United Nations TD/B/C.II/30

United Nations Conference on Trade and Development

Distr.: General
9 February 2015

Original: English

Trade and Development Board
Investment, Enterprise and Development Commission
Seventh session
Geneva, 20–24 April 2015
Item 5 b) of the provisional agenda
Policies to promote collaboration in science, technology and innovation for development

Policies to promote collaboration in science, technology and innovation for development: The role of science, technology and innovation parks

Note by the UNCTAD secretariat

Executive summary

Science, technology and innovation (STI) parks are widely used as instruments to promote collaboration among actors in the innovation system, particularly between enterprises on the one side and universities and research centres on the other. Since STI parks have been implemented in very different economic and technological contexts, a wide variety of innovation outcomes may be observed. This note presents some considerations on the dimensions of the performance of STI parks as instruments of innovation policy that may be of relevance for policymakers in developing countries and suggests several issues for discussion.

GE.15-02111 (E)
1502111

Introduction

1. STI policies for development are grounded on the notion that the long-term productive potential of an economy is largely dependent on its ability to enhance its productivity through technological progress and innovation. To this end, many countries adopt policies to upgrade their capacities to generate, exploit, transfer and apply knowledge. One such policy concerns building networks and linkages among STI stakeholders in the public sector, the business community and academia to encourage their collaboration in research and development and, more generally, in innovation.

2. While such collaboration can be and often is global in nature, its impact on economic development will necessarily be greatest when based on rich national, regional and even local interactions. Many developing countries have insufficient scientific and technological experience and capabilities, and policy support will therefore be instrumental in initiating, growing and bringing to sustainability networking activities and interactions such as innovation clusters and hubs, STI parks and business incubators.

3. Such instruments to promote technological development have been applied in a wide variety of contexts and using various models and approaches. Policymakers need to share experiences and insights in order to better develop, improve and implement policies on STI collaboration that are appropriate for their particular contexts and goals. This note presents some elements to facilitate discussion by the Investment, Enterprise and Development Commission of the various approaches in using instruments to promote collaboration among actors in the innovation systems of developing countries. Given the high prevalence of STI parks in the STI strategies of many countries, this note emphasizes the experiences available with regard to this particular policy instrument.

4. This note is structured in five chapters, as follows: chapter I discusses the importance of collaboration in innovation systems; chapter II describes the practical modalities of and functions performed by STI parks; chapter III discusses the challenges that STI parks present to policymakers and lessons available in this regard; and chapter IV presents some tentative conclusions and suggested questions for discussion by the Investment, Enterprise and Development Commission.

I. Collaboration as a key feature of innovation systems

5. An increasing number of stakeholders become involved as national innovation system policies develop and mature. The performance of a national innovation system is strongly influenced by the depth and quality of collaboration among the three main agents: Government, firms and academia.

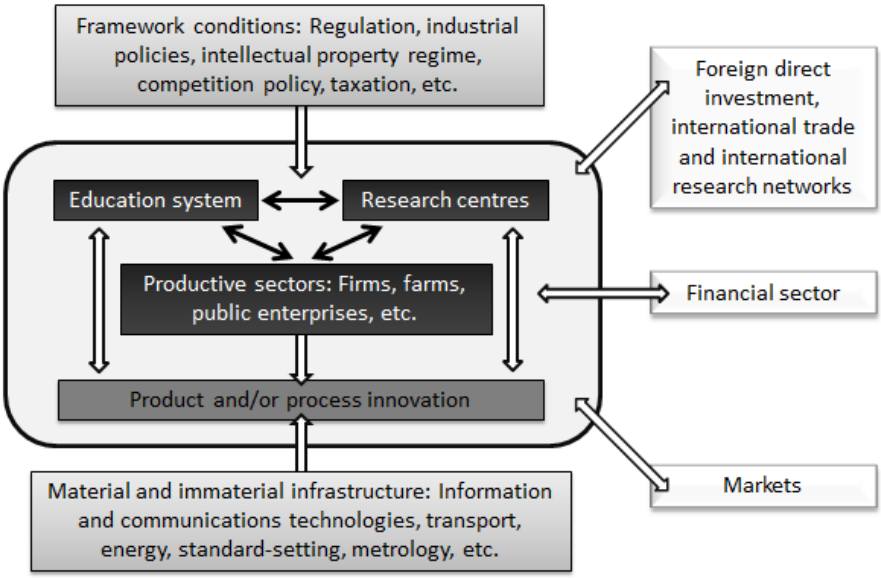
6. In the past, innovation was mainly understood as a linear process, starting with science and moving through applied research and product development to distribution; collaboration between academia and public research organizations[1] and firms was therefore based on a joint interest in commercializing research results, and the key lever for such collaboration was intellectual property. Underlying intellectual property processes correlate

[1] Public research organizations include research organizations and higher education institutions that conduct research and development, funded from public sources as well as from charitable and non-profit foundations. It is a broader term than academia and is used throughout this note.

with the notion of innovation as a linear process.[2] Patenting, copyrighting and licensing have become important mechanisms for knowledge and technology transfer.

7. While intellectual property remains a key factor in collaboration among innovation actors, the deepening of understanding of innovation has resulted in a broader palette of modalities of collaboration. The richness and depth of the interaction that develops in an innovation system is the key to developing absorptive capacities and facilitating the flow of tacit and experiential knowledge. The figure shows how collaboration takes place through multiple linkages among various stakeholders, taking the shape of collaborative research, informal contacts, contracted research, research consortia, seminars, workshops, conferences, technical assistance programmes, licensing, technology and knowledge transfer agreements, consulting, training or permanent research institutions.[3]

A national innovation system



Source: UNCTAD/DTL/STICT/2013/8.

8. Collaboration can result in direct knowledge and technology transfers when stakeholders coordinate and plan activities such as, among others, joint research ventures or consulting projects and public–private partnerships for research and development. However, indirect and informal channels of knowledge and technology transfer may develop as forms of collaboration that, for example, result in transfers of tacit knowledge, on-the-job training or more formal results such as intellectual property or publications. From a policy standpoint, the effectiveness and efficiency of collaboration in an innovation system is harder to quantify than intellectual property outcomes because knowledge flows can be both direct and indirect. However, the evaluation of collaborative outcomes, in particular between public research organizations and firms, is crucial to developing STI policy such as investing in developing STI parks with the specific aim of stimulating direct and indirect knowledge and technology flows. Chapter III considers the issue of evaluating the performance of STI parks and reviews available evidence of their impact.

[2] JG Goddard and M Isabelle, 2006, How do public laboratories collaborate with industry? New survey evidence from France, Working Paper No. 602, Institute for the Management of Research and Innovation, Paris-Dauphine University.

[3] This list is not exhaustive, as new forms of collaboration are continuously evolving.

9. The traditional argument for Government involvement in science and technology-related research is the existence of positive externalities (e.g. creating knowledge and technology flows, increasing research and development collaboration, improving human capital mobility, etc.) that result in suboptimal private investment in research and innovation. Governments in many countries therefore directly support science and technology-related research through funding or tax incentives and actively manage many public research organizations, including in such areas as health, agriculture and defence. This model remains valid when policy is based on an innovation systems approach, but in this context the existence of systemic failures requires other kinds of policy interventions aimed at establishing and strengthening collaborative linkages and eliminating coordination failures. The individual agents affected by systemic problems often lack the incentive or means to address them.

10. While innovation takes place mainly in firms, they do not innovate in isolation. By moving firms out of their physical and informational isolation, policymakers hope to improve the likelihood of success of innovative products, services or processes. STI parks can resolve two problems with regard to innovation. First, the possibility for scaling up innovation is greater in an environment with numerous potential collaborators and a well-managed infrastructure. Second, operating in proximity with actual or potential collaborators enhances the ability of firms to learn, to increase their absorptive capacity and to develop their tacit and experiential knowledge more quickly and profoundly.[4]

11. STI parks are probably among the most widely used instruments to promote collaboration in STI. Stanford Industrial Park, established on land owned by Stanford University near San Francisco in 1951, is considered the first such park, and played a key role in the development of Silicon Valley. Today, according to the International Association of Science Parks and Areas of Innovation, STI parks are in operation or under development in virtually all developed countries and at least 36 developing countries. Chapter II discusses the shape that this STI policy instrument has taken over time and in various countries.

II. Science, technology and innovation parks as science, technology and innovation policy instruments

A. Defining science, technology and innovation parks and other types of clusters

12. The terms research, science and technology park (STP) or more recently STI park designate a type of specialized cluster aimed at stimulating collaboration between the research system and firms in order to stimulate innovation based on research and development. Such parks have proliferated widely across the world and there is a high degree of diversity in their natures and functions, in part due to their evolution over time. There is no single, standard definition of different types of clusters or STI parks. Because of this, it is difficult to develop precise distinctions of what they are and how they function, although they all share some similarity in purpose. This chapter presents a typology of different types of clusters, focusing on the special nature of STPs.

13. It is useful to place STPs in the broader context of clusters, which are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions in specific fields that compete but also

[4] UNCTAD/DTL/STICT/2011/7.

cooperate.[5] The geographic co-location of firms can create positive economic externalities, referred to as agglomeration economies. Clusters are therefore often referred to as spatial agglomerations of firms and related institutions or organizations. Individual firms are often unable to innovate on their own and require a functioning innovation system or ecosystem and network of firms. Agglomeration economies help explain why firms, particularly small and medium-sized enterprises, often form into clusters to improve their ability to compete and survive. Clusters may form spontaneously through organic patterns of historical development or may be planned or constructed through deliberate policy action by policymakers. They can, but do not always, stimulate knowledge flows, upgrading and innovation among firms located in them.

14. The idea of a cluster is relatively old, but there is little consensus on its definition, which includes many different types of physical agglomerations that differ in both their nature and functioning, including industrial districts or estates, special economic zones and export processing zones.[6] STPs may also be considered a special type of cluster. The earliest clusters developed in the 1950s, notably Stanford Industrial Park and along Route 128 around Boston, while the first STPs in Europe were established in the late 1960s in France and the United Kingdom of Great Britain and Northern Ireland.[7] Since the 1980s, various types of parks have proliferated worldwide, including industrial parks, business parks, research parks, STPs and business innovation centres. The terms innovation park, innopole and techno-city have also been used.[8] In France, the terms technopole and technopolis are used, while in Germany, the term innovation and technology centre is common.[9]

15. Industrial parks are clusters that concentrate on manufacturing, without any specific involvement from universities or public research organizations. The manufacturing may be of any type and does not have to be knowledge or skill-intensive, with research and development as an important basis for production. Business parks co-locate firms that may be involved in a variety of different business activities, without the aim of promoting close collaboration among them but acting more as a real estate venture that provides good infrastructure for general business activity. As with industrial parks, the firms that locate in such a park do not need to be knowledge or skill-intensive in nature.

16. Parks are diverse and do not necessarily conform to conceptual categorizations. The definition of science parks adopted by the International Association of Science Parks and Areas of Innovation states: "Organizations managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology amongst universities, research and development institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high-quality space and facilities."[10]

[5] ME Porter, 1998, *On Competition* (Boston, Harvard Business School Press).

[6] J Potter and G Miranda, eds., 2009, *Clusters, Innovation and Entrepreneurship* (Paris, Organization for Economic Cooperation and Development).

[7] DNE Rowe, 2014, *Setting Up, Managing and Evaluating European Union Science and Technology Parks: An Advice and Guidance Report on Good Practice* (Luxembourg, European Commission).

[8] Ibid.

[9] European Commission, 2008, *Regional Research Intensive Clusters and Science Parks* (Brussels).

[10] Rowe, 2014.

17. A proposal to provide a typology of different parks states that research parks, STPs and innovation centres are all designed as research-intensive locations that focus on using and/or creating knowledge and linking that knowledge to innovation, but that they differ in the extent to which they focus on research, research and development or research, development and design, as well as whether actual production also takes place in the park.[11] Research parks focus largely on research or research and development, with no production in the park. Science parks focus on research, development and design, which includes research and new product and process development and design, while actual production generally takes place elsewhere. For both research parks and science parks, the presence of public research organizations in the park, including research institutions and universities, is critical. Technology parks focus on production as well as research, development and design and host high-technology firms and may or may not include public research organizations. Innovation centres or business innovation centres appear to be a hybrid of STPs that can offer a wide variety of services and focus on high-technology activities. This typology highlights the main common characteristic of STPs: they seek to physically co-locate research and development organizations and firms in order to promote collaboration and innovation in knowledge and skill-intensive activities.

18. There are, however, many variations of these definitions that can be found in different sources. The term science park of the International Association of Science Parks and Areas of Innovation includes science, research and technology parks. The term research park is more prevalent in the United States of America, whereas science park is more prevalent in Europe and technology park is more prevalent in Asia.[12] Some analysts use research, science and technology parks interchangeably or introduce alternative categorizations.[13]

B. Typical features of science, technology and innovation parks

Expected outcomes

19. The goals of policymakers and other stakeholders involved in establishing, supporting and operating STI parks are varied. One study identified the following three: reindustrialization and the creation of new jobs in new industries; regional development; and the creation of synergies that stimulate the creation of new technologies and innovation.[14] The creation of new firms based on high technology has, over time, become a more visible objective, with the increased importance of high-technology production in recent decades. This is often expected to happen through the spin-off of new firms, which can be incubated in a park.

20. Based on a study of 40 science parks in Europe, one study reported that most of the parks included the following among their objectives:

- Facilitate interaction between companies, universities and research centres
- Be a hub for business development policy

[11] P Escorsa and J Valls, 1996, A proposal for a typology of science parks, in: K Guy, ed., 1996, *The Science Park Evaluation Handbook*, Technopolis, Brighton: 66–81.

[12] AN Link and JT Scott, 2007, The economics of university research parks, *Oxford Review of Economic Policy*, 23(4): 661–674.

[13] See, for example, European Commission, 2008, and M Castells and P Hall, 1994, *Technopoles of the World: The Making of Twenty-first Century Industrial Complexes* (Abingdon and New York, Routledge).

[14] Castells and Hall, 1994.

- Provide a favourable environment for the development of local businesses
- Help promote a more modern and dynamic image of the region
- Attract businesses to the park[15]

21. The study also identified several generic aims that are common to most, if not all, science parks, even though they might not be explicitly stated in a park's formal list of objectives, including the following:

- Foster the start-up and/or early growth phase of new high technology-based firms
- Attract existing firms, particularly from outside the region, to establish research and development-intensive activities in the park (not applicable to some science parks that are essentially innovation centres aimed only at the development of new high technology-based firms, which are common in Germany)
- Facilitate technology transfer between organizations in the park, particularly from universities or research centres to firms
- Contribute to the economic development of the region

22. A key goal is likely to be promotion of innovation and technological upgrading and, alongside, increased productivity and an improved competitive position for firms in the cluster. These outcomes flow from the three benefits that can result from the geographical proximity achieved by clusters. First, an increased division of labour in the labour market enables firms to reduce search and training costs. Second, the division of labour in intermediate supplier industries provides firms with access to specialized suppliers of materials and components, finance, marketing, business services, etc. Third, knowledge spillovers take place, such as transfers of knowledge of market opportunities and technologies from both formal and informal links among actors in the park.[16]

23. With respect to STPs, it is likely that the last of these three benefits is a central goal of innovation policymakers in establishing such parks. Fostering linkages and promoting collaboration among research organizations, firms and Government (the triple helix) to generate knowledge flows and spillovers is a common priority of policy intervention in many countries. Inter-firm collaboration is also important in practice, particularly between small and large firms and between firms operating in a common value chain with fragmented production. STPs are often seen as a potentially useful tool for promoting close collaborative linkages.[17]

24. Innovation systems are most effective when such linkages are strong and drive close collaboration. To achieve such an outcome, STPs are expected to develop into dynamic research and development-based local or regional innovation systems. Policymakers should aim to develop a strong innovation system, characterized by a dense and highly integrated network, with strong collaborative linkages and active flows of knowledge (including tacit knowledge) and technologies through technology transfer and diffusion. The universities and other research organizations that are part of an STP are intended to drive such flows of knowledge, as well as create a flow of educated and skilled human capital to firms. Knowledge and skills are likewise intended to flow back in the opposite direction, as well

[15] Escorsa and Valls, 1996.

[16] Potter and Miranda, 2009.

[17] There is substantial literature supporting this view and it has become generally accepted in STI policy. See, for example, the following: European Commission, 2008; P Quintas, 1996, Evaluating science park linkages, in: K Guy, ed., 1996, *The Science Park Evaluation Handbook*, Technopolis, Brighton: 98–111; and Rowe, 2014.

as among firms in the STP. These flows are expected to lead to technological learning and stronger technological capabilities and, as a result, technological upgrading and innovation by firms in knowledge and research-intensive industries. Such innovative firms would create high value-added jobs, translating into higher wages and output, economic growth and structural transformation in the region of a park. This is likely to be the ultimate goal of policymakers that are involved in supporting STPs.

25. In addition to such ultimate policy goals, there is likely to be an intermediate goal of achieving the co-location of a critical mass of firms and research organizations in a park in order to generate the development of dynamic collaborative networks among them, which create dense knowledge flows and trigger technological innovation.

26. The managers and financiers of a park, if they are not purely public sector bodies, are likely to have more commercial goals, concerned with generating adequate return on funds invested and ensuring a certain rate of return, often called the hurdle or minimum rate of return to make an investment profitable, for investment projects in general. This implies related goals such as achieving adequate rates of occupation and new firm entry into the park to generate revenues that contribute to achieving financial goals. There may, therefore, develop tensions between the two general aims in creating and running parks, the commercial aim of the financial viability of the park versus the ultimate policy goal of stimulating effective collaboration and innovation.

27. The wide diversity of goals creates challenges for evaluating the performances of STI parks, as discussed in chapter III.

Role of private and public partners and governance

28. STI parks are often considered an important part of regional-level STI policy, as opposed to national-level STI policy, although parks may represent a national-level policy issue for small countries. They may also be a part of national STI policy in countries that are large enough to have substantial regionally based policymaking and institutional development. Given the potential interest of different levels of government in STI parks, public bodies at the national, regional or local level are usually involved in the ownership and financing of parks to a greater or lesser extent.

29. There are many models of ownership and wider governance of STI parks and no truly typical model. In the European Union, around 55 per cent of STI parks are publicly owned, including by local government, regional government and universities. Mixed public–private ownership structures account for slightly more than 30 per cent of parks. These mixed structures typically include local government, universities and private firms. Privately owned parks represent over 14 per cent of parks in the European Union, with private firms and private universities both involved as owners.[18] Management is often via a private management company, but they may also be managed by a university that is a part owner or by a public body or a foundation. Financing arrangements for STI parks are likewise diverse, with both public and private sources being the norm. A survey of parks in the European Union reported that they rated all of the following as very important sources of funding: the European Commission; regional organizations; national Government; local government; universities or research and technology organizations; and banks. Public financing may also take place to support incubators in a park. In addition, STI parks and incubators themselves may provide financing for firms locating in a park, which may be in part public financing. Public financing is also often provided indirectly through the

[18] Rowe, 2014.

financing of research and development at universities and other public research organizations.

30. STI parks that are privately owned and/or operated are more likely to be run as real estate businesses that seek not only to create linkages, collaboration and knowledge flows, but also to earn revenues from property rental and service fees. One study reported that the approach to STI parks varied between the United Kingdom and a group of other European countries: in the United Kingdom approach, parks were fundamentally a real estate operation selling quality sites in a high-technology environment to companies that require such sites, whereas in countries such as France, Greece, Italy, Portugal and Spain, they were viewed as instruments of regional development.[19] As a result, there was more public sector participation in the ownership and support of parks in the latter. The public financing of research and development may be structured in such a way as to incentivize collaboration by research organizations with firms.

31. There is also a wide diversity in the nature of firms that operate in STI parks. Tenants of parks in the European Union are dominated by micro and small and medium-sized enterprises in terms of the number of firms.[20] Most firms that locate in parks in Europe are from the same country, with some 8 per cent being transnational corporations. Most (71 per cent of the total) of the same-country firms are local and the rest are regional (12.9 per cent) or national (16 per cent) firms. In developing countries, parks often aim to attract transnational corporations to locate in a park alongside local firms. The main technology sectors represented in European parks are, in descending order, information technology and/or communications, biotechnology, computers and/or informatics, energy, Internet technologies and services and software.

III. The contribution of science, technology and innovation parks to innovation policy and overall development

A. Park operations and science, technology and innovation policy objectives

32. STI parks are increasingly seen as important targets for public sector support in terms of policy and funding. One reason for their growing popularity is that STI parks provide highly visible means to signal commitment to supporting technological innovation leading to better competiveness and increased employment. In this regard, it has been acknowledged that there is a strong link between economic diversification and national innovation capacity and successful STI park projects.[21]

33. The focus of the contribution of STI parks to development strategies has moved from providing quality infrastructure, to attracting technology businesses, to becoming a major element of STI policy and hence of development policy in general. In the past, the major concerns for park operators were making land available, financing the building of parks and their infrastructure and providing financial easing for tenants through fiscal incentives and subsidies. Today, an increasing number of policy concerns are raised. Policymakers need to distinguish between two sets of policies, a primary set directed at STI parks themselves and a secondary set meant for parks to pursue vis-à-vis their partners and tenants.

[19] Escorsa and Valls, 1996.
[20] Rowe, 2014.
[21] Ibid.

34. With regard to the primary policy set, policymakers need to consider issues related to the following four key areas:

- Policy coherence: There should be a close alignment between the national development strategy, the national innovation policy and the sector profile of a park. This requirement is often difficult to achieve due to inconsistent linkages among various policymakers at various levels of government and their differing time horizons and sets of incentives.
- Financial sustainability: A decision should be made early on about the sustainability and independence of a park, and a governance framework developed supporting the intended financial outcome. At the outset, an STI park requires public funding to attract tenants and establish partnerships. In the long term, financial autonomy is desirable, though not at the expense of giving a low priority to the innovation-nurturing role of the park. Public investment in STI parks should look for medium to long-term returns. Policymakers therefore need to be well-informed and understand the factors that can affect the performance of a park during its life cycle.
- Outreach: STI parks should make their tenants more attractive to national and international partners. Doing so depends not only on the actual innovation quality of an STI park's activities but also on the public relations and marketing activities of the park in its entirety.[22] Partnership capacities, logistics, infrastructure, regulatory and administrative facilities and incentives may be offered and need to be actively and successfully promoted. International partnerships may be developed with foreign firms and multinationals and with public research organizations and private research firms, given the increasing internationalization of research and development activities.[23] Regional and South-South cooperation may help develop complementary capacities. Differentiation and the development of a competitive advantage and unique profile may also be a worthwhile policy objective.
- Tenant funding: Innovation is risky and uncertain and entrepreneurs that cannot secure funding may see the knowledge competencies they have assembled dissipate quickly. The uncertainty of innovation outcomes is an important disincentive for traditional financial institutions seeking investment opportunities. As a result, innovative firms experience high costs of capital that are only partly alleviated by venture capital.[24] Venture capital itself depends on the existence of a well-functioning equity market in which it can divest its venture when it matures, and this may not be available in many developing countries. Therefore, financing of the activities of park tenants may need to rely on public investment vehicles or funding developed through public–private partnerships. The actual form of funding may be diverse and should be appropriate to the recipient firm and its innovative proposition and may include, for example, seed funding, the secondment of staff from public research organizations or loan guarantees.

35. With regard to the secondary policy set, STI parks should develop the following three areas:

- Tenant selection: Tenants are normally selected from a priority sector and from a technology or knowledge-based sector or industry. Selection will involve

[22] H Tcheng and J-M Huet, eds., 2012, Of science parks and men: Cities, the catalysts for development in emerging markets, Convergence Letter, BearingPoint Management and Technology Consultants.

[23] UNCTAD, 2005, *World Investment Report* (New York and Geneva, United Nations publication).

[24] BH Hall and J Lerner, 2009, The financing of research and development and innovation, Working Paper No. 15325, National Bureau of Economic Research.

encouraging local universities and public research organizations to cooperate and even become tenants. Knowledge and technology transfer can take many forms and may produce relationships that are founded in legal instruments such as intellectual property and non-disclosure agreements. Establishing and managing these tend to require a sophisticated set of skills; tenants may need to be guided and STI parks need to provide expert advice on intellectual property. Another important consideration is assessing the absorptive capacity and overall competency of tenants, in particular regarding entrepreneurship and management skills.

- Incubation: business incubation facilities and support are needed in order to increase the chances of innovations maturing into commercial products and services. This means that there may be a need to provide on-site business support services. STI parks need to have their own business development competencies that can develop cooperation and linkages with regional and national markets and international value chains and can guide tenants in the economic discovery of the commercial potential of their innovations. It is unlikely that there will be many tenants with meaningful revenues and profits during the early stages of establishment and policies on terms and conditions for tenants may need to reflect this reality.
- Capacity to assess innovation outcomes: STI parks need to identify themselves as agents in a national innovation system and move substantively beyond acting as landlords. STI parks need to look closely at how they and their tenants integrate with other STI stakeholders and need to reference their success to strategic social and economic targets as defined in a national development policy, such as, for example, the creation of highly qualified jobs and new technology businesses and sectors and the strengthening of export sectors and participation in international value chains.

B. Performance dimensions and science, technology and innovation policies

36. The metrics for judging the performances of STI parks are not straightforward. Success is generally assessed by comparing performance against a park's objectives and these may be numerous and diverse. The assessment of actual performance against stated objectives is problematic for at least three reasons. First, it is likely that the objectives of some parks will be poorly defined or even contradictory. Second, different parks are likely to have different sets of objectives with different emphases or weightings, reducing the possibility of comparing experiences. Third, data measuring positive externalities can be difficult to establish.[25] In addition, measurements and comparisons of outcomes can be deemed rigorous only if there is a control group where policies on STI parks are absent.

37. Performance indicators for STI parks often amount to easily measurable indicators of commercial feasibility. Innovation system and qualitative indicators, such as the development of linkages and collaboration or technological upgrading and innovation, are not always included. Nevertheless, basic indicators may include the following:

- Area of land under development in hectares and building space constructed in square metres, a measure that is particularly prominent in the early years of an STI park's development
- Number of companies located in the park and number of people they employ (additional information may relate to the type of employment created and the number of qualified scientists and engineers employed)

[25] Escorsa and Valls, 1996.

- Number of companies that have graduated from the park and their employment numbers
- Rental and services income per month, per year and over time
- Type and range of common services provided by the park, such as broadband telephony, videoconferencing, meeting rooms, secretarial support, networking events, virtual accommodation address facilities, etc.
- Type and range of professional services provided either directly by the park management itself or indirectly by others encouraged by the park management to offer these services, such as bookkeeping and accountancy, mentoring, access to finance, marketing support, public relations support, general business advice, technology transfer facilitation and networking with the knowledge base
- Funding for capital and operational purposes raised and spent
- Inward investment projects attracted to the region by the park itself and/or in cooperation with others such as inward investment attraction bodies or regional development agencies

38. Other success criteria may include survival rates of tenant firms, whether research linkages are more likely to form with on-site or off-site firms and the impact of a park on overall employment growth, university publication and patenting activity. These may be developed with reference to an off-site control group of firms. Surveying the motivations of firms to locate in a park may also develop useful insights.

39. A number of studies have reached mixed conclusions. One study established that a large percentage of STI parks in the United States either ended as outright failures or contributed little to economic objectives, reporting that only 25 per cent of STI parks in the United States achieved their goal of attracting and fostering research and development activity, contributing to job creation and economic growth, while another 25 per cent became purely real estate operations that contributed little to economic objectives and 50 per cent failed.[26]

40. Another study suggested that the ability of STI parks to develop linkages between higher education institutions, such as universities and colleges, and firms was the key criterion by which to judge their success.[27] A major determinant of a firm's decision to locate in an STI park hosted by a public research organization is to acquire access to scientists at the university and research facilities, and the largest development impact in regions in which STI parks locate is therefore likely to be growth in research and development activity. As weak linkages and interactions among STI stakeholders is a common systemic failure, in developed and developing countries, fostering linkages and promoting collaboration are generally high priorities of an STI policy. Promoting the technological upgrading of firms is another common goal of STI policy. When collaborative networks are forged and information, knowledge and technologies flow quickly due to physical proximities in STI parks, technological learning can enhance technological and innovation capabilities.

41. More recent studies indicate that the main contributions of STI parks are in the creation of high-quality employment and new technology businesses and in the

[26] M Luger and H Goldstein, 1991, *Technology in the Garden* (Chapel Hill, University of North Carolina Press).

[27] P Westhead and S Batstone, 1998, Independent technology-based firms: The perceived benefits of a science park location, *Urban Studies*, 35(12): 2197–2219.

establishment of national or regional visibility for technology and innovation.[28] Technology transfer from academia to firms is also noted as an important outcome and is a result of the types of linkages that STI policy aims to create through STI parks. However, linkages may take many forms and are difficult to detect, for example the transfer of tacit knowledge.

42. A central issue for policymakers is distinguishing the measurement of processes versus outcomes. Linkages are the means of achieving desired outcomes and are indicators that innovation processes are active. Whether an STI park can assist its tenant firms to generate commercial innovation outcomes is linked to but not directly contingent on such processes. Finally, there is the issue of the time horizon of evaluations; certain criteria require a long-term assessment while others may be examined on an immediate or regular basis. One study suggested that, given the difficulty of detecting and evaluating linkages at any given time, there was a case for combining process-oriented evaluation that focused on measuring the development of collaborative linkages with the assessment of outcomes that were achieved in terms of outputs and impact.[29] However, actually implementing such evaluation remains a major challenge.

C. Challenges in evaluating science, technology and innovation parks and related policies

43. The time horizon problem of evaluating STI parks is further complicated not only by the fact that certain outcomes materialize in the future but that major costs and investments are incurred in the early stages of a park's lifespan. At the outset, the largest cost item is generally the real estate purchase and infrastructure development. However, funding may be required throughout a park's development. Income streams that emerge over time may gradually begin to contribute, as compensation for high up-front expenses. Based on purely financial indicators, it is unlikely that STI parks can be managed as profitable business investments, as their goals are generally more complex and related to realizing positive externalities that would otherwise be lost without their activity. The mix of public–private financing during the lifespan of a park is likely to change, with private investment gradually increasing and eventually, as the park reaches maturity, becoming the dominant source.

44. With regard to the development of linkages and collaborative networks, a short-term time horizon is inadequate in evaluating performance or outcomes. Collaborative processes require time to develop and consolidate, as a culture of cooperation builds and the level of trust needed for close partnerships is created. Regardless, evaluation data must be developed and recorded as a time series, on a continuous basis from the date that a park is set up.[30] A unique data set at a national or regional level allows for comparisons among parks at different points on their development curve even if this means confining collection to information that can be easily accessed from the records of an STI park and its tenants, often including, for example, financial performance information and data on the numbers and types of businesses in the park that are starting up, closing down or leaving.

45. Another important concern is the fundamental mismatch between the relatively long term that an STI park and its first tenants need to become commercially viable and the shorter time horizons of Governments and administrations during which they propose and commit to attaining certain economic growth and social development targets. If an STI park requires 10 or 20 years before it develops commercial potential, there will in the meantime

[28] Rowe, 2014.

[29] Quintas, 1996.

[30] B Hogan, 1996, Evaluation of science and technology parks: The measurement of success, in: K Guy, ed., 1996, *The Science Park Evaluation Handbook*, Technopolis, Brighton: 86–97.

be a need for public financing and policy support that may extend over several political administrations, and policy continuity may become an important challenge. Therefore, any evaluation will need to judge data and surveyed information against the background of an assessment of policy continuity, including the continuity of funding commitments as well as broader policy support over the long term.[31]

46. In addition to challenges concerning the time horizon, there is an issue of additionality, that is, the extent to which any positive changes that an STI park tenant has experienced may be attributed to being located in the park. At the regional or national level, benefits in the locality of a park must be weighed against losses and opportunity costs experienced by tenants due to their relocation from other sites.[32] Such costs and losses need to be set against any benefits from developing close linkages with tenant public research organizations. Assessments therefore need to recognize the cost of both existing linkages and severed previous linkages. The need for a control sample of firms located outside STI parks is once again evident, and it has been suggested that a full assessment of additionality would benefit from a representative survey of businesses not located at an STI park as a control group.[33]

47. However, conducting policy research with a control group can be difficult, as developing a representative sample of firms with a similar mix of technology or knowledge-based products and services is challenging, while persuading the same firms to take part in a survey that has no direct benefits for them may be ineffective. The solution would be to establish well-defined but simple metrics backed by convincing and overwhelmingly supportive policy leadership.

D. Science, technology and innovation park-related challenges in developing countries

48. The experiences of several developing countries, as noted in the UNCTAD work programme on STI policy reviews, suggests that while STI parks have become a popular instrument for supporting innovation, a strong policy commitment requires a number of supporting conditions, including the existence of knowledge and technology leaders, in the form of universities, research and development institutions and private firms or, alternatively, the ability to attract foreign technological firms. A national policy formulated as an innovation system strategy, with appropriately developed cooperative linkages and incentives attracting and supporting high-technology firms, is another key condition.[34]

49. Such conditions are not easy to meet in developing countries. For example, a review of STI parks in Latin America shows that most need to increase their sizes, strengthen their bases of advanced knowledge institutions or high-technology firms and increase their efforts to encourage technological cooperation among firms located in them.[35]

50. The management of an STI park should aim to outgrow its role as a provider of infrastructure and move on to developing competencies assisting the incubation of new technology-based firms, thereby supporting the development of regional and sectoral innovation systems with sustained linkages to local public research organizations, firms and industries. For example, in Latin America, the most dynamic STI parks exhibiting higher

[31] Rowe, 2014.
[32] Quintas, 1996.
[33] Rowe, 2014.
[34] A Rodríguez-Pose, 2012, *Los Parques Científicos y Tecnológicos en América Latina* (Washington D.C., Inter-American Development Bank).
[35] Ibid.

levels of technological content are those located close to the best universities in the region, in cosmopolitan areas that can provide a critical mass of high-technology firms. Reverse developments have also been noted, as STI parks can become enclaves with limited linkages to the local economy or technology transfer towards domestic industries.

51. Finally, there is a need to establish a distinction between an industrial estate and an STI park. From a development perspective, they may be more similar than in a developed market economy context. However, the policy framework and support for STI parks must be distinct and focused, as the sought outcome is of a completely different quality.

52. Recent case studies in the context of the UNCTAD programme on STI policy reviews in developing countries and issues worth considering are described in the following paragraphs.

Thailand

53. The Government has established several STI parks since the late 1990s. Thailand Science Park, launched in 1996 in the northern suburb of Bangkok, is the most advanced, and hosts four national high-technology research centres (Nanotec, Biotec, Mtec and Nectec) with 1,800 researchers, of which 480 have PhDs. Sixty tenant enterprises, with about 500 staff members, 60 per cent of which are research and development personnel, are located in the park. Tenant firms largely work in research and development related to the fields of the four national research centres. Around 20 tenants are electronics and computer firms, 13 are biotechnology firms and 27 are in the metal and material industry. The park also includes the Business Incubator Centre, an incubator to facilitate the growth of small innovative businesses, which has incubated 74 start-ups and supported research and development projects in a number of established firms. In addition, the park offers innovation-related services such as intellectual property management and technological services, and is host to three universities and one medical school. The park has provided Thailand with a well-developed physical research and development infrastructure, yet has been less successful in supporting and attracting private research and development efforts and incubating research and development firms. Phase II of the park was opened in 2014, but there have been difficulties in attracting firms to the park, as many prefer more central locations in Bangkok.

54. In addition to public efforts to establish STI parks, private efforts such as Amata Corporation's Science City have also supported the establishment of scientific poles in large private industrial estates.

Dominican Republic

55. Technological parks have been promoted by law (No. 392-07, 2007, on competitiveness and industrial innovation) as one of three instruments to support innovation and technological development in the country. However, according to an innovation survey conducted in 2010 and interviews carried out in the context of the STI policy review, the development of technological parks as a place for the development of prototypes and for conceptualizing ideas before creating companies and bringing them to the market is still very limited.[36] The law provides tax exemptions, offering clear incentives for the renovation of equipment and machinery, but is insufficient on its own in promoting the creation and local adaptation of technology. Activities have been focused mainly on the promulgation of a legal framework that promotes these industrial areas. With the exception of Parque Cibernético in Santo Domingo, progress still needs to be made in promoting

[36] UNCTAD/DTL/STICT/2012/1.

innovation or transferring technology within the established industrial parks. A fundamental policy challenge is changing the understanding of the parks, as STI parks rather than industrial enclaves, with the implementation of the requisite strategies for linking them with other companies in the Dominican Republic.

Oman

56. An important part of Oman's industrial activities takes place in eight industrial estates and free zones. A recent development has been the establishment of a ninth high-technology industrial estate, located near Muscat close to Rusayl Industrial Estate, Innovation Park Muscat and Sultan Qaboos University. Opened in 2003, Knowledge Oasis Muscat is Oman's flagship technology park, and its objectives are to develop public–private partnerships nurturing knowledge-based businesses while remaining focused on promising entrepreneurs and small and medium-sized enterprises. The park hosts more than 60 firms and provides office and business incubator accommodation to technology-oriented businesses, including technology start-ups. The STI policy review noted that links and synergies with academia may benefit from further development and that developing the presence of foreign companies with significant research and development activities would be beneficial.[37] Education is another key factor, and additional graduates with competencies relevant to industry are needed. Linkages are underdeveloped, and industry may need to increase its participation and influence in curriculum development for schools and universities, while improving cooperation with public research organizations on research and development and technology adaptation and innovation.

57. Efforts are being made to set up small and medium-sized enterprise incubators, such as in the Salalah Free Zone. Many requests for incubation come from entrepreneurs with academic knowledge but modest entrepreneurial and practical experience, and training is provided to remedy this. Small and medium-sized enterprise start-ups require more than physical space, and STI park management needs to improve access to advice, coaching and contact with venture capitalists.

58. The Government is expending significant efforts to strengthen linkages underlying the innovation system and STI park development policy. In this regard, facilitating engagement in international collaboration with foreign firms and public research organizations is an area where cross-cutting policy action needs to match efforts at physical clustering and where the innovation system strategy – being developed at the time of preparation of this note – is expected to offer improved results.

IV. Conclusion

59. The outcomes of STI parks as innovation policy instruments present a varied picture. Among other factors, where a proactive STI policy is in place, clear strategic goals have been identified and effective engagement with the local knowledge base has been established and nurtured and commitment maintained over reasonable time horizons, there is evidence of successful outcomes related to the generation of innovation-led economic activity, gains in competitiveness and better employment. However, many STI park initiatives must address challenging STI environments, in terms of technological capabilities, business environments and financial stability. Given the sophisticated skills involved in starting up a complex system of multiple knowledge and business interactions, it is to be expected that the operation of a certain number of STI parks has tended to focus

[37] UNCTAD/DTL/STICT/2014/1.

more on immediate financial considerations (i.e. operation of a park as a real estate undertaking) rather than on long-term innovation outcomes.

60. Particularly in developing countries, where innovation systems present well-known weaknesses, it is important that the Government and other actors considering investing in the establishment of STI parks be able to draw on solid evidence of good practices in STI park design, governance and operation. Areas in which such evidence would be particularly useful, and which the Investment, Enterprise and Development Commission may wish to consider in its discussions, include the following:

- How should a tenant selection policy for STI parks be defined and fine-tuned?
- Should STI parks respond to priorities linked to the development of new industrial sectors or focus on existing local economic structures?
- What are the most successful models of public–private partnerships in the operation of STI parks?
- What are the managerial and STI-related skills that the management of STI parks need to focus on?
- What are the main dimensions along which the performance of STI parks should be measured and what indicators are best suited for this?