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SCIENCE/TECHNOLOGY PARKS AND INCUBATORS IN ESCWA MEMBER COUNTRIES: MODELS AND CRITERIA

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A. INTRODUCTION

Investment in science, technology and innovation has made a very significant contribution to the economic growth of many countries, both developed and developing, around the world. The implementation of new technologies has had tangible impact in many spheres of the international economy and holds the promise for furthering socioeconomic development in the developing world.

An integrated set of prerequisites is required for reaping the full benefits of technological advances needed to solve the numerous problems posed by socioeconomic development. Science and technology policies are essential for creating an appropriate environment for a dynamic system of innovation. They are scarcely sufficient, however, without policies that condition and mold legislative environments and regulatory measures to facilitate continued and relatively safe investment in innovative inputs designed to boost productivity and competitiveness at the level of firms, sectors and nations. Resources and the support provided by adequate institutional forms and networks constitute another set of essential ingredients required for a viable system of innovation.

The science and technology policy literature, which constituted a thriving area of both theoretical research and heuristic study in recent years points to a number of important lessons for countries in the process of technological capacity building. One of the more prominent of such lessons is to set clear policy objectives that directly relate to socioeconomic development objectives. Such objectives in the ESCWA member countries include the need to:

- diversify traditional economies;
- generate as much growth as possible;
- guarantee adequate responses to the demands of the region's growing and youthful populations;
- come up with adequate solutions for a number of environmental problems in urban and rural settings.

It may readily be seen that none of these problems can remain the sole preserve of any one type of institutional set up, particularly in the ESCWA member countries. Government and university research and development institutions tend to produce diffuse and long-term solutions. Nor could such problems be left to the private sector alone with its proverbial hastiness to recoup investment and move on for further conquests. Non-governmental organizations, with their, generally, limited resources and preoccupation with solving the most urgent development problems, would not fare much better on their own. Rather, an approach is needed where the propensity for governments to target strategic and long-term objectives, the dynamism inherent in the practices of private enterprise and the resoluteness of non-governmental organizations may be combined to achieve optimal results.

Technology parks, incubators, innovation centers and industry clusters are new models that aspire to tackle many of the above-mentioned problems through capitalizing on the strong points of parties including government, private enterprise and non-governmental organizations. The present introductory account is dedicated to exploring possibilities offered by three such institutional forms, namely technology parks, incubators and industry clusters.

It is intended as the first part of a wider study addressing the whole spectrum of such institutional forms, charting modalities for their design, establishment, as well as outlining criteria for their success and monitoring their progress.

B. MODALITIES FOR CAPACITY BUILDING

Capacity building modalities can take several forms, the most important of which are: Science/technology parks, incubators, innovation centers, centers of excellence and technology clusters. In the following sections science parks, technology incubators and industry/technology clusters will be presented with case studies illustrating each of them.

I. SCIENCE PARKS, TECHNOPOLES AND SCIENCE CITIES

Science parks and related entities proliferated during the past twenty years or so, not only in the United States and the European Union, but also, though more recently, in countries of South East Asia and Latin America.

California's Silicon Valley, North Carolina's Triangle Park, and the Cambridge Science Park are often cited by proponents of such initiatives as examples of enormous successes in employment creation, new technology generation, etc. The fact that successful technology initiatives such as these are few is often glossed over. Nevertheless, there is general agreement that the science park concept, with all its shades and variants, is worthy of focused attention by institutions and countries engaged in technology-related development.

1. WHAT IS A SCIENCE PARK?

According to the United Kingdom Science Park Association (UKSPA), a science park is "a property-based initiative which has formal operational links with a university or other higher educational or research institution". It is intended to "encourage the formation and growth of knowledge based businesses and other organizations normally resident on site." Furthermore, according to UKSPA, one of its main management functions is to actively support technology transfer to, and enhance business skills in, the park's tenant firms.

Thus, in general, a science park is based on property holdings and has links to a university or research institution. Its aim is to encourage the commercial application of technology, growth of tenant businesses, and technology management skills. It should be noted though that some science parks may emphasize some mission elements over others and depart from above definition. Others may concentrate on providing aid for new technology-based firms.

2. SERVICES OFFERED BY SCIENCE PARKS

Science parks support their tenants by performing two main roles. Firstly, they provide them with technological support, involving ready access to relevant and up-to-date technological knowledge, through contact with a university research center. This is a role that is sometimes referred to as "technology brokering". Secondly, science parks support their tenants by providing business linkages, advice and services as well as general assistance. The latter function, in particular, could cover quite a wide range of contacts, encompassing basic building maintenance, secretarial and administrative services, advanced business and financial counseling as well as access to sophisticated research equipment and instrumentation.

3. WHAT MOVES BUSINESSES TO JOIN PARKS?

Tenant businesses may join a park because of a prior relationship with one of its tenant institutions, e.g. a university laboratory or a research center. Another reason appears to be "prestige and status". Additionally, science parks may be expected to facilitate the creation of a sense of collective identity among tenants. They also influence the manner in which the perceptions of outsiders about tenant businesses are formed. In this sense, it is proposed that a given park's location, the amenities it enjoys and the fringe benefits made available to its tenants may contribute more to the tenant businesses' image than the fact that a network of relationships is formed within the park.

4. SCIENCE PARKS AS NETWORKS

One of the more prominent functions of a science park is to facilitate the formation of networks involving multilateral formal as well as informal interactions among a variety of institutional forms. In general, bringing businesses and researchers into contact would not be expected to spontaneously give rise to network formation. Rather, networks are formed on the basis of mutual needs. As in any other form of socioeconomic interaction, parties will only cooperate when at least one entity has a need for something, a good or a service, that another party is thought to be able to deliver.

5. SCIENCE PARKS AS A TOOL FOR LOCAL DEVELOPMENT AND EMPLOYMENT

Science parks can play an important role in local, as opposed to national, development. This role is often manifested in supporting new businesses and generating new employment opportunities as well as contributing to a new image for the locality in question. Naturally, such an image will, in turn, help create a positive feedback loop furnishing further support to a park's business and employment generation potential. Nevertheless, several reports have focused on failings by science parks to deliver on their promise of employment generation especially when preliminary studies are based on unrealistic expectations. In this connection, it may be useful to recall that the success of California's Silicon Valley may be only partly attributable to the Stanford Research Park. Studies of the evolution of high technology firms in the developed countries indicate that growth was more often seen as seeded by existing high technology capabilities either in the same field or in other related ones.

Science parks in the United States, on the other hand, appear to have significant implications for local development. This conclusion is based on the observation that industrial research laboratories tend to agglomerate in urban areas with good universities due to the fact that they attribute the presence of such universities to the general desirability of their locale. These results receive indirect support from a study on high technology locations in Great Britain,[1] which concluded that both high technology manufacturing and services tended to avoid areas with extensive traditional economic activities.

6. SCIENCE PARKS AS AGENTS FOR TECHNOLOGY TRANSFER

One of the main roles of science parks is to facilitate technology transfer from university research institutions into the business domain. This role is naturally based on the notion that bringing researchers and business people into close proximity would ultimately enhance technology transfer and development opportunities. It is reasonable to assume that businesses may become aware of technological developments that lend themselves to commercial application at an earlier date when they are located in close proximity to high technology institutions. Exploitation and further development of the original ideas can thus mature before the competition.

In general, SMEs in the developed countries have sought academic cooperation for one or more of the following objectives:

- acquiring information and ideas concerning new products and services;
- obtaining reliable information on specialist technologies, including their potential, limitations, implications of their adoption and suitable implementation modalities;
- attaining an improved public relations profile;
- promoting recruitment activity;
- facilitating employee training in specialized techniques.

Many of these objectives imply some form or other of technology transfer indicating that relationships aimed at technology transfer involve other benefits, such as access to more expensive equipment or enhanced recruitment activity.

7. SCIENCE PARKS AS INNOVATION CENTERS

Another role of science parks concerns stimulating innovation through interaction and cross-fertilization of ideas between researchers and entrepreneurs. It is reasonable to expect that the agglomeration of university research facilities and enterprises, such as normally brought together in science parks should lead to more efficient use of innovation resources.

The current modern innovation model emphasizes the need for closer proximity of commercial, R and D, production and marketing units for successful innovation, i.e. closer linkages between components nearer to

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[1] Begg, Gordon and Cameron 1988, as quoted by Ferguson, 1995, http://www.ekon.slu.se/~richardf/scipklit/scipklit.html

the demand, rather than the supply sources of technological innovation. This would in turn favor even more strongly the science park concept.

In the same vein, it is essential to point out that while feedback from production and marketing is important in attaining incremental improvements in design, production, marketing, etc., radical innovations will nevertheless need to rely on stronger links to sources of entirely new knowledge.

With specific reference to the role of a science park as the locus of innovation networks, it is essential to appreciate the fact that an innovation network is generally regarded as an entity somewhat exceeding, in scope and functions the traditional scope of a science park. An innovation network may be defined as the set of mainly informal, but also formal, socioeconomic relationships among actors and entities spanning a given geographical domain, ultimately projecting an external 'group image' and creating a distinct internal identity, both acting in unison in promoting local innovative capability.[2]

This definition of an innovation network emphasizes the essential implications of the local environment or "milieu" for innovative behavior. Two main components of such an environment are:

- distinct possibilities for collective learning;
- reduced uncertainty and associated risks as a result of innovative behavior.

8. SCIENCE PARKS; INSTITUTIONAL ASPECTS

A better understanding of science parks necessitates a closer look at their components and the principal actors involved in their operations. These actors are commonly categorized within two classes: participants and promoters. Participants include tenant firms, research institutions and universities and the park management. Promoters include local and national political institutions, and figures as well as property developers. Naturally, the roles of these two actor types may intermingle. The following paragraphs will briefly address principal science park components and their functions.

a) Tenant firms

Tenant firms in a science park are instrumental in defining its nature and orientations. In particular, their diversity in terms of size, immediate business interests, technological status and future ambitions are all factors that contribute to, indeed mould, the park's character. Thus, while a given class of tenants may consist of small start-up firms with new product ideas and no business experience, others may be made up of service and consultancy firms aimed at transmitting acquired expertise, including technological knowledge, to firms both inside and outside the park. Another type of tenant firm may be the operational arm of a medium-large corporation wishing to maintain close contact with researchers and other firms within the park.

The three main tenant types are considered in the following paragraphs.

1) Start-up firms

Strong evidence exists as to the positive role played by science parks in improving the rate of survival of tenant firms in comparison to non-park ones[3]. In particular, it is found that parks offering business services provide valuable support for new firms with little or no business experience. Four types of start-up tenants may be hosted by a science park:

- firms with research ideas aimed at developing standardized commercializable products ("soft firms");
- firms in possession of standard products that may be marketed with a set of specific, but possibly diverse, customers in mind ("hard firms");

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[2] This definition of an innovation network is adapted from that put forward by Camagni 1991, as quoted by Ferguson, 1995, http://www.ekon.slu.se/~richardf/scipklit/scipklit.html

[3] Bower 1993, as quoted by Ferguson, 1995, http://www.ekon.slu.se/~richardf/scipklit/scipklit.html

- firms dedicated to developing a specific new product and initiating production ("garage firms");
- firms whose founders are ex-researchers from large firms, or R and D institutions, ("spin-out firms").

2) Outward looking firms

Outward looking tenant firms often use the park primarily for prestige purposes and constitute a predominant group of tenants in developed country science parks. Many such tenants are essentially small consultancy firms whose business does not preclude a fair amount of networking with other park firms. Nevertheless, they probably fulfill an important role in technology diffusion, by disseminating technological knowledge, originating from, or assimilated by, the park's research facilities and brought to maturity through the efforts of R and D operations involving other park tenant firms.

3) Inward looking firms

In developed country parks, inward looking firms are found to share a number of characteristics that tend to distinguish them from non-park firms. For example the majority of inward looking tenant firms concentrate on R and D inputs and R and D related services. Founders of inward looking tenant firms are also more likely to possess experience in an associated field rather than precisely the same field chosen for their firms' activity. Moreover, these firms are more likely to be funded by venture capital.

b) Research facilities

Research facilities located in science parks include independent research institutes as well as university and corporate research departments. Entire research institutions are located in some developed-country parks. Both branches of public sector research institutes as well as commercial research centers are found in science parks. It has also been the case that major commercial research centers have been keen to relocate, or branch out, into science parks close to government authorities that award research contracts, examples of such cases are to be found in the United States where commercial defense research facilities are located in parks in the proximity of contract-awarding government departments, or in parks where such departments are actually represented.

The presence of research institutions within parks opens opportunities for involvement in R and D contracts. Additionally, the fact that a park environment facilitates the formation of networks of sub-contractors enhances the chances of a research institute's ability to bid for contracts.

c) Universities

The wider impact that universities have on society as a whole is beyond question although it may be rather more difficult to quantify. In short, the traditional functions that universities play in society, including high-level education and training, dissemination and creation of new scientific and technological knowledge may all be put to fruitful use within the framework of a science park. However, linking universities to business has been one of the more arduous tasks that faced both academia and the business domain, even in the advanced countries.

In principle new knowledge created as a result of scientific and technological research is transferred through cooperative programs involving university researchers and business firms investing in the development and marketing of the product in question. Another mode of transfer that science parks may foster is that in which new knowledge leads the researcher, or group of researchers, to actually cross the border separating academia from the business world, in order to exploit their discovery through a spin-off company. While the latter modality is on the increase, the former, more traditional, modality for the transfer of scientific and technological knowledge may be far more predominant.

Local businesses benefit from local universities by:
- hiring qualified graduates to conduct operational activities;
- using faculty members and researchers as consultants;

- sponsoring joint university-industry research centers;
- training their manpower through seminars and workshops;
- utilizing university facilities such as laboratories, libraries and specialized equipment.

Of all the above modes of utilizing the "products" of university endeavors in the developed countries, the most useful appears to have been the hiring of local university graduates with educational qualifications and experience that embody the results of their recent R and D involvement[4]. In a modern university system such graduates will help incorporate new scientific and technological knowledge in the workplace. Furthermore, graduates would be expected to exploit their relationship with ex-professors or fellow researchers in a manner that maximizes benefits for business.

Science parks have often been built as addenda to universities, which derive four major benefits from becoming associated with parks. Firstly, through supporting a park a university invariably enhances its profile as it is seen to directly contribute to tangible socioeconomic development and job creation. Secondly, research done by the university for business enterprises often induces marked and welcome changes in undergraduate as well as graduate course curricula. Thirdly, park tenants offer university graduates opportunities for internships in an environment combining proximity to their alma mater as well as invaluable contacts in relation to commercially oriented research. Fourthly, through performing research activity for, as well as jointly with, park tenants, the university's research teams acquire training that is hardly available otherwise in addressing real life situations where their expertise may be brought to bear on practical problems.

There are certainly other benefits that may become available to university staff rather than to the university as an institutional entity. Thus, provided sufficiently liberal regulations are in place, university researchers, and at times graduates, have the opportunity of adding to their earnings as well as moving completely to the other side of the fence by starting their own spin-off enterprises on the basis of a new research finding or a patent.

Thus, science parks are one modality for fostering healthy interaction between universities and business enterprises, and the benefits of inducing such interaction should be enormous. For one thing, they bring both universities and business enterprises into close proximity and remove at least some of the psychological barriers that may hold them apart. Additionally, the benefits associated with casual links between university staff and enterprise owners and their technical staff may often be of immense value in creating local knowledge networks.

9. PARK MANAGEMENT

A park's management team could play an important role in its success, or failure, for that matter. In the simplest case it may be one person, the park's manager, who has the most influence over the park's operations. A park's manager should, of course, be guided by its charter as well as strategic and executive plans adopted by its governing body. In many ways a park's management team will need to act as a technology broker or intermediary in linking park tenants to sources of technology knowledge in associated research institutions. In essence, managers determine the park's character, through their contributions to formulating the park's goals, and through communicating these goals to their tenants and other institutions.

10. EVALUATING SCIENCE PARKS

The development of science parks may be visualized as taking place in two phases, an institutional phase and an entrepreneurial phase. The first commences as the park's facilities are set up including the research institutions or branches thereof. This phase is not generally expected to lead to greatly enhanced employment levels since it is often that the research outfit will move into a park with its own staff. The entrepreneurial phase commences a few years following the institutional phase. In this phase park enterprises

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[4] Bania, Eberts, and Fogarty 1993: 762, as quoted by Ferguson, 1995, http://www.ekon.slu.se/~richardf/scipklit/scipklit.html

are expected to succeed in entrepreneurial ventures creating new jobs and enhancing technology-based economic growth. The entrepreneurial phase is generally far less predictable than the institutional phase. Clearly evaluating the success of a science park can only be usefully made with reference to the particular phase in its evolution.

11. Concluding Remarks

In a sense one of the major shortcoming of the science park concept is the fact that they have been associated with highly inflated claims. Reports of legendary successes of some park projects many have taken them to constitute a panacea for promoting new business enterprises and innovation. Thus, they are envisioned simultaneously as effective instruments for local development and technology transfer, stimulators of innovation and seedbeds for new business enterprises. In practice it is almost impossible for a single science park to carry out all of these tasks to perfection.

This may be an argument for policies targeting the creation of several park entities and for allowing such entities to develop and evolve with a view to answering the range of tasks that the optimal park is envisioned to handle.

In essence, successful management of a science park will need to be based on tenant firms' needs and goals and on bridging these needs with the roles that the park is designed to play.

12. Case Study: Sophia Antipolis, a French Technopole

The Sophia Antipolis Technopole, which was launched over 30 years ago (1969), is one of the first science and technology parks in Europe. Today it constitutes a model for economic development that is referenced worldwide and has distinguished itself in several fields including information and communications technologies as well as biotechnology, health and earth sciences.

Located in the South of Europe on the French Riviera, between Nice and Cannes, the Sophia Antipolis Technopole was established on a vast wooded plateau and presently covers 2,300 hectares. Its success has led the authorities to plan an extension that will double this area in the near future by adding development land to the north of the present site. About 1,200 firms employing nearly 21,000 engineers and technicians, a university, engineering schools and research centers with 5,000 researchers and students are currently located in this park.

a) Aims and objectives

The Sophia Antipolis technopole had for primary aim the development of the region by creating a center of excellence in new technologies that attracts world leaders in these technologies and increases employment through start-up companies.

Constant creativity and innovation in an appropriately rich environment where novel ideas can be launched and tested, are basic objectives of the park, leading to partnerships between industry, research and education, and to integrating the needed research and education with the enterprises in order to develop these new technologies.

b) Science and technology domains and sectors of activities

Major domains of science and technology expertise available at the Sophia Antipolis Technopole are: Information and Communication Technologies, Medical and Chemical Sciences, and Natural Sciences. In all these domains, research and development, education, engineering and production are carried out on the park.

The various firms, institutes and other establishments present on the Sophia Antipolis Technopole can be classified into seven sectors according to their activities with the distribution of firms and jobs in these sectors. The ICT sector is the largest among the technology-oriented firms and provides the highest number of jobs (almost 9000 or 44% of the total number of jobs), while services/manufacturing sector has the largest number of firms (almost 590 firms or 50% of all firms). Actually, the information technologies sector is the most dynamic one with 1,104 new jobs out of the 1,994 created in 1998 (i.e. almost 55 % of the total number of jobs)[5].

c) Evolution of institutions

Over 70% of the firms located in the park are very small firms with less than 10 employees. This was not the case 10 years ago. The evolution towards a large number of very small tenant firms indicates a trend that ruled during the last decade whereby start-up firms have been on the increase in the park. It may also indicate that technopoles are more attractive for small and very small industries that need to share resources, facilities and services as well as interact with research institutions already located in the park.

Between 1997 and 1998 the growth has been nearly 11% for jobs, 5.5% for firms and 5% for occupied space. However, this increase was not uniform across the different sectors. Information Technologies had the highest rate of increase, while the number of firms in the Natural Sciences sector decreased. This increase in the number of firms has also been reflected by an overall increase in the number of jobs.

d) Telecommunications infrastructure

Firms and other institutions that get established in Sophia Antipolis can benefit from a telecommunications network based on the most advanced technologies. This network relies on an infrastructure of optical fiber and is based massively on the SDH optical technology. This makes it possible to offer services such as videoconferences, digital video transmission, advanced services for company communication or access to fast Internet. Since 1996, Sophia Antipolis has also benefited from the advantages of an asynchronous transfer mode (ATM) platform offering a rate of 155Mbps.

e) Socio-professional associations and clubs

The Sophia Antipolis Foundation, established in 1984 carries out a fundamental mission on the park, namely the scientific and cultural animation through various socio-professional associations, clubs and programmed activities focusing on innovation.

Telecom Valley is one of these associations grouping institutions on the park that work in the telecommunications field, whether in research and development, production, training or consulting. It aims at facilitating the exchange of knowledge within the Sophia Antipolis community, attracting new partners in ICT, promoting the competencies of its members, establishing an international presence by carrying out high quality technology related events and cooperation programs with similar associations, and providing advice to its members[6].

The Sophia Start-up Club comprises over 200 actors in the new economy such as professionals with project ideas, investors, and venture capitalists. These members hold regular meetings to discuss potential projects and concretize those leading to start-up firms.

Furthermore, a training activity has been put in place by the Foundation to help employees manage human resources, innovation and new technologies in SME; another activity is a series of seminars aiming at keeping employees in the various firms continuously qualified by revalorizing their knowledge.

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[5] See www.saem-sophia-antipolis.fr and www.sophia-antipolis.org

[6] See www.telecom-valley.fr

f) *Evaluation of Sophia Antipolis technopole*

The Sophia Antipolis Technopole was the first model of a "Science City" with a close-knit community providing all the necessary infrastructure and support for high technology industry with university-linked research and development facilities, training centers, offices, professional associations, residential accommodation and hotels, as well as sport and leisure facilities. This model has been followed by the Japanese to develop their industrial cities of the future as well as by Edinburgh University and local authority by launching the Edinburgh Technopole.

Early evaluations of the Sophia Antipolis Technopole were not positive. In 1986, Perrin regarded this technopole as a "*prestige park*" for established multinationals without being very successful in generating a mass of small enterprises and cross-fertilization across the various enterprises was not taking place[7]. Quéré considered that it lacks the "innovative milieu" and technological management that is needed, with the resulting domination of multinationals and state research centers[8].

A more recent judgment, taking into account the above evaluations, was given by Castells and Hall who admitted that "Sophia-Antipolis is a success at one level because it has worked: the park has been developed, it has brought in firms and jobs. But it has not so far worked at a deeper and more critical level, which is the creation of a true milieu of innovation: the necessary synergies are not yet richly developed. It may be a matter of time, more time perhaps than the two decades, so far, of life at Sophia-Antipolis... The verdict, as with other such developments, needs to be suspended."[9].

The number of small tenant enterprises has increased drastically during the last decade and the domination of the multinationals and research centers is not anymore valid. Many of the very small firms are start-ups that have to be innovative in order to survive.

Moreover, higher education and research activities have developed in order to satisfy the needs of firms in the park. Centers of expertise in ICT and life sciences have developed as a result of the joint work of researchers in academic institutions and engineers in the private industries as well as the performance of young firms.

Crossed partnerships and financing between the Grandes Écoles and firms on site or from the outside have also contributed significantly to the development of research and teaching programs that are more and more specialized and recognized internationally.

Thus it seems that after three decades, Sophia Antipolis has matured sufficiently to start fulfilling its important mission in the domain of innovation and the creation of small firms able to interact with established firms, universities and research centers, thus increasing the synergy and productivity of society based on the latest technologies. This is in addition to its other important missions in which it has succeeded previously such as creating jobs, bringing together academic and industrial partners and establishing the appropriate environment for interaction between universities, research centers and industry.

13. Case Study: UK Cambridge Science Park

The Cambridge Science Park has been one of the most successful innovation parks, and has come to parallel Silicon Valley. It represents a high technology center that is truly entrepreneurial, and a symbol of the innovative milieu. Furthermore, it has distinguished itself in computing hardware and software, scientific instrumentation and biotechnology.

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7 Perrin, J.-C, "Le phénomène Sophia-Antipolis dans on environnement regional," in Aydalot, P. (ed.) *Milieux Innovateurs en Europe, pp.* 283-302, Paris GREMI (1986).

Perrin, J.-C. "Les P.M.E. de HT à Valbonne Sophia Antipolis," *Revue d'Economie Régionale et Urbaine*, 9:629-43, (1986).

8 Quéré, M. *Sophia-Antipolis dans le Contexte Français*, Paris: GIP "Mutations Industrielles", (1990).

9 Castells, M. and Hall, P. (eds) Andalicía: Innovación Tecnológia y Desarrollo Económico, Madrid: Espasa-Calpe (1992).

Located on the northeastern edge of the City of Cambridge, it has been built by Trinity College in a region that was considered as a rural backwater and that became in the late 1970's and early 1980's the fastest growing region of the UK. By December 1999 there was 64 companies on the park employing some 4,000 people, and the park led to formation of a cluster of high technology companies in the Cambridge area reaching nearly 1,200 companies employing around 35,000 people.

g) *Aims and objectives*

The main aim of the Cambridge Science Park was to create an environment that can nurture and develop science and technology based industries in the Cambridge area by increasing interaction between Cambridge University and these industries. The objective was thus to increase the payback from investment in basic research and an expansion of higher education, in the form of new technologies.

It is worth noting that during the recessions of the 80s and 90s, Trinity College maintained its commitment to the original concept of the park as a specialized location for high technology industry and research although it would have been possible to fill space with businesses from other sectors to maintain rental income.

h) *Sectors of activities*

There are currently 66 companies located on the Cambridge Science Park that carry out research and development tasks as well as consulting and services in various technological domains. The strongest sector in the Cambridge Science Park is currently the healthcare/life sciences sector, which has become during the past decade the dominant technology sector[10]. The Information and Communication Technologies sector is the second most developed sector on the park and accounts for 32% of the companies located in the park.

i) *Evolution of institutions*

Today, the number of companies continues to expand, with a variety of high-quality technology businesses setting up on the periphery of the City. The research consultancies, Cambridge Consultants, PA Consulting, The Technology Partnership, Symbionics and Scientific Generics are some of the world leaders in their field. More recently, the American computing giant, Microsoft, established its first European research base in Cambridge. One-third of these companies have benefited from being located on the Cambridge Science Park and its annex St John's Innovation Center.

j) *Evaluation of the Cambridge Science Park*

The effect of this science park on the development of the Cambridge area has been explosive[9]. The number of high-technology firms was 30 in 1959, and in 1974, i.e. four years after the establishment of the park, this number became 100. By 1984 there were more than 322 high-technology companies in the area, employing 13,700 people (representing 17% of total employment), and by 1999 this number increased to over 1200 companies employing some 35,000 people[7].

Indirectly, the University of Cambridge has played a key role in the development of the area through the science park since it has been at the origin of virtually all new companies in some way or another. It is worth noting that some 17% of the companies were formed by people coming straight from university, while other companies were indirect spin-offs of the University research, and other start-ups existed because of the presence of the University nearby. Furthermore, most of these companies are very small with an average size of 11 employees per company.

The success of the Cambridge Science Park is widely recognized and is part of what has been known as the "Cambridge phenomenon", which is considered as a symbol of the innovative milieu. The fact that Trinity College has a tradition of encouraging excellence has certainly played an important role in attracting

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10 See www.cambridge-science-park.com

companies to the area. The demand for products in some fields in which Cambridge University was carrying development with tenant companies on the park has also played a positive role. Other factors for success include the low cost of start-up on the park, the establishment of renowned consulting and research companies, as well as the lending policies of Barclay's Bank in the late 1970s. By creating an environment that promotes industrial collaboration, the park has taken research beyond the laboratory, to the market place, and developed strong technological partnerships.

Some negative aspects have been reported[9] such as the takeover of small companies by multinationals (e.g. Acorn was taken over by Olivetti and Applied Research of Cambridge by McDonnell Douglas), and the fact that most new firms remained small without any help from large companies nor from government and without networking sufficiently with each other. But the Cambridge Science Park case showed that it is possible to start from virtually nothing and achieve a critical mass.

It has also shown that in order to be successful, a science park needs to build up a network of individuals and institutions that interact positively, that the process takes time to mature and that the government did not matter much. (This latter point has to be taken in the UK context and may not be replicable elsewhere.) Actually, networking of institutions has been an important factor in the development of the park. Research collaborations and technology transfer have been, and are still, carried out through various levels of networking between the University and the tenant companies located in the park or in the Cambridge area. Thus, individual researchers are able to advise industry and disseminate their expertise through these networks, as well as take part in the commercial decision-making.

II. TECHNOLOGY INCUBATORS

1. INTRODUCTION

Technology incubators are, essentially, a special case of business incubators focusing on new enterprises whose operations are based on new or advanced technologies. Technology incubators gained prominence as a development policy tool in several industrialized countries in the late seventies, and early eighties. Several OECD countries, the United Kingdom, France, Germany, and Italy, for example, adopted technology incubation as a means for promoting job-creating innovative enterprises and the commercialization of university research. Several industrializing countries followed suit with the number of technology incubators in some of these countries, growing enormously during the eighties and nineties. More recent efforts at setting up technology incubators around the world have been characterized by a distinct focus on the development and diffusion of specific technologies such as information technology and biotechnology.

Incubation initiatives are a relatively recent development policy instrument. This accounts for the fact that rigorous economic analyses of incubation ventures are still sparse. Nevertheless, assessments of incubator performance in many parts of the world indicate positive impacts, mainly in terms of increasing the chances of new firm survival rates. The broader and longer-term economic and innovative impact and implications for innovation activity, are nevertheless in need of focused consideration as issues regarding costs and benefits of public support for incubators in comparison to alternative measures for promoting commercialization of knowledge-intensive enterprise and technology dissemination have not been fully resolved as yet.

2. OBJECTIVES OF INCUBATION SCHEMES

In general, technology incubators provide possibilities for enhancing overall economic growth and development, facilitating restructuring, technology diffusion and commercialization as well as job creation.

Overall economic development: In seeking to revitalize economic development, incubators, particularly those located in universities, are able to play a dual role. They act as pilot facilities for the transformation of research results into commercial products and services, on the one hand, and provide an environment for training incipient entrepreneurs, on the other. Additionally, incubators often have an outreach role, fostering dissemination of technical skills in the local labor market.

Economic restructuring: Apart from the concrete roles that incubators may have in the economic sphere and in technology dissemination and capacity building, incubation initiatives have provided valuable opportunities for addressing local development. Restructuring is, indeed, at the root of many local incubation initiatives. In the United States technology incubation projects were undertaken at the local and state government levels with a view to establishing clusters of technology-based firms in order to reverse the declining fortunes of certain industrial regions. In Italy, the establishment of *Business Innovation Centres* (BICs) was the result of regional development policies in depressed northern and middle Italy, particularly targeting areas where the lack of infrastructure impedes the growth of small firms.

Addressing specific economic development problems: Examples of incubators created to address specific economic challenges are provided by regional development policies in Japan where incubators-related initiatives have been launched at least partly with a view to promoting knowledge-based industries around major metropolitan areas. The ADT network of technology and business incubation centres in Germany, have similarly helped introduce new modalities in creating business opportunities in eastern Germany in aid of the reunification process.

Creating employment opportunities: Job creation has been another important goal of incubation schemes in several developed countries. Thus, the *Centre D'Initiatives Locales* (CIL), in Saint Nazaire, France, for example, was set up to help create new jobs[11] and to diversify the local economy which had thus far been mostly dependent on large metalworking firms. Technology incubation in Israel was adapted as an instrument to help provide job opportunities for immigrant scientists and engineers from the former Soviet Union.

Incubators and technology commercialization: In the context of university-based incubators, the perception that most universities have technology for commercialization is challenged by some on the grounds that university research results are rarely of commercial value. On the other hand short-term demands of industry may compromise longer-term goals and objectives of university research.

Incubators as property and real estate development ventures: Incubators can be lucrative property-based ventures. The *Italian Business Innovation Centres* (BICs), quoted in a study by OECD, illustrates this aspect in securing sufficient interest by investors. On the demand side, firms may often be keen to join a given incubator facility on account of tangible and intangible benefits involved.

3. SERVICES PROVIDED BY INCUBATORS

Uncertainty generally clouds the start-up phase of an enterprise no matter what sort of business it is embarked upon. Challenges facing enterprises as they are launched and commence operations include:

- substantial entry costs;
- high fixed costs;
- lack of access to equity capital;
- lack of effective specialized technical support and infrastructures;
- inadequate market information;
- insufficient management skills.

Technology incubators provide both tangible and intangible support to their tenants. More common sources of problems faced by new technology-based start-ups, and spin-off enterprises originating in universities and large firms relate to cash flow and access to basic services. Thus, in addition to providing incubator tenants with science and technology expertise and physical facilities an incubator should also facilitate access to venture capital and a variety of other business-related services intended to enhance their chances of survival during early development stages.

[11] With local unemployment levels approaching 17 per cent at the time of its inception.

Locating incubators within larger complex facilities aimed at catalyzing innovative activity is intended to facilitate links to other sources of support services. The fact that few incubators are capable of providing a sufficiently wide range of such services necessitates networking to other effective resources of public and private support. The issue of networking in particular has been taken to a higher level in Italy where the National Research Council's *Consorzio Roma Ricerche* is helping link innovation centers, technology-oriented business innovation centers and science parks in Central Italy into one network with the specific objective of helping SMEs access technology services and managerial know-how.

4. CUSTOMIZATION OF INCUBATOR SERVICES

The need to tailor incubator support services to the needs of committed as well as prospective clients is a subject that has to be tackled at the earliest stages of an incubation initiative. However, it is often remarked that customizing an incubator's services may be overdone.

A particularly valuable service that may be in great demand in the developing countries of the ESCWA region, where venture capital is still relatively underdeveloped, is advice regarding financial aspects of entrepreneurial activity including help to entrepreneurs and new firms in raising start-up funding.

5. INSTITUTIONAL AND ORGANIZATIONAL ASPECTS

In the developed countries technology incubators have been incorporated within a number of institutional forms, such as innovation and technology centers as well as science, technology and research parks. Within such institutional forms, technology incubators are often affiliated with sources of new technological knowledge in the public or private sectors, including universities, R and D centers, firms with significant R and D capabilities, etc.

There is no single format for organization of a technology incubator. The need to instill flexibility and versatility and to accommodate to the local environment dictates otherwise. In particular, the fact that a multiplicity of stakeholders with essentially differing objectives may be involved in the same incubator calls for a large measure of dynamism in incubator organization and management.

6. EVALUATION OF INCUBATOR INITIATIVES

The success of incubators must, naturally, be gauged against the objectives of the stakeholders and main players involved in the establishment and running of the incubation scheme. An explicit statement of these objectives and clearly elucidated mechanisms for measuring success in achieving them is thus absolutely necessary. Incubators in the developed countries are generally considered successful if they:

- generate net income for the main stakeholders;
- generate appreciable tax revenues;
- develop new businesses that graduate and create jobs within specified time limits;
- diffuse technology within the region or country in question.

Clearly, different hierarchies of outcomes will pertain in the case of the developing countries. At least in the short run, it is considered that the latter two are particularly important in the case of many, if not most, ESCWA member countries.

The success of incubators, in general, is often viewed in reference to a traditional linear model: a young enterprise takes up tenancy for a few years, graduates and hopefully grows creating further employment opportunities. The main shortcoming of this model is the fact that it ignores the, often important, secondary benefits arising from the creation of a network of new technology-based businesses in new areas and sectors that did not exist in the past. This notion has important ramifications in terms of the design of incubation initiatives at the national level and justification for support by governments and development agencies.

In summary, the fact that evaluating incubator performance is difficult at best has led to the development of good or best practice approaches. Definitive criteria for cost-benefit analysis may still be applied in isolated cases. If used over a sufficiently long period they may well provide useful insights. Best practices are often all that is left by way of guidance for future entrepreneurs and are often handed down as "items of faith" to start-up businesses[12].

7. Issues in technology incubator management

The following is a brief account of considerations that need to be taken into account in devising management policies for technology incubators.

Networking and resource policies: Care should be taken in the first place to formulate clear criteria at the policy and strategy levels with regard to establishing linkages to, and networking with, institutions and funding sources outside the incubator. Building linkages and networking with an incubator's socioeconomic surroundings and financing sources should be vigorously sought. With regard to resource policies, one of the main lessons learnt so far concerns the need for incubators to diversify sources of financing and limit reliance on subsidies.

Incubator occupancy periods: Since technology incubators may be lucrative property-based ventures, there is a very strong need, at the incubator management level, to balance the shorter-term high occupancy rates against longer-term technology commercialization targets.

Incubator rent: Since most incubators charge rent that generally falls below market values it is essential to ensure strict compliance with entry requirements. This is such a crucial issue in incubator management that some incubators associated with universities and science parks in the United States and the United Kingdom, tend to charge rents that exceed current market values.

Enterprise graduation: Criteria of varying severity and complexity have been adopted for graduating businesses from technology incubators. Often, claims of 80 per cent graduation rates are made by some incubators for businesses following 3-5 years of incubation. In Israel, about 50 per cent of incubated enterprises are graduated, but graduates are essentially fully grown successful firms generating wealth and skilled jobs. In this respect, it is essential to adopt relatively flexible policies that are able to take into account the peculiarities of the various enterprise types and the surrounding market conditions.

Finally, there is obviously a strong need for improved analyses of technology incubator impacts on firm and job creation, technology diffusion, entrepreneurship. Such analyses will help identify good practices that are more closely in tune with particular institutional and even cultural settings.

8. Incubators and entrepreneurship

A major goal of incubators has been the development of an entrepreneurial culture and the promotion of SME productivity and competitiveness. This is based on the increasingly widespread appreciation of the role played by entrepreneurship in creating innovative inputs at the firm and national levels. Thus, while large firms are still responsible for creating significant spin-offs, anecdotal evidence, principally from the United States, indicates that increased entrepreneurial activity is indebted to the growth of new technology-based firms.

9. Approaches to setting up incubators: institutional aspects and policy setting

The development of science parks in the United Kingdom benefited from the structure of the property market and the presence of relatively flexible regulations that allowed academic staff to take part in private enterprise activities. In contrast, the development of technology incubators in the United States was

12 Analysis of technology incubator initiatives is carried out by the Working Group on Innovation and Technology Policy (TIP) of the OECD Committee for Scientific and Technological Policy (CSTP), for instance.

championed principally by universities in association with local development institutions. In France, on the other hand, incubators were mainly sponsored by local and municipal government departments.

10. Regulatory aspects:

Issues pertaining to regulations and property laws should be awarded due attention in planning the establishment of incubators. In particular, institutional affiliations of the various players involved in setting up an incubation scheme must be reviewed early and sufficiently closely to discern possible conflict areas. For example, in situations where universities are involved in incubator facilities, differences in the public university system and the regional tax-base will need to be addressed. Thus, while most municipalities in France receive tax revenues directly from local firms, land and property allotted to public universities belong to the central government, opening the door for possible conflict.

11. Support for incubator initiatives

In many countries support by central and local government authorities for incubator initiatives is predicated on conceived market discrepancies and gaps in institutional infrastructures, which are, therefore, filled by small technology-based businesses.

The extent and duration of support offered by incubation schemes varies from one country/location to another. In Israel, for example, support focuses on the initial start-up phase for SMEs championed by qualified scientists and engineers. As mentioned below, priority for provision of support in Israeli initiatives that originated in the nineties was given to immigrant entrepreneurs from the former Soviet Union.

In many other countries such as Australia and Italy, incubators provide services to existing small businesses, which lack access to business and technological services in addition to start-up firms. Even large companies and national laboratories are also allowed access to incubators to launch new ideas.

12. Virtual or non-property-based incubators

Examples of "virtual incubators" or non-property-based ventures abound in a number of countries including Australia, Italy, and the United States. They generally serve two essential objectives:

- as a cost-effective way of providing incubation services to small entrepreneurs in areas or application sectors lacking critical mass;
- as a means of testing demand, possibly with a view to customizing future physical facilities more precisely to the needs of prospective clients.

13. Case study: The Israeli Incubators Program

Israel appears to have recognized over a decade ago the importance of technological incubators in the new economy. The state, more specifically the Office of the Chief Scientist in the Ministry of Industry and Trade, took over the organization of a Technological Incubators Program in the early 1990's when immigration from the former Soviet Union was at its peak. By helping start-up companies make their first steps into the marketplace the incubators seem to have contributed to Israel's economic growth during the 1990's.

When the program started its budget at the Office of the Chief Scientist (OCS) was US$1.8 million and there were about 50 projects. In 1999 the budget had risen to US$30 million and there were approximately 200 projects being carried out. Currently, there are 26 technological incubators in Israel and they are distributed around the country, all except one being under OCS supervision[13].

[13] See http://www.incubators.org.il/ for further details on these incubators

k) Objectives of the incubators program

The ultimate aim of the technological incubators program was to boost the nearly US$20 billion worth of goods (of which 70% has technological components) that Israel exports annually.

Therefore the main objective of the program to provide a sheltered environment in which scientific and technical professionals/entrepreneurs with potentially marketable new inventions can nurture their innovative ideas. In this environment they would receive financial support and expert business advice, while making use of subsidized office resources. Moreover, during their stay will, the entrepreneurs should get acquainted with potential high technology investors.

l) Organization of the program[14]

The Office of the Chief Scientist at the Ministry of Industry and Trade administer the program. A steering Committee on Technological Incubators is chaired by the Chief Scientist and includes a public representative from the high technology industry, another representative of the incubator graduates, the coordinator for industry at the Budget Division in the Ministry of Finance, as well as the Director of Technological Incubators at the OCS.

This *Steering Committee* has an important role in supervising, guiding and controlling the incubators. It holds the incubator management responsible for the operation of each project in that incubator, which should be sound, professional and efficient. At the same time support funds for the management of an incubator and for its projects are transferred to the incubator after it signs the agreement with the government.

The *incubators*, although they belong to the OCS network, are each an individually owned non-profit organization. Public agencies participate alongside the government in the expenses of running the incubators, but private donors, local authorities, universities and high technology business enterprises are also involved.

Being an autonomous non-profit corporation, each incubator is managed by a *professional director*, together with a *policymaking board* and a *project committee* that selects and monitors projects. Professionals of the highest caliber from industry, business and scientific institutions compose these two bodies.

Each incubator is structured to permit 10-15 research and development projects to run simultaneously with all needed support to the projects in all respects.

m) Project organization

To apply, a project must have a substantial R and D component and should be based on innovative technological ideas with the aim of developing a product with export marketing potential. An entrepreneur and a team of 3-6 development people should be involved in the project. The budget for any project should not exceed US$172,000 per year with a grant amounting to 85% of approved budget.

Each project is first looked over by an expert in the relevant scientific field to investigate its feasibility. Then business experts examine every aspect of the project's commercial implications, including potential markets, pricing, investment overheads and competitors. Applicants must ultimately be approved by both the steering committee of each individual incubator and a national coordinating committee of the OCS. Those thought to have serious potential are accepted for two years.

When accepted, a project is registered as a limited-liability company, with an agreement signed between the project developers and incubator management. This agreement stipulates the developers' rights and ensures management's ability to attain its goal and meet its commitments to the State. In particular, initial ownership of the project shall be determined by the rules of the Steering Committee; the State shall be reimbursed up to

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[14] Based on http://www2.matimop.org.il/hamama/rina-96.asp

the sum of its grant through royalties on sales (usually 3% of eventual sales or consulting fees); and the new product shall be manufactured in Israel.

During the start-up company stay in the incubator, the entrepreneur should carry his/her idea to the stage of explicit product definition and proven technological and marketing feasibility, as well as learn how to operate as a commercial venture. After leaving the incubator, the start-up company should be able to continue on its own and obtain regular State support in addition to outside investment.

n) Fields of activity of incubators and projects

Although most incubators start by accepting projects in all technological fields, some choose a specialization at the beginning (e.g. Software incubator). Others gradually specialize in some specific fields after success of several start-ups specializing in these fields have graduated from that incubator or because they can benefit of nearby facilities in research institutes in these fields.

Each project though has a specific field of R and D activity and electronics remains the most important field of activity followed by medical equipment and then by software. The projects in these three fields of R and D constitute nearly two thirds of the total number of projects.

o) Achievements of the program

The number of projects that are currently in the incubators is nearly 200 involving about 900 professionals, have of them being recent immigrants most of whom hold a master's or Ph.D. degree.

By January 2000, 592 projects had graduated, 52% of which (308 projects) have been able to go into production and obtain the necessary finances to make it on their own. On the other hand 48% have been discontinued for lack of finances or difficulties in marketing or in financing the project. The successful ones currently employ over 1900 professionals and they are (generally) expanding their businesses, thus increasing the number of employed professionals.

Each of these successful start-up companies has managed to attract investments ranging from US$50,000 to US$27 million. The total investment made so far in these start-ups is in excess of US$320 million, with an average of US$1.3 million per project.

With the help of this program, Israel has today, in absolute terms, the second highest number of start-up companies in the world after the US. There are nearly 1600 identified start-up companies and an estimated equal number in various stages of formation. Actually, the network of technological incubators established by OCS contains the largest concentration of start-up enterprises in the country. Some 40 start-ups leave the incubators annually manufacturing a diverse range of innovative products for the high technology market.

New immigrants constitute nearly half the professional manpower in the incubators projects and helped diversify the country's traditional strength in such sectors as software, electronics, telecommunications, medical equipment and biotechnology. They are also particularly strong in fields such as, innovative materials and new industrial processes for which incubator projects are being initiated.

p) The role of universities in incubators and start-up companies

In addition to their indirect contribution to the incubator program, by producing thousands of graduates each year in the various fields of science and technology with the basic knowledge to work in the incubators, Israeli universities get involved in commercializing the innovative ideas, products and systems generated by their research. This is carried out through various means such as licensing agreements and technology transfer agreements with existing companies, becoming partner in start-up companies or launching their own start-ups.

Some technological incubators are also strategically located near the country's universities, where researchers work closely with entrepreneurs and the university graduates are often inventors whose patents are being developed. Actually, most of the universities in Israel have developed, or are partners in, technological incubators.

q) Venture capital and the incubator program

There are about 50 venture capital funds active in Israel and dedicated to high technology, as well as about 20 diversified funds investing in start-up companies. Nearly US$2 billion were raised since the early 1990's, out of which US$200 million were from the government plus a first wave of private investment amounting to US$400 million and a second wave of US$1.4 billion.

By setting up the Yozma Venture Capital Fund in 1992, the government seed money helped the venture capital sector get off the ground. This fund was a tool for organizing and expanding the first stages of a venture capital market and it succeeded in coalescing local and foreign multinational investors together in risk taking.

There are currently 57 technical venture capital funds in operation according to Israel Venture Association 1999 yearbook. Furthermore, there are 31 private equity funds and 13 investment companies[15].

The average annual returns for the start-up companies are 30-50%, with some having several hundred percent annual profits. It is estimated that high technology start-ups will be exporting at least US$5 billion annually, while all Israeli exports amount currently at US$20 billion.

r) Assessment

In Israel's technological incubators program the government is a full partner in the incubator process. Within the framework of the technological incubators the entrepreneurs are provided with subsidized premises, financial resources, project tools, professional guidance and administrative assistance. During its tenure in the enclosed environment of the incubator, a start-up company is meant to turn its abstract ideas into products of proven feasibility, innovative advantage and competitiveness in the international marketplace.

The training, support and assistance during the initial stage have helped reduce drastically the failure rate of early stage companies. This is also due to the rigorous initial selection process and close monitoring by OCS of all incubators through various mechanisms, including the Steering Committee.

By sharing the risks involved in the pursuit of R&D, the government has enabled start-ups to flourish. The effectiveness of the policy is evident, as many of these companies have found major investors from both Israel and abroad. It is too early to predict what percentage of incubator-bred start-ups will ultimately enjoy commercial success, but indications are that it will be considerably higher than the 10% success rate registered in high technology start-ups in the United States.

In any case, the technological incubators seem to have become massive repositories of potential ideas for new high technology ventures of the future. Moreover, the sheltered business environment offered by the OCS's technological incubator program has been especially beneficial for new immigrants[16].

During the 1990's Israel has known a multi-year economic growth of more than 7% per year and high technology start-up companies have played a major role in improving the economic situation in Israel. It seems that the ongoing nurturing of start-up technological companies should produce a more significant economic growth in the near future. The success of these start-ups is also expected to hasten Israel's integration into the global economy and help increase investment and decrease inflation.

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[15] See http://www.ishitech.co.il/jan00ar1.htm

[16] "Israel Hits Rich Seam in Ex-Soviet Immigrants", Science Magazine, May 1999, Vol 284, www.sciencemag.org

III. HIGH TECHNOLOGY INDUSTRY CLUSTERS

Several developed and industrializing countries have adopted strategies first identified by a number of innovation economists during the latter decade of the twentieth century in seeking to establish "clustering" of high technology enterprises engaged in similar or related industries[17]. There are several instances where these "industry clusters" have been located within the vicinity of universities, research facilities and vocational training centers, resulting in the creation of "High Technology Industry Clusters" (HTICs)[18].

14. WHAT IS A HIGH TECHNOLOGY INDUSTRY CLUSTERS?

In essence an HTIC is a geographic concentration of competing, collaborating and related enterprises as well as technology and academic institutions that are building upon a set of relationships and common interests to improve individual efficiency and competitiveness in specific areas of production and services, thus driving the economies of the region and the country. The type of relationships that link partners in a cluster fall into three main categories:

a) Buyer/Supplier Relationships: relying on a core of enterprises that produce goods and services for sale to final consumers and of enterprises operating within earlier stages in the value-adding chain that supply intermediate goods, services and raw materials for assembly or conversion into final goods and services. Activities targeting distributors of final goods and services may also be a part of such clusters.

b) Competitor/Collaborator Relationships: in which enterprises that produce the same or similar goods and services at a specific level in the value chain co-exists with the hope of sharing information about product and process innovations and market opportunities. This may be especially important for small enterprises hoping to develop the ability to supply larger markets than those they normally serve. In the industrialized countries competitor/collaborator relationships are also utilized in jointly accessing and utilizing innovations within the context of pre-competitive or strategic alliances.

c) Shared-Resource Relationships: firms rely on the same sources of raw materials, technology, human resource development programs and attendant facilities and information. Naturally, many of these resources could be used by the various partners to produce a diversity of goods and services for completely different markets.

HTICs are usually supported by investors, institutions such as government agencies and universities, as well as the community and other stakeholders that affect the cluster's competitiveness.

15. APPLICATIONS OF HTIC

Potential applications of HTICs and their benefits, can be categorized in terms of their time horizons:

- HTICs are valuable tools for short-term enterprise agglomeration that will pay off within one to two years.
- ITCs are useful as strategic initiatives aimed at retaining firms and extending existing industry clusters that will pay off over a two-to-five-year horizon.
- ITCs can form basis for long-term efforts to support socioeconomic development and to establish new directions for such efforts and implement organizational changes that may be expected to pay off over extended periods.

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[17] See http://www.sbaer.ucla.edu/docs/proceedings/95sbah01.txt

[18] The "HTICs" is used in this paper to denote institutional forms that have been recently adopted, particularly in the US under the name "industry clusting". Adding "high technology" to the original term is intended to reflect the fact that in all instances of reviewed industry clusters a predominant new technology component was present. Additionally, almost all available case studies refer to participation by universities and research institutes as well as existing technology/research parks and innovation centers in the clustering exercise.

16. EVALUATION OF HTICs

Successes achieved by clusters targeting specific industrial activities, e.g. in the food industry, medical biotechnology or microelectronics, have been due to two main reasons:

1. Clusters have resulted in phenomenal growth in the targeted industrial segment as well as in a chain of related businesses, including suppliers, specialized and general service industries as well as basic support industries, e.g. construction, real estate development and retail businesses.
2. Additionally, much of this growth has often been achieved with limited public support. Thus, given the right setting, both physical and legislative/regulatory related industries and businesses would seek the region designated for a cluster in order to enhance its competitive status. In many instances, support needed from government does not need to exceed a business-friendly regulatory climate and tax deferment or other similar incentives, e.g. exemption of import duty on selected items of equipment or material input.

Industry and technology clusters HTIC s are now being adopted as a means of improving regional industrial and technology development on the basis of socioeconomic relationships involving specific manufacturing and service industry segments. The concept provides help in the formulation and fine-tuning of socioeconomic development strategies. Experiences in HTICs point to their effectiveness in improving industry agglomeration at minimal costs. In addition, HTICs are useful tools for defining medium- and long-term industrial and technology development strategies.

When successfully implemented, HTICs capture the essence of socioeconomic relationships among specific industry sectors and the community. They provide rich ground for dynamic interaction among a range of essential partners in development than is available through traditional forms.

17. CASE STUDIES FROM THE US

HTICs most thoroughly studied are those located in the United States. Two emerging HTICs in Minnesota are presented below, followed by a brief summary accounts of a number of technology parks, innovation centers and programs that have taken part in high technology industry cluster schemes and some of whose accomplishments are documented on the Internet[19].

s) Minnesota's Information Technology Cluster

The Minnesota Information Technology Cluster (MITC) is a large employer of the state and includes several large categories of firms in the telecommunications, hardware and software fields. Defining or "mapping" the MITC was carried out through meetings of representatives from the Minnesota High Tech Association, industry representatives, the Minnesota Department of Economic Security, St. Paul Planning and Economic Development, the Office of Technology Policy and other collaborating organizations[20]. These meetings took place in 1998 and 1999, and a draft map of the cluster was developed by the State and Local Policy Program (SLPP) and presented to industry leaders and analysts

Although the map was considered as too large and complicated to be implemented, but the main categories within MITC were agreed upon. They are: hardware, software, services, networking and telecommunications. Each of them was also subdivided into sub-categories.

In order to seize the opportunity that the IT industry presents and put Minnesota on the IT map, the cluster group identified major issues that must be addressed namely:

1. Increase and enhance the quality of workers in the IT industry;
2. Establish a strong telecommunications/information infrastructure;

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19 Terry Bibbens, "High Technology Development: Industry clusters" in http://www.sbaer.uc1a.edu/docs/proceedings/95sbah01.txt

20 Lee W. Munnich Jr., "Industry Clusters – An Economic Development Strategy for Minnesota Preliminary Report" (1999), http://www.hhh.umn.edu/centers/slp/edweb/ic-rep.htm

3. Build greater awareness of the importance of the IT cluster to the state, its opportunities and challenges;
4. Revise some regulations, tax policies and create incentives for joining the cluster.

An action plan to address these key issues has been developed while additional industry, government and educational leaders are sought in order to advance with the planning and implementation of MITC.

t) Southwest Minnesota's Precision Agricultural Chemical Application Industry Cluster

Southwestern Minnesota is extremely competitive in certain sectors of the agriculture and construction manufacturing market including the precision agricultural chemical application industry. Thus starting in 1997, the State and Local Policy Program initiated the Southwest Minnesota's Precision Agricultural Chemical Application Industry Cluster by focusing on understanding and organizing pilot clusters in greater Minnesota. A cluster map of the industry was developed, relationships among firms in the cluster were defined, and key issues affecting the growth of the industry (generally and in the region) were also identified[20].

Collaboration among cluster members as well as with government and educational organizations were found necessary on issues such as workforce, training, software design and standards. Education and training were considered as top priority. Also, to address fluctuations in demand for the industry, firms need to diversify their product lines, thus ensuring better health. The cluster would next tackle the problem of workforce shortage, while learning how to work collaboratively as a cluster with each other, education and government.

u) The North Carolina Biotechnology Center

The Research Triangle Park (RTP) in North Carolina was launched with funding support from the state. Essentially a biotechnology center aimed at encouraging small biotechnology-based or related businesses of all types, RTP is good model of public/private partnership.

The process that led to the success of RTP presents a number of interesting lessons, pertaining to legislative aspects as well as means of obtaining the continued support of a variety of officials. Analysis of approaches to other economic development organizations is also quite instructive. In effect, dealing with industries in the RTP and their trade associations was a key ingredient of the success of the program.

Three universities (Duke University, North Carolina State at Raleigh, and the University of North Carolina at Chapel Hill) were inducted to create a critical mass of academic and research capabilities. Integrating these academic institutions into active economic development activity provided them with challenges as well as enormous benefits.

v) UCSD-CONNECT

The idea of integrating the business community with the University of California, San Diego (UCSD), a leading research institution since its founding in 1960, was conceived in the mid eighties, in response to federal research grant shortages. In a sense this initiative was indebted to the fact that UCSD was not selected in the federal SEMATECH (Semiconductor Manufacturing Technology Consortium) and MCC (Microelectronics and Computer Technology Corporation) research programs. The reason given for the exclusion of USCD at the time was that it was not well connected to high-technology industries.

This caused the university authorities to adopt an active "corrective strategy" that included placing an economic development organization in the Extended Studies Department (ESD) of the university whose principal aim was to provide connectivity to the technology industries. The resulting UCSD-CONNECT program has since attributed much of its success to being insulated from the more traditional academic departments within the confines of ESD. An additional reason that is also quoted in explaining the success of UCSD-CONNNECT is the strong entrepreneurial leadership provided by the key persons involved in the operation.

One of the main tasks undertaken by UCSD-CONNECT has been to provide close integration of the industry research efforts and those of the UCSD academic organizations. The initiative succeeded in developing effective networking arrangements preceding the "incubator without walls" concept.

Rather than single-handedly seeking to develop programs covering the wide range of needs UCSD-CONNECT adopted a strategy whose principal tenet was to join forces with trade associations and other concerned non-governmental organizations and has preserved a leadership role for itself only when such only absolutely essential.

Funding of the UCSD-CONNECT cluster is arranged entirely from the private sector sources. In this respect UCSD-CONNECT constitutes a model for countries and regions in building high technology industrial clusters while they have no access to public financing from state or regional sources.

w) The Ben Franklin Partnership Program

Designed and launched in 1982, this program, was intended as a means for facilitating or bringing industry and universities together in order to improve the economic climate for Pennsylvania's technology-based industries.

The program's main focus was to target the science and technology sector in improving the performance of the State's economy. Investment by the Commonwealth of Pennsylvania was instrumental in getting the program off the ground.

The Ben Franklin Partnership Program is broadly based in that it encompasses four Advanced Technology Centers (ATCs), each constituting a consortium of private firms, economic development groups and universities.

In essence, this is a State driven program. However, it is also overseen by the Pennsylvania Department of Commerce's Office of Technology Development.

x) Missouri Innovation Centers

The State of Missouri is home to a wide spectrum of production activities, including high-technology aerospace industries, such as McDonnell-Douglas, and agricultural production. Partnerships encompassing entrepreneurial foundations were initiated with modest State funding in order to develop biotechnology manufacturing and tele-computing research centers. The resulting Missouri Innovation Centers have focused on the market potential of small, new technology enterprises.

The primary mission of the Missouri Innovation Center in the City of Columbia is to stimulate the creation of enterprises with significant growth potential to market innovative products and/or services in the national and international markets. In particular, the innovation center in Columbia aims at serving startup companies with sales below $1 million, which generally lack technology and export management expertise and are usually short of cash. The Columbia Innovation Center's projects include:

- entrepreneurship training: including a 9- to 12-week training program for new entrepreneurs;
- financial management training for entrepreneurs;
- an entrepreneurial scholars program designed to infuse new ideas and technologies to existing companies through research conducted by young graduates working in close contact with experienced senior executives from industry;
- a publication providing information on flexible financing possibilities including equity placements and means for making stock offerings to the public.

C. CRITERIA FOR ENHANCING SUCCESS

Although it has been recognized that science parks and technology incubators could facilitate technology transfer, enhance high technology dissemination and possibly contribute to economic development, there is no unique recipe that guarantees their success on these fronts in all countries. ESCWA member countries have a good deal in common, but their economic systems possess marked variations, especially with regard to the involvement of the State in planning or running the economy. Moreover any national initiative should be adapted to the economic system in the country and should focus on the development needs of that country as, often, expressed in its strategy and development plans.

There are, however, important lessons to be learned from experiences in the developed and newly industrialized countries, leading to the formulation of criteria that would increase the chances of success of national initiatives such as science parks and technology incubators in the region. In the following paragraphs such criteria are discussed according to their relevance to the ESCWA member countries. They can help in designing and implementing science parks and incubators in these countries, by maximizing success and reducing failure while taking into account economic, social and political circumstances in these countries.

I. POLITICAL, LEGISLATIVE AND REGULATORY ENVIRONMENTS

In order for national initiatives in science and technology to flourish, legislation to facilitate the establishment of such ventures and regulate their activities is of the essence. Legislative changes will differ from one country to another, especially between liberal and centrally controlled economies. In particular:

- Political backing for S and T initiatives at the national and local levels in view of employment opportunities that such initiatives may provide in the medium- and long-term, would make the environment more fertile by removing or smoothing obstacles that may face such endeavors (without such backing the Sophia Antipolis Technopole, for example, would never have existed);
- A national S and T strategy, specifying areas of priorities for the national economy, is essential for guiding the public and private sectors in launching appropriate initiatives leading to synergy and faster growth;
- Intellectual property rights laws are a necessary component of the national innovation environment. Their ratification and observation play an important part in the innovation process, including the activities of technology innovation centers, incubators and science parks;
- A special status should be defined for science parks, incubators and innovation centers through appropriate laws granting them preferential treatment and encouraging their creation;
- In centrally planned economies, the public sector should permit a more prominent role for private enterprises since "mixed" initiatives would be beneficial for the national economy.
- National programs supervised by government agencies aiming at organizing and promoting initiatives such as incubators and involving the necessary technological competencies, help produce positive results in record time (e.g. Israeli Incubators Program);
- For small countries of the ESCWA region, multinational initiatives make a lot of sense and should receive the political and legislative backing they deserve in any mutually suitable form (e.g. their location close to free zones could significantly boost their chances of success).

II. FINANCIAL ASPECTS

Adequate financial support is a key factor in the success of a technology incubator and science parks. Such support usually comes from a variety of sources, including government, private business, non-governmental organizations, multinational and international firms, as well as international agencies and donor groups. Appropriate feasibility studies can make such sources of financing easier more readily available.

Governments on the other hand can provide indirect support through investment laws and tax incentives. Incidentally, most taxation systems in the ESCWA member countries would need reviewing and regular updating to accommodate the requirements of the global economy. They should also take into consideration the needs of S and T initiatives that will enhance the performance of system national innovation and thus competitiveness in the global market.

On the other hand, the private sector as well as banks and financial institutions should be encouraged to provide venture capital for technology-based initiatives including since parks, technology incubators and industry clusters. Depending on the economic system in force, this encouragement can be implemented through tax cuts or legislation.

Start-up companies need post-graduation capital investment that may not be available from banks or private investors because of the high risks involved. In the interest of the national economy, projects with clear objectives leading to the development of the national economy should be supported by government grants and loans. Depending on the national S and T strategy, various programs can be made available for these start-up companies to apply to and receive the necessary capital in accordance with well-defined rules, including monitoring and regular assessment of the company by competent parties.

III. PARK AND INCUBATOR CREATION AND ESTABLISHMENT

Carrying out a factual and balanced feasibility study for any initiative is a key factor for success. Exaggerated expectations and inflated claims of initial success can only lead to failure.

A fact that appears to carry great importance in launching park and incubator initiatives is their location. Prerequisites for an optimal solution include:

- desirable working and living environments;
- proximity to a major university or research institution;
- steady supply of skilled manpower.

The first factor is essential for attracting tenant firms and their employees. Proximity to a university or research center provides a science park with access to research facilities, simplifies technology transfer operations, and allows incubation of spin-off enterprises that may very well be launched by staff from universities and research centers associated with the park to carry out tasks including: consulting, directing, and continuing education. Additionally, the proximity of a science park to a university should guarantee a continuous stream of skilled manpower as well as possibilities for continuous training and rehabilitation.

Moreover, locating businesses (in science parks) and universities, or research centers, will often facilitate technology transfer operations. The transfer of technology from universities to small and medium-sized enterprises (SMEs), often suffers hindrances that include:

- lack of exposure of academic staff and researchers to business requirements;
- essential unwillingness to cooperate with business enterprise, often due to:
  - different value systems that govern academic research and business communities;
  - pressures of academic life;
  - inclination towards perfectionism;
  - lack of practicality and hostility to compromise;
  - diminished regard for deadlines, profitability and confidentiality.

Thus, while it is certainly important to attain improved communication between R and D activity, on the one hand, and production and marketing units, on the other, it is probably of equal importance to narrow, as much as possible, the distance, imposed by differing value systems, underlined no doubt by psychological factors, as well as policy issues, between academic researchers and enterprises. This would, naturally, require greater emphasis in the implementation of the science park concept on means that ensure effective communications throughout the entire innovation process.

IV. PARK AND INCUBATOR MANAGEMENT

Management in science parks and incubators has a key role in their success. Managers of science parks should have solid research and development background as well as business and industrial experience, while those of incubators should be experienced entrepreneurs. Board of directors of both science parks and incubators should include representatives of the leading institution, investors and tenants, who should be responsible for make sure that the objectives and modalities are clear enough and compatible in order to avoid potential conflicts.

Screening of tenants in a park should be carried out very carefully and strictly but without overdue rigidity. Monitoring and regular assessment should be performed on a regular basis in order to solve problems as early as possible.

Management in Science parks should actively seek linkages at the national and international levels. Strategic alliances with reputed international companies are also needed to develop a global market for the products and enhance competitiveness.

In technology incubators, there is a need to adopt clear objectives and monitoring modalities as well as strict selection rules for projects. Moreover, experience suggests the need for stakeholders to possess clear objectives from the outset in order to avoid friction between different actors and to assessment of progress. The establishment of advisory boards of incubators involving a mix of public and private stakeholders provides a mechanism for continuous monitoring and guidance.

Strategic alliances and partnerships with internationally renowned companies are important for increasing the visibility of the park and create the necessary international backing.

V. MATURITY OF SCIENCE AND TECHNOLOGY INSTITUTIONS

Although both science parks and technology incubators require a minimum level of maturity on the part of national S and T institutions, there is no doubt that incubators are easier to establish and run, even in developing countries, given their relatively modest requirements in qualified manpower and investment. Science parks, on the other hand constitute major undertakings that require State involvement as well as that of the private businesses and high-level S and T institutions. Since collaborating S and T institutions will play a critical role, whether by supplying qualified researchers or providing backing for laboratories and educational facilities that are needed by the parks, it is essential to ensure that only top-notch S and T institutions are inducted into park and incubation schemes.

VI. NETWORKING

Networking of various S and T initiatives such as science parks, technology incubators, innovation centers and industry clusters is essential for their success, especially in ESCWA member countries, where resources are often limited. Duplication of activities and resources can be simply avoided through networking of similar and complementary entities.

Moreover, linkages between incubators, start-up companies and investors are necessary for the good functioning of the incubator and survival of the emerging companies. These companies have to keep close contacts with potential investors and capital venture institutions in order to get the necessary finances for their projects upon graduation and even in the following years before reaching the "critical mass" that will allow them to cover their financial needs.