Leveraging Science and Technology Parks to accelerate Africa's growth: The DPSIR Approach

Philip K. Mwendwa

School of Education, Humanities and Social Sciences, Kabarak University, Kenya

(philkimms@gmail.com)

https://doi.org/10.62049/jkncu.v4i2.102

Abstract

Science and technology parks are major investments that are majorly focused on realizing faster economic growth and innovation. The parks carry great prospects for regional economic diversification. However, over the years, Science and technology parks have encountered challenges that call for proactive management, sound policies and innovativeness. This paper used the Drivers, Pressures, State, Impacts and Response (DPSIR) approach to determine how Africa can leverage science and technology parks to accelerate growth. The study used secondary data from books, scholarly journals and technical reports. After the published sources were collected, an analytical framework was developed with three categories including drivers, pressures and impacts. The results of the study indicate that the main drivers of science and technology parks development are government policy, academic research, urge by countries to keep pace with technology and public private partnerships. It was also established that the parks had impacts such as promoting economic development and sustainability in urban growth as well as improving knowledge transfer from universities to industry. Governments have responded by coming up with policies that support the establishment of these cities. The study recommends that governments and other stakeholders need to invest more in science and technology parks through policies and public private partnerships to accelerate growth in Africa.

Keywords: Science And Technology, Technology Parks, Drivers, Africa, STPs

Introduction

Science and technology parks (STPs) have the potential to significantly contribute to the advancement of a nation's innovation capabilities and competitiveness, particularly in developing and emerging economies (Suleiman, 2023). They play a crucial role in facilitating the exchange of knowledge and technology between universities, research and development institutions, businesses, and markets. STPs create a favourable atmosphere for the exchange of knowledge between firms located within the park, universities and market (Díez-Vial and Montoro-Sanchez, 2016). Science and technology parks act as catalysts for the development in a region by accelerating economic growth and revitalizing urban areas. The Science and technology parks aim to promote networking among their occupants by establishing a conducive environment for collaboration by carefully selecting tenants and fostering connections among these companies through organized events and introductions (Koçak & Can, 2014). The United Nations Conference on Trade and Development (UNCTAD) and World Bank categorize STPs within the broader classification of Special Economic Zones (SEZs). SEZs encompass geographic regions with unique business regulations and a diverse array of incentives aimed at drawing in investors and companies across various manufacturing, technology, and service sectors (IASP, 2018).

After their emergence in the 1950s in United States of America, STPs spread gradually to other parts of the world (Iago, et. al, 2018). This was attributed to the success stories in Route 128 and the Silicon Valley. According to Suleiman (2023) leveraging STPs, can effectively address Libya's existing obstacles and capitalize on fresh prospects within the worldwide knowledge-based economy. However, studies have shown that not all STPs have been successful (Yang, et. al, 2009) asserts that the success of one STP cannot simply be replicated in another STP in a different region. Despite being operational for several years, studies have shown that the influence of STPs on the economy and development is still not clear (Vasquez-Urriago, et. al., 2016).

In light of the fact that STP literature is currently in a nascent phase of growth, scholars in recent years have sparked a significant scholarly discussion regarding the extent to which these property-based initiatives truly improve the performance of companies and the economic development of regions (Martı´nez-Can˜as et al., 2011). Companies that are located in the parks do not have a comparative advantage with those located away from the parks (Bakouros, et. al., 2002). The authors established that most of the STPs in Greece did not live up to the expectations. Similarly, Cao (2004), Macdonald & Deng (2004), and Hu (2007) raised doubts regarding the effectiveness of STIPs in enhancing innovation capability of on-park firms and promoting regional economic growth in China.

The main drivers for the establishment of STPs are to provide an infrastructure base for administrative, logistical, financial and technical support to new companies to gain market share (Suleiman, 2023). Díez-Vial and Montoro-Sanchez (2016) observed that STPs are normally established to aid in the transfer of technology from universities to companies. Additionally, STPs serve as the primary drivers of public and private efforts to advance research, development, innovation, and technology transfer (Guadix et al., 2016). Their objective goes beyond mere economic gains, encompassing social and cultural benefits as well, rendering them a worthwhile investment for public entities. By fostering the establishment of businesses and partnerships with academic and research institutions, they stimulate job creation and draw in technology-driven companies (Guadix et al., 2016). This literature points to the fact that STPs are instrumental in the growth of firms. This study will use the DPSIR approach to establish how cities can leverage science and technology parks to accelerate growth.

Methodology

An in-depth analysis of literature was conducted to establish the drivers, pressures, state and impacts of STPs in growth. Relevant publications were identified by searching the keyword "Science and Technology parks". The study used the four-step methodology as described by (Lage and Godinho, 2010).

- Conducting a wide and thorough search for publications under the keyword
- Filtering the publications by determining their relationship with the topic of study
- Developing a criterion for classification of the analysed publications
- Present the results of the analysed publications and provide a detailed view of the current information on the subject.

First, an online search using the keyword "Science and technology parks" was done. A total of 87 publications were identified. Secondly, the publications were filtered by initially reading the abstract to ascertain their relevance to the study topic. Filtering reduced the number of relevant publications to 63. Reading of the full text of potentially relevant studies to confirm their relevance was also done. Then a data extraction form was developed to record key information including authors, publication year, methodology and key findings. A classification criterion was then developed with three classes (themes) including drivers, pressures and impacts (Table 1).

Table 1: Classification of publications

Class	Total Number Identified	Number Selected
Drivers	25	20
Pressures	19	20
Impacts	29	25
Total	87	63

Results of the Literature Analysis

To present the results of the study, each of the classes of were discussed in detail.

Drivers of Science and Technology Parks

This study identified the major drivers for the development of science and technology parks as technology, policies, actors, capital and governance (Table 2).

Table 2: Drivers of the development of science and technology parks

Driver	Number of Publications	Percentage (%)
Policies	5	25
Actors	2	10
Technology	6	30
Governance	4	20
Capital	3	15
Total	20	100

The results indicate that most of the science and technology parks develop due to the need to keep pace with technology and innovations. Good policies (25%), governance and government policies (20%), capital (15%) and actors (10%) were also cited as drivers to development of science and technology parks. Dameri (2013) identified technology as the main driver to the birth and development of a smart city. This agrees with Anttiroiko, et al. (2014) who noted that ICT was the main driver in initiating the development and growth of smart cities. Yigitcanlar, et al. (2017) found out that technology roadmap, technology taxonomy and technology architecture were the main focus areas in the development of smart cities. Similarly, Kunzmann (2014) established that the main driver of science and technology parks was technology since it makes life easy, convenient and secure. Moreover, Suleiman (2023) observed that investing in science and technology parks has the potential to significantly boost innovation-driven growth and development in Libya. However, Sun et al. (2016) observed that smart city was based on organization, service, technology and service relationships. Further, the authors stated that enabling policies and taking measures to reduce the negative impacts slowing the growth of technology parks was also a major driver.
The findings of Nam and Pardo (2011) indicated that the drivers of technology parks were institutions, people and technology. The authors observed that technology parks grow when human and social capital is invested. Moreover, Abdoullaev (2011) found out that digital capital, physical capital, social capital and natural capital were the major drivers to the development of technology parks. This agrees with VanWinden and Van Den Buuse (2017) who observed that science and technology parks need support from the host municipalities and governed through partnerships for funding and subsidies. In addition, EASP (2019) asserts that the engagement of local government and implementation of policies facilitates the advancement of indigenous innovation in technology parks, while also receiving continuous positive support from the local populace.

Deakin (2013, 2014) observed that governance issues were at the center of the development of technology parks. Public-private academia partnerships were identified as the main solution to the governance issues in the establishment of science and technology parks. Similarly, Bolivar (2018) found out that the public value creation in technology parks surpassed the capacity of traditional institutions and there was a need to develop new governance structures to take care of this. Kim (2014) stated that the top-down governance structure adopted when technology parks were being developed in Northeast Asia was inadequate since it was devoid of public participation and the social fabric consideration. Further, ESCAP (2019) observes that in the 1960s, South Korea initiated national industrial strategies aimed at swiftly transitioning the nation from an agrarian-based economy to an industrialized one. These centralized strategies focused on boosting economic growth, fostering heavy industries like fertilizer and cement production, and enhancing national infrastructure through the construction of roads, railways, and ports. The establishment of industrial parks played a crucial role in realizing these objectives. Similarly, in Singapore, the government came up with a policy that aimed to create an R&D environment that would enable it to "sustain competitiveness" in the face of growing global competition which led to the establishment of the first STP in the country, the Singapore Science Park in 1980s (Ningrum & Runiawati, 2020). Additionally, Launonen & Viitanen (2011) established that in the Republic of Korea, Daedeok's designation as a special R&D zone and innovation cluster has facilitated the allocation of essential resources to the park, resulting in the establishment of a conducive business environment.

Pressures Underlying Science and Technology Parks

The underlying pressures to the establishment of technology parks include need to link innovations with development, need to have environmentally friendly cities, need to transfer knowledge from learning institutions to the real world, need to have incubation areas and accelerate economic development. Dizdaroglu (2012) established that the rationale to the development of smart cities was to provide for environmental sustainability. On the other hand, (Afzalan, 2017) asserts that current technology parks projects emphasize on economic development and improving quality of life using modern technologies. Angelidou (2017) found out that most of the science and technology park strategies mainly focus on leveraging technology to advance the transfer of knowledge and innovations. Similarly, Yigitcanlar et al. (2017) stated that technology parks are seen as innovation hubs. This also agrees with Mamhoori (2017) who identified that Pardis Technology Park in Iran was established with the main aim of fostering and backing hi-tech companies to enhance their competitiveness in the global market.

Science and technology Parks are supposed to drive economic and environmental transformations. Caragliu and Del Bo (2018) established that technology park strategy is associated with better economic performance. Cugurullo (2016) observed that environmental sustainability was a major consideration in development of Masdar City. Similarly, Martin et al. (2018) suggested that emphasis on environmental protection rather than just urban development was important in the development of smart cities. In a contrary opinion, Murat & Baki (2011) pointed out that evaluating the impact of an STP on technological advancement and its role in creating economic growth and employment opportunities in the vicinity can pose challenges.

Impacts of Science and Technology Parks

Science and technology parks have impacted society in different ways (Table 4).

Table 3: Impacts of Science and Technology Parks

Impact	Number of publications	Percentage (%)
Economic development	4	16
Social exclusion	3	12
Environmental degradation	2	8
Extreme dependency on technology	3	12
Enhancing quality of life	6	24
Sustainable urban development	4	16
Interaction between academia and industry	3	12
Total	25	100

Results indicate that the main impact of science and technology parks is enhancing the quality of life which accounted for 24% of the total reviewed publications. Economic development and enhancing sustainable development had equal contribution of 16% while social exclusion, extreme dependency on technology and interaction between industry and academia accounted for 12% each.

Economic and Social Commission for Asia and the Pacific (ESCAP) [2019] established that Industrial parks are designed to cater for the needs of industrial tenants such as textile or heavy chemical producers by offering land for operations, essential facilities, and specialized infrastructure. This act as a catalyst for economic development by assisting in growth of newly established firms to survive and gain market share. Further, Díez-Vial & Fernández-Olmos (2015) found out that enhanced product innovation occurs when companies conducting internal research and development activities exchange knowledge reciprocally with other firms that are similarly engaged in R&D.

In concurrence, Rodríguez-Pose & Hardy (2014) asserts that the old generation science and technology parks were mostly focused on promoting trade and investment to stimulate industrial growth and boost the economy, while also aiming for additional benefits such as technology transfer, knowledge sharing, and collaboration. Similarly, ESCAP (2019) observed that the establishment and success of Kanagawa Science Park (KSP) led to the park having its renowned domestic tenants, such as Hitachi and Fujitsu. These companies have brought in high-quality R&D facilities and set the stage for successful incubation activities by inspiring local innovation efforts. The STP has supported the growth of more than 500 companies, with 11 of them being listed on the Tokyo Stock Exchange. In contrasting these findings, Iago et al. (2018) established that Science and Technology parks do not always generate economic growth.

In developed countries, technology parks contribute to uniformity in development and eliminate "shadow areas". In addition, Höjer and Wangel (2015) stated that the importance being attached on smart cities could be attributed to the need for sustainable development. This agrees with the findings of Nilssen (2018) who established that Science and technology cities were becoming important in solving most of the urban problems. The parks are important in improving social, environmental and economic issues (Trindade, et al. 2017). Moreover, Zhang & Sonobe (2011) observed that industrial parks are commonly seen as an effective remedy for congestion issues in China where various local authorities have taken the initiative to establish multiple industrial parks in order to alleviate the congestion caused by industries within their respective townships, cities, or provinces.

ESCAP (2019) noted that a STP could be established as an extension of a university in a specifically designated neighboring location. Further, the European Commission (2013) added that the majority of STPs have focused management strategies on facilitating knowledge sharing and technology dissemination, along with strategies for establishing connections with public research institutions and professionals in the science industry. Lofsten and Lindelof (2005) noted that one of the key features that differentiate science and technology parks from other traditional industrial parks is their link with universities. Similarly, Berbegal-Mirabent et al. (2015) observed that an STP can function as a foundation for R&D since research facilities require a location.

The proximity of research companies or institutes does not automatically ensure research collaboration, but it also does not hinder it. Ultimately, such proximity offers the potential for collaboration, even if it is not guaranteed. Moreover, Suleiman (2023) points out that STPs plays the role of elevating the standard and significance of education and research through the promotion of connections between academia and industry and granting entry to state-of-the-art facilities and equipment. In addition, International Association of Science Parks and Areas of Innovation (2012) added that an STP can render R&D financially feasible. Research equipment can be costly for a single company, particularly if it is only needed occasionally. Hence, it would be more economical for multiple companies within an STP to share the equipment whenever feasible.

The presence of a university near a knowledge-based firm in a science and technology park creates conducive atmosphere for technology and knowledge transfer (Díez-Vial, I., and Montoro-Sanchez, A., 2016). Moreover, Díez-Vial & Fernández-Olmos (2015) established that firms that have established prior collaboration agreements with universities and research institutions would derive the greatest advantage from the park, as they would be able to seamlessly integrate existing knowledge within the park and enhance their product innovation. Additionally, Simsek, K. and Yıldırım, N. (2015) found out that certain factors such as employee satisfaction, resistance to change, financial constraints and administrative issues in companies located in Science and Technology parks could jeopardize innovations.

However, Iago et al. (2018) observed that companies located in science and technology parks had no comparative advantage than companies located in other areas. Similarly, Lewis &Straza (2021) noted that academic institutions and researchers frequently prioritize the pursuit of knowledge and the publication of research papers. These research advancements may not necessarily contribute significantly to the creation of innovative solutions or to the economic growth. This means that there will be incompatibility with the companies within the Science and Technology Park (STP) that are more focused on the development of new products. In addition, the level of research and development efforts and cooperation between tenant companies in STPs is generally limited.

Science and Technology parks have been associated with the risk of social exclusion (Yigitcanlar, 2016). For instance, despite the fact that Masdar smart city was developed with the aim of promoting social justice and equity, the city only reserves a small area for the less privileged groups. The author adds that Tianjin city faces similar problem due to its failure to recognize the complex nature of the socio-cultural processes. To ensure sustainability, Panchol, et al. (2017) observes that local communities and other stakeholders should be incorporated in decision making process.

Science and technology cities have also encouraged environmental degradation. For instance, Songdo, a smart city in Korea, was strongly opposed by local and international environmentalists since it was established on a wetland thus destroying home of several rare species (Shwayri, 2013). Further, the overreliance on technology to solve environmental problems has also been identified as a major drawback of science and technology parks (Yigitcanlar, 2017). To solve this, Martin et al. (2018) proposes that citizens should be empowered and involved in the development planning of science and technology parks. Additionally, Zhang & Sonobe (2011) argued that the STPs occupy vast expanses within major urban centers, leading to congestion.

Conclusions

This study concluded that the major drivers for the development of science and technology cities are technological development, good policies and governance. The major pressures underlying these drivers are the need to link innovations with development, achieve environmental sustainability, accelerate knowledge transfer from learning institutions to industry and accelerate economic development. It was also established that Science and technology cities have also had major impacts including enhancing quality of life, achieving sustainability in urban development and economic development. There is a need for further studies to establish how these technology parks can be applied to accelerate economic growth in the developing world. Public-private partnerships can also be established to accelerate the development of Science and Technology parks.

References

Abdoullaev, A. (2011). Keynote: a smart world: a development model for intelligent cities. *The 11th IEEE International Conference on Computer and Information Technology (CIT)*.

Afzalan, N., Sanchez, T., & Evans-Cowley, J. (2017). Creating smarter cities: Considerations for selecting online participatory tools. *Cities, 67*, 21–30.

Angelidou, M. (2017). The role of smart city characteristics in the plans of fifteen cities. *Journal of Urban Technology, 24*(4), 3–28.

Anttiroiko, A., Valkama, P., & Bailey, S. (2014). Smart cities in the new service economy: Building platforms for smart services. *AI & Society, 29*(3), 323-334.

Bakouros, Y., Mardas, D., & Varsakelis, N. (2002). Science Park, a high-tech fantasy? An analysis of the science parks of Greece. *Technovation, 22*(2), 123–128.

Berbegal-Mirabent, J., García, J. L. S., & Ribeiro-Soriano, D. E. (2015). University–industry partnerships for the provision of R&D services. *Journal of Business Research, 68*(7), 1407-1413.

Bolivar, M. (2018). Governance models and outcomes to foster public value creation in smart cities. *Scienze Regionali, 17*(1), 57–80.

Cao, C. (2004). Zhongguancun and China's high-tech parks in transition: "Growing pains" or "premature senility"? *Asian Survey, 44*(5), 647–668. http://www.jstor.org/stable/4128548

Caragliu, A., & Del Bo, C. (2018). The economics of smart city policies. *Scienze Regionali, 17*(1), 81–104.

Cugurullo, F. (2016). Urban eco-modernisation and the policy context of new eco-city projects: Where Masdar city fails and why. *Urban Studies, 53*(11), 2417–2433.

Dameri, R. (2013). Searching for smart city definition: A comprehensive proposal. *International Journal of Computers & Technology*, *11*(5), 2544-2551.

Deakin, M. (2014). Smart cities: The state-of-the-art and governance challenge. *Triple Helix, 1*(1), 7.

Deakin, M. (Ed.). (2013). *Smart cities: Governing, modelling and analysing the transition*. New York: Routledge.

Díez-Vial, I., & Fernández-Olmos, M. (2015). Knowledge spillovers in science and technology parks: How can firms benefit most? *The Journal of Technology Transfer*, *40*, 70-84.

Díez-Vial, I., & Montoro-Sanchez, A. (2016). How knowledge links with universities may foster innovation: The case of a science park. *Technovation, 50–51*(1), 41–52.

Dizdaroglu, D., Yigitcanlar, T., & Dawes, L. (2012). A micro-level indexing model for assessing urban ecosystem sustainability. *Smart and Sustainable Built Environment, 1*(3), 291–315.

ESCAP, U. (2019). *Establishing science and technology parks: A reference guidebook for policymakers in Asia and the Pacific*.

European Commission. (2013). *Setting up, managing and evaluating EU science and technology parks*. Available at https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/stp_report_en.pdf.

Felsenstein, D. (1994). University-related science parks: 'Seedbeds' or 'enclaves' of innovation? *Technovation*, *14*(2), 93–110.

Guadix, J., Carrillo-Castrillo, J., Onieva, L., & Navascues, J. (2016). Success variables in science and technology parks. *Journal of Business Research*, *69*(11), 4870-4875.

Höjer, M., & Wangel, J. (2015). Smart sustainable cities: Definition and challenges. *ICT Innovations for Sustainability*, Springer, Cham, 333-349.

Hu, A. G. (2007). Technology parks and regional economic growth in China. *Research Policy*, *36*(1), 76–87. http://ideas.repec.org/a/eee/respol/v36y2007i1p76-87.html

Iago, C., Vinicius, A., & Herbert, K. (2018). Science and technology park: Future challenges. *Technology in Society*. https://doi.org/10.1016/j.techsoc

International Association of Science Parks and Areas of Innovation. (2012). *Science and technology parks throughout the world: IASP general survey 2012*. April 2012, Málaga.

Kim, J. I. (2014). Making cities global: The new city development of Songdo, Yujiapu and Lingang. *Planning Perspectives, 29*(3), 329–356.

Koçak, Ö., & Can, Ö. (2014). Determinants of inter-firm networks among tenants of science technology parks. *Industrial and Corporate Change, 23*(2), 467-492.

Kunzmann, K. R. (2014). Smart cities: A new paradigm of urban development. *Crios, 1*, 9–20.

Lage, J., & Godinho, F. (2010). Variations of the Kanban system: Literature review and classification. *International Journal of Production Economics, 125*(1), 13–21.

Launonen, M., & Viitanen, J. (2011). *Hubconcepts: The global best practice for managing innovation ecosystems and hubs*. Helsinki: Hubconcepts Inc.

Lewis, J., Schneegans, S., & Straza, T. (2021). *UNESCO science report: The race against time for smarter development* (Vol. 2021). Unesco Publishing.

Löfsten, H., & Lindelöf, P. (2005). R & D networks and product innovation patterns, academic and non-academic new technology-based firms on science parks. *Technovation, 25*(9), 1025–1037.

Macdonald, S., & Deng, Y. (2004). Science parks in China: A cautionary exploration. *International Journal of Technology Intelligence and Planning, 1*(1), 1–14. http://www.inderscience.com/search/index.php?action=record&rec_id=4923

Martínez-Cañas, R., Ruiz-Palomino, P., & Saez-Martínez, F. J. (2011). A literature review of the effect of science and technology parks on firm performance: A new model of value creation through social capital. *African Journal of Business Management, 5*(30), 11999–12007.

Martin, C. J., Evans, J., & Karvonen, A. (2018). Smart and sustainable? Five tensions in the visions and practices of the smart-sustainable city in Europe and North America. *Technological Forecasting and Social Change*. http://dx.doi.org/10.1016/j.techfore.2018.01.005.

Murat Ar, I., & Baki, B. (2011). Antecedents and performance impacts of product versus process innovation: Empirical evidence from SMEs located in Turkish science and technology parks. *European Journal of Innovation Management, 14*(2), 172-206.

Nilssen, M. (2018). To the smart city and beyond? Developing a typology of smart urban innovation. *Technological Forecasting and Social Change*.

Ningrum, S., & Runiawati, N. (2020, August). An overview of the development of STPs in Indonesia. In *Proceedings of the 3rd International Conference on Administrative Science, Policy, and Governance Studies, ICAS-PGS 2019, October 30-31*, Universitas Indonesia, Depok, Indonesia.

Pancholi, S., Yigitcanlar, T., & Guaralda, M. (2017). Societal integration that matters: Place making experience of Macquarie Park Innovation District, Sydney. *City, Culture and Society*. http://dx.doi.org/10.1016/j.ccs.2017.09.004

Shwayri, S. (2013). A model Korean ubiquitous eco-city? The politics of making Songdo. *Journal of Urban Technology, 20*(1), 39–55.

Simsek, K., & Yıldırım, N. (2015). Constraints to open innovation in science and technology parks. *Procedia-Social and Behavioral Sciences, 235*, 719–728.

Suleiman, N. (2023). The importance of investment in science and technology parks (STPs) for Libya. Accessed from https://medium.com/@n.suleimnabid/the-importance-of-investment-in-science-and-technology-parks-stps-for-libya-f5792d60ea6b on 26th June 2024.

Van Winden, W., & van den Buuse, D. (2017). Smart city pilot projects: Exploring the dimensions and conditions of scaling up. *Journal of Urban Technology, 24*(4), 51–72.

Vasquez-Urriago, A., Barge-Gil, A., & Rico, A. (2016). Science and technology parks and cooperation for innovation: Empirical evidence from Spain. *Research Policy, 45*(1), 137–147.

Yang, C., Motohashi, K., & Chen, J. (2009). Are new technology-based firms located on science parks really more innovative? *Research Policy, 38*(1), 77–85.

Yigitcanlar, T. (2016). *Technology and the city: Systems, applications and implications*. New York: Routledge.

Yigitcanlar, T., Sabatini-Marques, J., Costa, E. M., Kamruzzaman, M., & Ioppolo, G. (2017). Stimulating technological innovation through incentives: Perceptions of Australian and Brazilian firms. *Technological Forecasting and Social Change*. http://dx.doi.org/10.1016/j.techfore.2017.05.039

Zhang, H., & Sonobe, T. (2011). Development of science and technology parks in China, 1988–2008. *Economics, 5*(1), 20110006.