest that governments and universities should recognise STPs not merely as infrastructure projects but as strategic partners in shaping innovation-driven regional and urban development.

Based on the longitudinal analysis, several theoretical implications can be derived that extend the ecosystem perspective on STPs and provide directions for future empirical research. The findings indicate that the transition from predominantly public governance toward hybrid governance models increases the strategic autonomy of STPs and strengthens their capacity to orchestrate innovation ecosystems. The diversification of service portfolios mediates the shift from infrastructure-based innovation support toward ecosystem-based value creation and stakeholder coordination, while urban spatial embeddedness enhances ecosystem performance by increasing interaction density, knowledge exchange, and social engagement among stakeholders. Furthermore, the integration of sustainability and ESG principles transforms STPs from technology transfer intermediaries into institutions balancing economic, social, and environmental innovation objectives. Together, these insights contribute to theory development by conceptualising STPs as institutional orchestrators whose effectiveness depends on governance configuration, spatial integration, and sustainability alignment. Future research may empirically test these relationships through comparative case studies and mixed-method research designs.

The past decade has marked a turning point in the global landscape of innovation, as STPs have emerged as key institutional actors capable of integrating technological excellence with environmental and social responsibility. Their transformation encapsulates the central argument of this study: STPs have become strategic shapers of innovation zones, defining not only where innovation occurs but also how it is governed, sustained, and directed toward a more inclusive and sustainable future.

Acknowledgements

Publication financed by the Krakow University of Economics within the framework of the 3 Conference Activity Support Program - WAK-2025.

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