Strengthening science, technology and innovation parks for industrial development through clustering

Technical note

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I. Introduction

Science, technology and innovation (STI) parks are designated areas that foster innovation, technological development and economic growth by concentrating resources, expertise and infrastructure to promote innovation. By bringing together a combination of universities, research institutions, technology firms, government entities, incubators and accelerators, and industry in a single geographic area that offers an intentionally collaborative ecosystem, STI parks play a critical role in supporting national systems of innovation by bridging technological and industrial gaps, enhancing competitiveness and facilitating sustainable development.

Clustering is a core feature of STI parks. Clustering refers to the spatial and functional agglomeration of interconnected businesses, research organizations and service providers that collaborate to enhance productivity, innovation and competitiveness. In simple terms, this means strategically locating similar or complementary entities close together to create a dynamic ecosystem that maximizes collaboration, innovation and regional economic development through technological advancement. This phenomenon, rooted in Alfred Marshall's concept of agglomeration economies, leverages proximity to create economies of scale, knowledge spillovers and inter-firm linkages, often referred to as "Marshall's Trinity" (Marshall, 1890).

> Clustering is a core feature of STI parks

In STI parks, clustering is used to create a synergistic environment where proximity; shared resources, services, facilities and amenities; access to talent and expertise, and collaborative networks all combine to create commercialization pathways for new technologies, generate new intellectual property and entrepreneurial ventures, provide incubation programming, mentorship, and coaching to support the success of start-up and spin-out ventures, and amplify innovation.

STI parks serve as modern versions of industrial clusters to drive industrial development. By fostering thematic co-location and value-chain integration, these parks create environments that enable innovation to thrive, allowing regions to compete effectively in the global knowledge economy.

In STI parks, clustering also facilitates deeper integration within industrial value chains, helping companies, especially small and medium-sized enterprises (SMEs), to overcome challenges related to resource constraints, market access and technology capabilities. Through clustering, STI parks provide a platform for collective action, value-added services, specialized infrastructure and targeted policy interventions, thereby creating favourable conditions for entrepreneurship, innovation and sustainable development.

This technical note highlights the transformative potential of STI parks when they are designed and managed effectively. As developing countries navigate technological disruptions and competitive pressures, clustering within STI parks offers a proven pathway to innovation-led growth, provided stakeholders act decisively to create enabling environments. Drawing on existing analytical work and good practices, it provides evidence-based guidance for policymakers, regional planners and innovation-ecosystem stakeholders.

II. Developmental benefits of clustering in STI parks

Well-structured clusters deliver a mix of economic, technological and social gains. The following evidence shows how STI parks translate proximity into measurable outcomes that matter to policymakers.

1. **Enhanced productivity:**
   Firms in STI parks benefit from economies of scale and scope, leading to higher productivity. For example, a recent study indicates that the Hsinchu Science Park in Taiwan Province of China contributes to higher total factor productivity and more efficient research and development (R&D) investment by new technology-based firms located within it compared to those outside the park. This advantage is sometimes attributed to clustering effects, better infrastructure, and enhanced linkages among firms and research institutions in the park (Fukugawa and Chang, 2025).

2. **Job creation:**
   STI parks generate high-skill, high-wage jobs in technology-intensive sectors. For example, India's Genome Valley has grown to more than 200 companies from 18 different countries, employing around 25,000 people in biotechnology and pharmaceuticals. This includes global brands, local manufacturers and contract development firms, as well as cutting-edge start-ups that comprise the cluster (Adams, 2025).

3. **Innovation and competitiveness:**
   Clusters foster intense competition and collaboration, driving innovation. Michael Porter's research highlights that clustered localities are more conducive to breakthrough innovations owing to rivalry and resource-sharing (Porter, 1998). The Association of University Research Parks (AURP) notes that parks with strong industry–academia linkages

Clusters translate proximity into productivity and innovation

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produce significantly more patents per firm compared with non-clustered settings. In addition, start-ups within university research parks and innovation districts have a five-year survival rate of 75 per cent, compared with a 49 per cent average and create 23 per cent more high-wage jobs than the overall industry average (AURP, 2023).

4. **Regional economic growth:**
STI parks attract foreign direct investment and stimulate local economies. Brazil's Porto Digital has transformed Recife into a technology hub, contributing US$1 billion annually to the regional economy (BBC, 2013). An STI park can play a pivotal role in a region's smart specialization strategy (S3) by acting as both a driver and beneficiary of targeted innovation priorities. S3 is a place-based innovation policy approach that aims to boost regional economic growth and transformation by focusing resources and investments on a limited set of priority areas where a region has competitive advantages or the potential to develop them. Málaga TechPark in Spain, for example, is closely aligned with the Andalusia Research and Innovation Strategy for Smart Specialization (RIS3), serving as a focal point for the region's digital and technology sectors. By concentrating resources, expertise, and collaborative networks within priority fields identified by the RIS3, the park helps accelerate innovation, attract investment, and foster high-value job creation. In turn, being embedded in the S3 process allows the park to access tailored public support, participate in strategic regional projects, and benefit from coordinated policy actions that enhance its competitiveness and impact. This synergy ensures that the park's development is both regionally relevant and globally competitive.

> Clustering attracts talent and investment that serve sustainable development

5. **Skilled workforce:**
Clustering attracts a concentrated pool of talent, providing a robust labour market (Cadorin et al., 2021). Beijing Zhongguancun Science Park (Z-Park) benefits from a skilled workforce, making it a hub for technology-intensive industries. Often dubbed "China's Silicon Valley", the park has leveraged its proximity to more than 40 universities and more than 200 research institutes to cultivate a talent pool that drives innovation across its core sectors.

6. **Investment attraction:**
Investors are drawn to environments where knowledge spillovers reduce the risk of innovation failure by enabling start-ups to access cutting-edge research, talent and networks. The presence of multiple innovative ventures makes STI parks attractive to investors and venture capital (Etzkowitz and Zhou, 2017).

These benefits make STI parks critical drivers of industrial development, particularly in emerging economies seeking to transition to high-value, knowledge-based economies. They collectively contribute to economic growth and technological advancement, making clustering a cornerstone of STI-park strategies.

Moreover, intangible dividends, such as improved entrepreneurial mindsets, strengthened local supplier bases and heightened global visibility, reinforce the tangible metrics mentioned. Policymakers can leverage these outcomes to justify continued public-sector support and to crowd in private investment, thereby sustaining a positive feedback loop between clustering and development.

III. Thematic clustering and co-location of value-chain actors

"Thematic clustering" within STI parks refers to the intentional grouping or concentration of companies, research institutions, service providers and organizations that operate within the same or closely related fields, industries, technologies, or research interests. A park with a thematic cluster in biotechnology, for example, might include biotech start-ups, pharmaceutical companies, university research labs, and specialized service providers.

This concentration of expertise serves to enhance sector specialization within the STI park community, foster an environment where technology transfer from research to market is accelerated, develop new technologies through collaborative efforts and knowledge exchange, and leverage shared interests, technologies and expertise.

It also creates synergies among STI park tenants, including universities, research institutes, start-ups and established firms. The co-location of value-chain actors such as companies, organizations or service providers that participate in and add value to a product or service as it moves through the various stages from conception to end use (including activities such as supplying raw materials, production, processing, distribution, marketing, retail, and even waste management or recycling) further strengthens these ecosystems. Transaction costs are reduced, supply chain efficiencies are improved and collaboration is fostered (Porter and Heppelmann, 2014). This proximity enhances collaboration, enables rapid prototyping and testing, and fosters workforce specialization (Feldman and Audretsch, 1999).

Shared sector focus unlocks deeper collaboration

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This approach of creating thematically clustered STI parks concentrates expertise and resources around a specific domain, creating the following benefits:

1. **Focus on specific themes:**
   Thematic clustering involves organizing entities around a defined area of specialization, such as biotechnology, artificial intelligence, clean energy, or advanced manufacturing. For example, the Zhangjiang High-Tech Park in Shanghai has a thematic focus on life sciences and pharmaceuticals, attracting companies and research institutes specializing in these fields (Tremblay, 2010).

2. **Enhanced collaboration:**
   By grouping organizations with similar goals or complementary expertise, thematic clustering fosters targeted collaboration. This allows for deeper partnerships, joint R&D projects, and faster innovation cycles. For instance, the Cambridge Science Park in the United Kingdom of Great Britain and Northern Ireland clusters firms in electronics and biotech, enabling cross-pollination of ideas within these sectors. In China, the Z-Park has been pivotal in fostering the growth of semiconductor, computer and telecommunications firms, both domestic and foreign, through its role in facilitating technology transfer (Tan, 2006). Focusing on electronics, green technology, information and communications technology (ICT), precision engineering, and biotech, the Hong Kong Science Park emphasizes the benefits of clustering by promoting collaboration among industry, academia and researchers (Brooke, 2012).

3. **Resource optimization:**
   Thematic clusters provide shared, specialized infrastructure such as laboratories, test facilities, data centres, networks and support services tailored to the selected industry. This reduces the costs associated with bringing new products and services to market and improves access to cutting-edge tools. The Hsinchu Science Park in Taiwan Province of China, focused on semiconductors and electronics, offers shared cleanroom facilities for chip manufacturing. Malaysia's Cyberjaya, part of the "multimedia corridor", focuses on ICT and digital technologies, hosting firms across the value chain, from software development to data centres. This specialization has positioned Cyberjaya as a regional tech hub, with firms benefiting from shared infrastructure and knowledge exchange (The Edge Malaysia, 2025).

4. **Knowledge spillovers:**
   Concentrating companies involved in similar industries promotes the exchange of specialized knowledge, both formal (e.g., patents, publications) and informal (e.g., networking, expertise-sharing). This is most evident in Silicon Valley's thematic clustering around tech and software, where proximity drives rapid knowledge transfer (Saxenian, 1994).

5. **Attracting investment and talent:**
   A clear thematic focus makes the park more attractive to investors, start-ups and skilled professionals in that domain. For example, the Elevate Quantum Tech Hub in Colorado clusters quantum technology firms, research institutes, and partners, with a specialized focus on quantum information technology and related fields. The hub's specialized focus has already catalyzed US$1 billion in venture capital investment, with projections of up to US$2 billion in private capital to support quantum start-ups and scale-ups by 2030 (Elevate Quantum, 2024).

6. **Policy alignment:**
   Thematic clustering often aligns with national or regional innovation strategies, enabling targeted government support through funding, tax incentives, or regulatory frameworks. For instance, Singapore's Biopolis cluster focuses on biomedical sciences, backed by government policies to establish it as a global hub (Poh, 2010).

Overall, thematic clustering of STI parks creates specialized ecosystems that amplify innovation and competitiveness by concentrating expertise, resources and networks around a specific sector, leading to greater efficiency and impact in that domain.

The International Association of Science Parks (IASP) 2022 Global Survey highlights that 68 per cent of STI parks worldwide prioritize thematic clustering to drive innovation, with ICT and biotechnology being the most common focus areas (IASP, 2022).

That said, economic clustering is particularly impactful in technology sectors where innovation, knowledge-sharing, access to talent and capital, specialized supply chains and economies of scale are necessary for success. The most notable sectors include:

1. **Software and information technology:**
   Clusters such as Silicon Valley and Bangalore drive rapid innovation through talent concentration, venture capital availability and collaborative networks. Proximity fosters quick iteration and knowledge exchange.

2. **Biotechnology and pharmaceuticals:**
   Clusters such as Boston's biotech hub and San Diego benefit from proximity to research institutions, specialized labour, regulatory expertise, clinical trial infrastructure and cross-sector collaboration in genomics, pharmaceuticals and medical devices, accelerating drug development.

3. **Semiconductor and electronics manufacturing:**
   The tech corridors established, for example, in Taiwan Province of China and the Republic of Korea leverage clustering for supply chain efficiency, specialized equipment, skilled engineers and precision manufacturing, reducing costs and time-to-market.

4. **Artificial intelligence and machine learning:**
   AI hubs such as Toronto and Shenzhen attract top talent in data science, have strong partnerships between academia and industry, and offer abundant computational infrastructure, enabling faster development of algorithms and applications.

5. **Clean energy, green tech, environmental innovation:**
   Clusters in places such as Denmark for wind energy and China's solar valleys centralize R&D and manufacturing and drive innovation through regulatory environments and policy support, making renewable technologies cost competitive.

6. **Gaming, digital media and creative industries:**
   These sectors thrive in clusters where creative and technical talent is concentrated, technology and creative services intersect, and where there is cross-collaboration between the gaming, film and design industries, fostering rapid prototyping and market testing.

Additionally, co-location facilitates both weak-tie and strong-tie networking, as described by Granovetter (1973). Weak ties connect firms across different sectors, providing access to new ideas and markets, while strong ties foster trust and collaboration within the same industry (Granovetter, 1973; Boschma and Frenken, 2010). STI parks often design physical and programmatic spaces – such as innovation

Specialized clusters amplify innovation and efficiency

High-tech hubs thrive on talent and connectivity

centres, networking events and shared facilities – to nurture these relationships. For instance, India's Biotechnology Industry Research Assistance Council (BIRAC) BioNEST incubators, embedded in STI parks, integrate research institutions and biotechnology start-ups to create a cohesive value-chain ecosystem (BIRAC, 2023).

By aligning actors around a common sector focus, STI parks help attract global investment, talent and partnerships, positioning regions as hubs for high-technology industries. However, thematic clustering requires careful planning to avoid overspecialization, which can limit resilience to market shifts, particularly in developing economies with volatile markets (Martin and Sunley, 2015). Effective thematic clustering requires careful strategic planning and sustained policy support. It involves mapping regional competencies, identifying synergies among firms and institutions, and designing park infrastructure that supports these linkages. Additionally, clustering should be responsive to global trends and local development priorities, ensuring alignment with national industrial and innovation strategies (Organisation for Economic Co-operation and Development (OECD), 2007).

Equally important is policy coherence at multiple levels. National governments need to signal long-term commitment to priority sectors, while local authorities must align zoning, infrastructure and workforce strategies with cluster objectives. Where such alignment is absent, STI parks risk becoming isolated real-estate ventures rather than dynamic innovation hubs.

Experience also shows that clusters thrive when they cultivate inclusive networks. Deliberate efforts to engage women-led start-ups, rural suppliers and under-represented research groups can broaden the talent pool and spread benefits more evenly across society. These inclusive practices, from gender-responsive incubator programmes to supplier-diversity targets, enhance cluster resilience and social legitimacy. For example, in Mozambique, the Maluana STI Park's incubator cycle deliberately includes cohorts of young women graduates, while the Femtech programme, supported by IdeiaLab, clusters women-led microenterprises in a shared support model that builds entrepreneurial capacity and peer learning (UNCTAD, 2024a). In Ghana, the Design Technology Institute uses a dual vocational system to cluster youth across digital, creative, and industrial domains, embedding them into innovation-ready value chains (UNCTAD, 2024b).

Finally, digital connectivity now underpins successful thematic clustering. High-capacity broadband, shared data platforms and cloud-based prototyping tools allow geographically compact parks to reach global value chains instantly. Policymakers should treat advanced digital infrastructure as essential cluster capital, not a discretionary add-on.

Inclusive networks and digital tools boost cluster resilience

IV. Mechanisms for integration and innovation within clusters

Despite the clear benefits that clustering can offer to participating firms, clustering efforts often remain at suboptimal levels when there are no explicitly supportive policies in place. This could be explained by several key factors:

1. **Lack of incentives for collective action:**
   Firms may be reluctant to initiate or join clusters without a coordinating mechanism, fearing that their investments in shared infrastructure or collaboration will not be reciprocated.

2. **Free-rider problem:**
   Some firms may hope to benefit from the cluster's advantages without actively contributing, leading to underinvestment in collective resources or initiatives.

3. **Low trust among firms:**
   Effective clustering requires a degree of trust and willingness to share knowledge. In the absence of policy frameworks or trusted intermediaries, firms may be wary of sharing proprietary information or collaborating with potential competitors.

4. **Concerns over intellectual property:**
   Fear of losing control over innovations or sensitive information can deter firms from engaging in joint projects or open innovation activities within clusters.

5. **Absence of best practices:**
   Without policy-driven dissemination of successful models, firms may not have access to examples or guidance on how to structure effective collaborative efforts.

6. **Cost of organizing collaboration:**
   Initiating and managing joint projects or shared facilities can be complex and costly, especially without external support or facilitation.

7. **Difficulty in managing joint projects:**
   Even when the benefits are clear, the practical challenges of coordinating multiple independent actors can be a significant barrier.

8. **Insufficient scale:**
   Individual firms may be too small to achieve the critical mass needed for a vibrant cluster, and without policy support there may be no mechanism to aggregate or attract enough participants.

9. **Missing support services:**
   Policies that provide essential infrastructure, legal frameworks, or financial incentives that make clustering more attractive and feasible may be lacking or inadequate.

Overall, while clustering offers significant advantages, the absence of explicit policies leaves firms to navigate coordination, trust, and resource challenges on their own. This often results in fragmented efforts, missed opportunities, and suboptimal levels of clustering, despite the potential collective gains.

> **Without policy support, clusters struggle to thrive**

Clustering therefore works best when deliberate "connective tissue" is built, specific policies are put in place, and STI park management actively provides opportunities for developing social capital and creating dynamics for inter-firm cooperation.

> **Strong clusters need connective tissue and collaboration tools**

The following paragraphs outline instruments, from knowledge-sharing platforms to public–private partnerships, that translate proximity into real economic value. STI parks employ several mechanisms to integrate actors and drive innovation within clusters:

1. **Knowledge spillovers:**
   Proximity enables both informal and formal exchanges of ideas, fostering innovation and encouraging the absorption of knowledge, thereby improving an enterprise's innovation ability and performance. This is particularly evident in the growth of high-technology enterprises in Sichuan Hi-tech Zone (Tong et al., 2023). Universities and research institutes within STI parks also act as knowledge hubs, disseminating cutting-edge research to firms.

2. **Inter-firm linkages:**
   Collaborative networks among firms enhance specialization and efficiency. In Malaysia's Cyberjaya, firms form tightly knit ICT supply chains, allowing for the rapid commercialization of digital solutions. These linkages reduce costs and improve competitiveness, as firms leverage each other's strengths.

3. **Public–private partnerships:**
   STI parks often rely on public–private partnerships to fund infrastructure, research and start-up incubation. India's Genome Valley in Hyderabad, a cluster of biomedical research, training and manufacturing supported by State and private investment, exemplifies how government backing can catalyse innovation through shared resources (*GKToday, 2024; Telangana Today*, 2025).

4. **Technology transfer and incubation:**
   Technology business incubators within STI parks support start-ups and university spin-outs and spin-offs by providing mentorship, funding and access to facilities. India's BIRAC BioNEST programme has nurtured biotechnology start-ups by offering subsidized laboratory spaces, networking and consulting services (BIRAC, 2023). AURP reports that among their members, STI parks have increased available programming in areas such as incubator space, networking facilitation, and entrepreneurial programming (AURP, 2023).

5. **Facilitating knowledge transfer and collaboration:**
STI parks create ecosystems where universities, research institutes and industries can collaborate. For example, in Asia-Pacific economies such as China and Taiwan Province of China, parks such as Z-Park and Hsinchu Science Park integrate universities with companies, fostering knowledge exchange and technology transfer. By hosting technology-transfer offices, incubators and accelerators, which help translate academic research into commercial applications, these parks address the gap between research and market needs. Knowledge transfer and collaboration are enhanced by STI parks providing physical infrastructure that encourages both deliberate and accidental interaction, including attractive common spaces designed to increase social engagement and shared amenities such as restaurants, bars, food courts, boardrooms, meeting rooms, and conference and exhibition spaces.

6. **Networking assets:**
Entrepreneurial and technology events, hackathons, innovation workshops and industry conferences foster greater connectivity and collaboration. Brazil's Porto Digital hosts regular technology festivals and innovation challenges to encourage interactions among firms, researchers and entrepreneurs. The IASP 2023 World Conference emphasized the role of such events in fostering global knowledge-sharing, with 72 per cent of surveyed park managers citing networking as a key driver of innovation (information conveyed during IASP, 2023).

7. **Shared infrastructure:**
Access to laboratories, testing and prototyping facilities, and high-speed data networks reduces entry barriers for firms and promotes collaborative R&D.

8. **Governance structures:**
Park-management entities play a critical role in coordinating stakeholder interactions; facilitating networking events; curating partnerships; facilitating the creation and growth of innovation-based companies through incubation and spin-off processes; and providing other value-added services, together with high-quality space and facilities (AURP, 2023; IASP, 2024).

9. **Digital platforms:**
Online collaboration tools and data-sharing platforms enhance connectivity among firms, particularly in large or multi-site parks.

These mechanisms create dynamic ecosystems in which innovation is both generated and commercialized, driving industrial growth. However, their effectiveness depends on governance structures, funding models and the ability to adapt to technological and market changes, especially in developing economies with limited resources.

Complementary policy levers can reinforce each mechanism. For instance, matching-grant programmes encourage firms to co-invest in shared R&D facilities, while voucher schemes lower the cost for SMEs to access testing laboratories. Governments can mandate that publicly funded research produced inside the park be licensed on fair, reasonable and non-discriminatory terms, accelerating diffusion to local enterprises.

Capacity-building remains essential. Park authorities can run targeted workshops on IP management, regulatory compliance and digital-transformation road maps, helping start-ups move from prototype to product. Joint faculty–industry appointments and secondments deepen trust and shorten the feedback loop between research and market demand.

> Ecosystems flourish when infrastructure meets interaction

Inclusive, data-driven tools shape future-ready clusters

To future-proof integration, STI parks increasingly deploy "soft-landing" programmes that embed visiting foreign firms in local supply chains, enabling technology inflows while opening export channels for domestic companies. Likewise, advanced cluster analytics dashboards provide real-time data on collaboration intensity, patent co-authorship and labour mobility patterns, giving managers evidence to refine support services.

Finally, gender-responsive measures, such as women-led accelerator cohorts, childcare facilities and codes of conduct against bias, ensure that integration benefits reach a wider talent pool, which in turn boosts cluster diversity and innovation output. In Uzbekistan, for example, emerging STI parks are integrating policies that promote female participation in park governance and entrepreneurship, including targeted support for women-led start-ups, flexible work arrangements, and access to mentorship networks (UNCTAD, 2024c). Similarly, Mongolia is expanding inclusive mechanisms through scholarship programmes, financial tools, and mentorship to ensure that youth and women are not only included in STI activities but also clustered in ways that enable shared growth, innovation diffusion and value-chain participation (UNCTAD, 2025).

V. Challenges and potential risks for developing countries

While clustering offers clear advantages, park managers and policymakers must recognize the constraints that can derail or dilute impact.

1. **Overspecialization:**
   Focusing on a single industry can make parks vulnerable to market disruptions. Clusters must continuously adapt to technological advancements and market changes to remain relevant.

2. **Governance conflicts:**
   Transitioning to innovation-driven models can create conflicts between public and private stakeholders over funding and priorities. Misalignment can hinder collaboration and resource utilization.

3. **Inequitable benefits:**
   Economic gains may concentrate among large firms or urban centres, exacerbating SME and regional disparities. For example, SMEs in India's STI parks often struggle to access resources, which limits their growth (OECD, 2024). The IASP 2022 survey indicates that 60 per cent of STI parks in developing economies face challenges in effectively engaging SMEs (IASP, 2022). Considering SMEs are usually the main employer in a country and many are run by youth entrepreneurs, effectively engaging them as well as those run by women will create significant positive socioeconomic impact.

4. **High initial costs:**
   Developing STI parks may require significant investment in infrastructure, research facilities and talent development. India's Genome Valley has required substantial State funding and the Genome Valley Phase-II project will entail an investment of Rs 2,000 Cr (US$231.22 million). This is in addition

to 10 pharma villages, with an additional investment totalling Rs 1 lakh Cr (US$11.561 billion). These initiatives are anticipated to generate employment opportunities for approximately 500,000 individuals (BioSpectrum, 2024). Ensuring long-term funding to maintain vitality can be a challenging task.

5. **Talent retention:**
    Proximity to global markets can contribute to brain drain, with talent migrating to developed economies. Malaysia's Cyberjaya, for example, faces challenges in retaining skilled professionals owing to competition from Singapore (Teoh et al., 2024). Stereotypes about women's suitability for science and technology careers, traditional gender roles, and unequal access to education, funding and mentorship have hindered the participation of women in technology-focused enterprises. For instance, in Uzbekistan only 23 per cent of women believe they are suited to science, technology, engineering and mathematics (STEM) careers (United Nations Development Programme, 2023).

6. **Environmental and social impacts:**
    Industry 4.0 technologies, while efficient, may increase energy consumption or cause job displacement, creating social and environmental trade-offs in resource-scarce settings.

Addressing these challenges requires adaptive policies, inclusive governance, proactive management and continuous evaluation to ensure STI parks deliver equitable and sustainable outcomes. Practical risk-mitigation tools include staged infrastructure financing, revenue-sharing models to involve SMEs and alumni networks that encourage skilled workers abroad to return or mentor local talent. Regular environmental-impact audits and social-safeguard frameworks can pre-empt negative externalities, ensuring that growth remains sustainable and broadly beneficial.

Smart policy
can turn risks
into resilience

VI. Lessons learned from case studies

Several STI parks in emerging economies exemplify good practices in leveraging clustering for industrial development:

1. Cyberjaya, Malaysia

Practice: Integrates the ICT value chain, from software development to data centres, fostering inter-firm linkages and knowledge spillovers;

Outcome: Achieves higher productivity than that of comparable non-park firms;

Lesson: Coordinated value-chain co-location and strong digital infrastructure underpin competitiveness.

2. Genome Valley, Hyderabad, India

Practice: Combines public–private investment with a focus on biotechnology and pharmaceuticals, hosting research institutes, start-ups and multinational firms;

Outcome: More than 25,000 jobs created and significant growth in pharmaceutical exports (Adams, 2025);

Lesson: Long-term public commitment and shared laboratory capacity catalyse innovation.

3. Porto Digital, Recife, Brazil

Practice: Leverages university–industry collaboration and technology festivals to foster innovation in ICT and creative industries;

Outcome: Contributes approximately US$1 billion annually to the regional economy and supports over 300 start-ups;

Lesson: Community-driven networking events sustain talent attraction and entrepreneurial culture.

> Success hinges on strategy, support and partnerships

4. BIRAC BioNEST Incubators, India

Practice: Embeds biotechnology incubators in STI parks, providing start-ups with subsidized laboratories, mentorship and networking opportunities;

Outcome: More than 500 biotechnology start-ups nurtured, speeding product development in health and agriculture;

Lesson: Targeted incubation plus grant finance bridge the early-stage funding gap.

5. The Innovation Hub, Pretoria, South Africa

Practice: Focuses on ICT, bioeconomy and green technologies, integrating incubators near universities and research institutes;

Outcome: More than 100 enterprises supported and about 2,500 jobs created;

Lesson: Close proximity to research organizations and consistent local government backing reinforce cluster growth despite resource constraints.

In each case, three elements recur: (a) a clear sector focus, (b) sustained public–private collaboration, (c) tailored support instruments.

Globally, several good practices emerge for effective clustering within STI parks:

1. Identify niche industries:
Tailoring cluster development to a specific industry ensures relevance and competitiveness. This involves conducting market analysis and engaging stakeholders to identify high-potential sectors.

2. Provide support services:
Offering incubators, laboratories and intellectual property centres is essential to support start-ups through the early stages.

3. Invest in workforce development:
Attracting and training skilled labour is vital.

4. Encourage collaboration:
Fostering industry–academic partnerships enhances innovation.

5. Financial incentives and venture capital:
Providing low-interest loans, tax reductions and venture-capital support encourages the growth of technology-based enterprises.

Where STI parks have been less successful in achieving their goals, several reasons have been identified. According to Massey and Wield (1992), for example, during the late twentieth century several UK-based parks failed to achieve their core objectives. The reasons include, inter alia:

1. Lack of distinct value proposition:
Many parks did not offer clear advantages over other locations. Firms often located in the parks for reasons unrelated to innovation, such as convenience or personal ties, rather than to access specialized resources or networks.

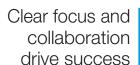### 2. Weak university–industry linkages:
The expected synergies between universities and tenant firms were often weak or absent, undermining the rationale for clustering.

3. Missed economic impact:
Many parks became little more than real-estate ventures, failing to generate significant economic or technological benefits for their regions.

4. Insufficient local capabilities:
Many STI parks failed to deliver optimal results due to a lack of local capacity in project design, implementation and management.

Clear focus and collaboration drive success

5. **Weak stakeholder coordination:**
   A lack of coordination and collaboration among key stakeholders often undermined STI park effectiveness.

6. **Inadequate planning and evidence base:**
   Failed parks frequently relied on generic models or untested assumptions rather than robust, evidence-based planning tailored to local strengths and needs.

7. **Overemphasis on infrastructure over ecosystem:**
   Some STI parks focused primarily on real estate and infrastructure, neglecting the development of active innovation ecosystems, support services and networking opportunities.

8. **Policy and resource constraints:**
   Low or inconsistent funding, lack of policy coherence, and weak institutional support hindered the development and sustainability of some STI parks.

9. **Poor monitoring and adaptation:**
   A failure to regularly assess outcomes and adapt strategies in some cases made it difficult to remain relevant and effective in changing technological and economic environments.

Both successful and less successful practices underscore that STI parks succeed not simply by clustering firms, but by cultivating genuine innovation ecosystems tailored to their regional context. STI park success depends on strong local capabilities, active stakeholder engagement, evidence-based planning, robust support systems, and continuous adaptation.

Ecosystems, not infra-structure, define STI park success

VII. Policy recommendations

Smart design makes STI parks deliver results

STI parks are powerful instruments for promoting industrial development through clustering, offering a platform for innovation, collaboration and economic growth. By fostering thematic clustering, integrating value-chain actors, and leveraging mechanisms such as knowledge spillovers and public–private partnerships, these parks enhance productivity, create jobs and drive regional competitiveness. However, challenges such as overspecialization, governance differences and inequitable benefits require careful management, particularly in resource-constrained settings.

The case studies demonstrate that success hinges on strategic planning, deliberate policy design, robust partnerships, infrastructure investment, stakeholder collaboration and inclusive ecosystems. Policymakers must adopt flexible, evidence-based strategies to maximize the potential of STI parks while addressing risks. By implementing the recommended policies, STI parks can be strong engines of sustainable, broad-based industrial development in the global knowledge economy.

The following policy actions outline what various levels of government and park managers can do to ensure the success of clustering:

1. Promote thematic specialization with flexibility:

a) Focus on high-potential industries and sectors aligned with regional and local strengths, industry needs and innovation dynamics. Effective thematic clustering involves evidence-based planning that includes mapping regional competencies, identifying synergies among firms and institutions, and designing park infrastructure that supports these linkages. Do not rely on generic models or assumptions, especially those that have proven successful in other settings.

b) Be responsive to both global trends and local development priorities, ensuring alignment with national industrial and innovation strategies.

c) Develop mechanisms to diversify activities over time to mitigate risks of overspecialization.

2. Foster value-chain integration:

a) Incentivize co-location of upstream and downstream actors through tax breaks, grants, or subsidized infrastructure.

b) Facilitate inter-firm linkages via shared facilities, amenities, and industry consortia.

c) Strengthen technology transfer offices to bridge research and commercialization.

3. Strengthen public–private partnerships:

a) Establish public–private partnership frameworks to fund infrastructure, research and incubation programmes.

b) Ensure transparent governance to align public and private objectives and avoid conflicts. Effective governance structures and private-sector engagement are essential to avoid administrative inertia and ensure responsiveness to market needs.

4. Enhance networking and knowledge spillovers:

a) Engage in active ecosystem and innovation community-building with an intentional mix of participants. Parks must go beyond providing space – they need to foster active collaboration and knowledge exchange, and provide support services to create real value for tenants and programme clients.

b) Design attractive physical and public spaces (e.g., co-working areas, communal facilities and amenities, innovation centres) and programmes (e.g., tech festivals, industry forums, incubators) to foster both weak and strong ties.

c) Support technology business incubators to nurture start-ups and university spin-outs, providing mentorship, funding and access to networks and domain expertise.

d) Host global events to enhance cross-border knowledge exchange.

e) Improve the availability of risk capital, government grants, location incentives, and credit facilities for firms within STI parks.

f) Deploy digital platforms to facilitate global networking, resource-sharing and data-driven decision-making.

g) Create incentive structures for joint research projects among firms, universities and research institutes.

5. Address inclusivity and equity:

a) Develop programmes to support SMEs, such as subsidized access to facilities or training, to ensure broad-based benefits.

b) Design policies that ensure broad-based participation, including support for marginalized groups and regions.

c) Implement regional development policies to prevent urban–rural disparities. Tailored support for SMEs will help to boost park inclusivity.

d) Promote the inclusion of women by designing gender-responsive policies, including clustering support for women-led ventures, gender-sensitive infrastructure, and use of inclusion metrics to monitor the progress and evaluate results.

e) Facilitate youth participation by clustering youth-led start-ups and training programmes to enhance peer learning, skill development, and integration into innovation ecosystems.

6. Mitigate environmental and social risks:

a) Integrate industry 4.0 technologies with sustainability goals, promoting closed-loop manufacturing and energy-efficient practices.

Partnerships and equity fuel lasting innovation

Sustainability, evaluation and networks secure long-term impact

b) Integrate environmental sustainability into park planning and operations, including green infrastructure and circular economy principles.

c) Invest in reskilling programmes to address job displacement, ensuring equitable transitions.

7. Monitor and evaluate performance:

a) Establish dedicated park management structures with stakeholder representation to guide development, monitor performance and resolve coordination challenges.

b) Establish metrics to assess STI park outcomes, including productivity, job creation and innovation outputs.

c) Implement robust monitoring frameworks to assess the effectiveness of clustering initiatives and inform policy adjustments.

d) Conduct regular evaluations to adapt strategies, drawing from IASP global survey methodologies (IASP, 2022). Regular assessment of objectives, outcomes and stakeholder needs helps parks adapt and remain relevant, preventing drift into mere property management.

8. Leverage global and regional networks:

a) Encourage STI parks to join transnational innovation networks.

b) Facilitate global partnerships to attract foreign direct investment and talent.

Taken together, these recommendations provide a practical roadmap for governments, governance boards, park management and advisory councils to unlock the full potential of clustering within STI parks, while ensuring that growth remains inclusive, sustainable and resilient.

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