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CAPACITY BUILDING IN TECHNOLOGY DEVELOPMENT: NEW INSTITUTIONAL FORMS

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I. INTRODUCTION

Throughout history, innovations based on new scientific and technological knowledge have led to productivity enhancement, improvements in living standards and long-term economic growth. In the course of the past few decades, in particular, innovations based on new technologies such as information and communications technologies, biotechnology and new materials have accelerated to an unprecedented degree, infiltrating many aspects of the global economy and holding out the promise of rapid socioeconomic progress in the developing countries.

Experience in a variety of political, economic and social settings indicates that a number of prerequisites are essential for devising cost-effective approaches to sustainable socioeconomic development capable of reaping the full benefits of technological innovation. Primarily, the capacity to access, adapt, disseminate and generate new technologies has to be based on sound science and technology (S and T) policies. Such policies, in turn, will bear fruit only when a dynamic system of national innovation is in place, allowing the integration of new technologies within the fabric of national economic activity. Policies governing national systems of innovation should guarantee:

(a) Rapid dissemination of new technologies;

(b) Incentives for private firms to innovate;

(c) Lifelong learning and upgrading skills;

(d) Continuous and relatively safe investment in innovative inputs to boost the productivity and competitiveness of existing firms and to encourage the start-up of new firms based on new technologies;

(e) Adequate institutional structures and networks.

The literature of science and technology policy, which has constituted a particularly thriving area of both theoretical research and heuristic study in recent years, points to a number of lessons for countries in the process of technological capacity-building. One of the most important of these lessons is that science, technology and innovation policies must be linked to socioeconomic development objectives. In all the ESCWA member countries, these objectives include:

(a) Restructuring and diversification of their economies and optimal use of their natural resources;
(b) The injection of new technologies into traditional sectors;
(c) Adequate responses to the rising expectations of the region's growing and youthful populations;
(d) Adequate solutions for a number of environmental problems in urban and rural settings.

Experience has also shown that attempts to attain objectives such as these through isolated policy, legislative and regulatory measures or exercises in institution-building and human resource development are doomed to failure. Demand-driven approaches in which policy, legislative and regulatory action is supplemented by appropriate institutional and human resource development schemes are much more effective. The role of national initiatives of this kind, developed in direct response to demand, is of incalculable importance for the attainment of the above objectives.

The fact that a number of ESCWA member countries have launched initiatives aimed at formulating national science and technology policies is an essential and auspicious initial step in the capacity -building process. Policy initiatives such as these will help set national priorities and lead to the development of implementation strategies in harmony with national visions, specific socioeconomic development needs and resource constraints. It is now apparent, however, that efforts along these lines must be supplemented with initiatives directly aimed at clearly defined objectives in the areas of institution-building, networking and human resource development. The keys to technological capacity-building are:

(a) Knowledge creation, normally the preserve of research centres and university laboratories;

(b) Knowledge acquisition, adaptation and dissemination, generally a task that falls to enterprises, in both the private and public sectors, but sometimes to universities and research centres as well;

(c) Human resource development, often a task for universities and higher vocational training institutes;

(d) Financing, based almost totally on government funding in the developing countries;

(e) S and T infrastructure building and support services, also almost exclusively the province of governments in the developing world.

The forging of strong bonds between institutions involved in these activities has been a major concern in both the developed and the developing countries. Initiatives have been launched with a view to fostering robust and cost-effective participatory approaches aimed at enabling such institutions to act in a co-ordinated fashion. Examples that have shown considerable promise for technological capacity-building and subsequent positive contributions to socioeconomic development include technology parks, technology incubators, innovation centres, high-technology industry clusters and research networks. Many such institutional forms have been set up in various parts of the world. Some have provided viable responses to long-standing problems in networking and co-operation among stakeholders concerned with technological capacity-building. Even more importantly, some have been shown to promote new forms of co-operation in various areas that had previously been virtually impervious to co-ordination and networking. A key factor in the success of such initiatives is capitalizing on the strengths of each of the parties involved, including government departments, private enterprises and non-governmental organizations.

In particular, some of these new institutional forms, such as technology parks, have been found to have an immensely positive impact on industry-university links. Technology incubators, when successfully set up and managed, have been found to afford an effective means of disseminating new technologies as bases for new business ventures. Others, such as high-technology industry clusters, have effectively fostered the rapid introduction of new technologies into obsolescent traditional industrial sectors. In general, given an adequate S and T policy framework, initiatives of this kind may:

(a) Provide support for industrial R and D by strengthening university-industry collaboration in solving industrial problems;

(b) Enhance technology diffusion mechanisms by establishing direct links between research and innovation institutions on the one hand and production/service firms on the other;

(c) Help create new technology-based firms capable of growing and leading to further job creation, higher productivity, lower prices and a greater variety of competitive products;

(d) Provide practical means for lifelong learning, manpower skill upgrading and the enhancement of employability and re-employability in a rapidly changing technological environment;

(e) Establish sustainable environments which are conducive to innovation and constitute fertile soil for technological entrepreneurship;

(f) Constitute practical testing grounds for the implementation of S and T policies, which require constant evaluation and overhaul if they are to remain effective;

(g) Strengthen public/private partnerships and foster co-operation between different actors;

(h) Facilitate technology transfer through the development of international collaboration mediated by technology-based multilateral firms involved in initiatives of the kind referred to above.

The proliferation of science, technology and research parks in Europe and the United States during the past 20 years has been the result of the above-mentioned advantages. In 1997, over 210 parks were to be found in the European Union, accommodating more than 11,200 firms with over 214,000 employees.[2] In the United States, science and technology parks tend to be larger than their European counterparts, as do the firms located there. There are six important research/science parks in the United States[3] that accommodate anywhere between 18 and 2,000 firms and employ a total of 12,000 to 34,000 people, average firm size being between 160 and 750 employees, except in the case of firms in the Irvine Spectrum park, which employ an average of 16 people each. Eight well-known European parks and technopoles[4] are home to between 35 and 2500 firms and employ 500 to 22,250 people, with average work force size ranging between 9 and 60 employees per firm.

Questions such as:

(a) Who should design and implement these initiatives?
(b) How should such initiatives be managed?
(c) On the basis of what criteria should they be evaluated?

merit attention. Answers to such questions will have to be based on specific conditions and overriding priorities in the ESCWA member countries in accordance with their future plans. Concerned government departments, universities and research and development institutions involved in science and technology capacity-building will often tend towards long-term solutions. On the other hand, the private sector, with its proverbial haste to recoup investment and move on to other conquests, is likely to be incapable of exerting a sustained impact. Non-governmental organizations, with their generally limited resources and their concern with solutions to the most urgent development problems, would not fare much better on their own. The situation thus calls for approaches in which governments' propensity to target strategic and long-term objectives, the dynamism inherent in the practices of private enterprise and the resoluteness of non-governmental organizations are combined to achieve optimal results.

Furthermore, effective implementation of these initiatives must be based on close consideration of national and local factors. Differences in economic and technology policy, legislative systems and technological maturity within the end-use sector, as well as differences in degree of industrial specialization, make it essential to customize capacity-building initiatives for specific situations, with a view to producing frameworks capable of providing maximum benefits while avoiding possible pitfalls.

This document discusses the most common models for technology-based initiatives, charting practical approaches to their design and implementation. It includes case studies for S and T policy initiatives as well as various technology capacity-building initiatives such as technopoles, incubators and high-technology industry clusters. These case studies are taken from various developed and developing countries, and are analysed in the context of their original setting and prevailing conditions. In so far as possible, lessons are drawn from these experiences in the hope of providing food for thought to designers of ESCWA country initiatives. Pioneering initiatives in some ESCWA/Arab countries are also discussed as pointers to the current status of the region. A framework for future action in the ESCWA/Arab countries is offered as a proposed set of guidelines for the promotion and development of further such initiatives. Recommendations adopted at an ESCWA expert group meeting on S and T capacity-building initiatives in November 2000 are also included.

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[2] OECD, *Technology incubators: nurturing small firms* (Paris: OCDE, 1997), p. 18.

[3] Stanford Research Park, Research Triangle Park of North Carolina, Charleston University Research Park, Metro Tech., Irvine Spectrum, and Louisiana Biomedical and Development Park.

[4] Sophia Antipolis, the Tetrapole in Grenoble, Nancy Brabois Innovation and the Villeneuve D'Ascq Technopole in France; Cambridge Science Park in the UK; Milano Centrale Servizi, the Area Science Park of Trieste and the Bari Technopolis in Italy.

II. INSTITUTIONAL FORMS OF S & T INITITATIVES

The various forms and styles of S and T capacity-building initiatives that have emerged over the past 20 to 30 years have given rise to a rather motley conceptual and terminological vocabulary. Similar concepts may have different names, and the same term may refer to initiatives with sometimes substantial differences in format and objectives. However, it is fair to say that many of the new institutional forms designed to support technology capacity-building are characterized by a specific physical location and co-operation between public- and private-sector institutions in the form of actions aimed essentially at building bridges between academia and industry, promoting innovation in small and medium enterprises (SMEs) and encouraging investment in technology-based start-up firms.

Brief definitions of some of the most common institutional forms of S and T initiatives and selected components are given in the following sections.

Technopoles

Technopoles are relatively new entities that extend over a well-defined geographical area where scientific and industrial activities are co-located, and where exchanges of expertise are greatly facilitated, owing to the proximity of the various institutions and their willingness to collaborate. For existing firms in new and evolving areas of applied science, technopoles offer an attractive environment, including ready access to research facilities. Technopoles usually involve urban development and may extend over a region that includes several cities. They comprise research laboratories for large firms, universities, research institutes and high-technology enterprises, as well as services for technology transfer.

Technology parks

Technology parks are similar to technopoles, but with more emphasis on the transfer of technological know-how and industrialization. Technology parks tend to have somewhat casual selection criteria, with a target clientele that is not always sharply defined. They may include technological and entrepreneurial tenants as well as service firms, financing institutions and governmental agencies.

Science/research parks and science cities

A park in which scientific R and D activities are predominant, whether in co-operation with research laboratories at universities or research institutes in the same location or somewhere nearby, is known as a "Science Park" or a "Research Park". When the park extends over a wide geographical area, it may be called a "Science City".

Innovation centres

Innovation centres, on the other hand, are capacity-building initiatives based on incubation schemes. Their principal aim is to help new high-technology firms survive their pre-launch, launch and early operational phases. They may also provide existing small firms with suggestions on improving their production processes. Members of an innovation centre are provided with access to R and D facilities and equipment from research centres or university laboratories, and are also offered guidance and assistance in becoming members of local or regional innovation networks. Naturally, firms that are selected as members of innovation centres tend to have a high-technology focus. Furthermore, owing to the demanding nature of the work involved, younger entrants often enjoy priority in tenant selection schemes.

Centres of excellence

These centres generally emphasize distinctive aspects of their output that set them apart from other institutions in the same field. Almost invariably, they operate at the forefront of S and T with the idea of producing an impact that will result in ground-breaking applications of new technologies.

Technology incubators

Technology incubators are a special form of business incubators. They focus on new enterprises whose operations are based on novel technological ideas that are likely to lead to a marketable new product. They provide common services as well as financial, legal and business support to these newly formed enterprises. The incubation process ends after a limited period of time, either with "graduation" of successful start-ups that move outside the incubator, or with the termination of incubation arrangements for one reason or another.

Innovation networks

Innovation networks include managers, bankers, venture capitalists, professors, graduates, scientists, artists and government employees working on, or toward, innovation-related targets in a variety of application areas. Of the several types of institutional forms discussed above, innovation networks are best suited to the adoption of virtual status. Frame 1 briefly describes the kind of relationship that exists between universities and industries locating in a research park.

Frame 1. Relationship types between universities and industries locating in a research park

Universities and private industry find that they can mutually benefit by locating in a university related research centre such as an innovation park. Being in close proximity to one another often facilitates an intimate working relationship and expedites the transfer of technology from the university laboratory to the marketplace. The types of relationships and exchanges possible between the universities and the industries locating in the research park can vary greatly. Some of the more common types of exchanges are listed below.

1. Industries and universities combine their resources to engage in joint research proposals and projects.
2. Research park employees teach or attend classes at university.
3. Faculty members serve as consultants to industry.
4. University graduates are recruited by the research park firms.
5. Industry has access to equipment, funds, fellowships, grants, or scholarships to the university.
6. The university has access to industry's labs and equipment for research and training.
7. Industry has access to equipment, labs, libraries, and other resources of the university.
8. Industry provides students with an opportunity for practical, hands-on training experience.
9. Industry provides part-time or summer training jobs for students.
10. Industry funds university research projects.
11. Industry advises the university on curriculum needs for students entering related fields.
12. The university offers seminars and conferences to industry.

Source: http://www.co.leon.fl.us/innovate/index.htm.

Virtual research centres/networks

Today's information and communications technologies make collaboration among distant researchers feasible by creating on-line research centres and co-laboratories. They can lead to virtual laboratories where widely separated researchers work with colleagues in different countries on specific projects or fields of knowledge.

In the real world, however, it is quite possible for some parks to defy classification in any of the above categories, as they may embody characteristics that derive from more than one scheme. Thus, a given park may possess tenants that are research-oriented, qualifying it for research park status, while at the same time it accommodates innovative firms seeking a favourable location in which to establish themselves, suggesting that it is actually an innovation centre.

Other terms that are sometimes used, such as "technology valley" and "innovation park", denote entities that are barely distinguishable from those defined above. For instance, a description of an innovation park[5] uses "innovation park" and "research park" interchangeably, the types of exchanges occurring within the park in question being very similar to those that take place in a science or technology park. The same applies to the general criteria for tenancy in that same innovation park, as set forth in frame 2.

Frame 2. General criteria for tenancy at an innovation park

The following criteria are used to select tenants at an innovation park:

1. Tenants must be engaged in research, education, testing, analysis, design, prototype development, production on a pilot scale and limited product assembly. This may include development of basic technologies, consulting services, training programmes and governmental liaisons.

2. The firm should be either research or technically oriented, or it must provide a convenient service to park tenants and/or universities.

3. While park tenants may engage in light manufacturing derivative of and related to research and development within the park, the degree of production allowed will be determined on an individual basis within the limits of Florida Statutes. Office suites located in the park must be for administration incidental to the firm's research and development programme.

4. Any manufacturing within the primary campus of the park should be prototype development, or the assembly of high technology products having high value to weight and volume.

5. The operation should be nuisance free and clean. Smoke, noise, vibration, odors, radiation, etc., will be minimized.

6. The anticipated facility should establish an appropriate aesthetic quality, which is in keeping with the Protective Covenants and desired character of Innovation Park Tallahassee.

7. The firm should have a logical tie with the academic programmes of the universities or economic strengths of the community.

8. The firm should provide continued impetus and stature to the development of Innovation Park Tallahassee.

9. The firm should have potential for contribution to the economic or cultural quality of the community and State.

10. The firm and/or its facility should have the potential of providing special assistance or benefits which enhance the concepts of Innovation Park Tallahassee.

Source: http://www.co.leon.fl.us/innovate/index.htm.

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[5] http://www.co.leon.fl.us/innovate/index.htm.

Given that no clear-cut taxonomy exists, the term "technopole" is used in this document as a generic designation[6] for S and T initiatives aimed at combining scientific knowledge with technological know-how, manufacturing and commercialization of the resulting products. In the following section, then, the term "technopole" will be used to designate any of the above-mentioned institutional forms of science/technology/research/innovation parks or valleys.

III. TECHNOPOLES

This section will take a closer look at technopoles, their roles and constituent entities, and the respective functions of those entities, in the hope of contributing to a better understanding of the ways in which they can make viable contributions to the creation of sustainable innovation capabilities, and ultimately catalyse socioeconomic development.

Technopoles and related entities have 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. The current assumption is that such initiatives stimulate innovation, technology transfer and general business development, and can play a useful role in regional economic development. This view has not gone unchallenged, however. Negative, or at any rate mixed, views on technopoles have been published, some raising doubts as to their utility and effectiveness as development policy tools. Nevertheless, continuing interest keeps many of them going and has even helped them to expand in numbers. Many experts continue to support the notion of technopoles as a useful means of technology transfer and national as well as local economic development.

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 success in job creation, new technology generation and the like. The fact that successful technology initiatives such as these are very few and far between is often glossed over. Nevertheless, there is broad agreement that the technopole concept, with all its shades and variants, is worthy of the attention of institutions and countries committed to technology-related development.

The success of the technopole concept is often attributed to the benefits of agglomeration, with reference to the gains that accrue when firms are able to operate in close proximity. The benefits of agglomeration include possibilities for group procurement, joint services, infrastructure arrangements and marketing, as well as enhanced availability of skilled labour. A psychological element having to do with the fact that a technopole brings together a group of actors with more or less similar goals may also be a factor.

A. WHAT IS A TECHNOPOLE?

According to the United Kingdom Science Park Association (UKSPA), a technopole 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.

The above definition clearly stresses the following key points:

(a) A technopole is based on the possession of property;
(b) It has links to a university or research institution;
(c) It aims at:

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[6] The choice of the term "technopole" should not be taken to indicate that these institutional forms are necessarily large in size. There are a number of technopole projects that encompass no more than a dozen enterprises and teaching/research facilities.

(i) Encouraging the commercial application of technology;
(ii) The growth of tenants' business and technology management skills.

There are differences between technopoles with respect to their essential functions in terms of technology transfer, innovation and business management as well as the clients they are intended to serve. Differences between varieties of technopoles on the basis of their functions lead to distinctions between research parks, innovation centres, technopoles and innovation networks.

B. Services Offered By Technopoles

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

The individual bundle of services offered by a given park is ultimately defined by its circumstances and the particular needs of its tenants. Looking at the range of services available from the various types of park entities, we observe that the discrete selections characteristic of particular types of parks merge into a more or less continuous spectrum of overlapping services.

C. Prerequisites For The Success Of Technopole Initiatives

The following ingredients have been found essential for successful technopoles:

(a) Desirable working and living environments;
(b) Proximity to a major university or research institution;
(c) A reliable supply of skilled manpower.

The first of these factors is essential for attracting tenant firms and their employees. Proximity to a university or research centre provides a technopole with access to research facilities, simplifies technology transfer operations, and allows the incubation of spin-off enterprises that may very well be launched by staff from universities and research centres associated with the park. In addition, the proximity of a technopole to a university should guarantee a continuous stream of skilled manpower as well as possibilities for continuing training and rehabilitation.

D. Technopoles As Networks

One of the more prominent functions of a technopole is to facilitate the formation of networks involving multilateral interactions, both formal and informal, among a variety of institutional forms. A positive-sum assumption underlies the technopole concept. According to that assumption, when the members of a diverse group are brought into close contact and subsequent repeated interaction, some of them may incur loss of time or other resources some of the time, but the group as a whole, or most of its members, will benefit most of the time.

In general, there is no reason to expect that simply bringing businesses and researchers into contact would spontaneously result in network formation. Rather, networks are formed on the basis of mutual needs. As in any other form of socioeconomic interaction, parties will only co-operate when at least one of them has a need for something, a good or a service, that another is thought to be able to deliver.

Universities in the developed countries have spun off software and biotechnology/medicine firms for the most part.[7] Other types of spin-off firms appear to originate from the R and D departments of established businesses.

From a policy perspective, therefore, attracting universities, research institutions and research divisions of large businesses may be more advantageous, in the long term, than attracting production divisions. This is naturally consistent with the seedbed role of technopoles.

E. Technopoles As Agents For Technology Transfer

One of the main roles of technopoles is to facilitate technology transfer from university research institutions into the business domain. This role, of course, is based on the theory that bringing researchers and business people into close proximity will ultimately enhance technology transfer and development opportunities. But technology transfer from researchers to business people may not occur as a result of the simple transmission of information about new technology, and consequently, close and continuous contact between the two parties is of the utmost importance. Feedback from business plays an essential role before, during and after the act of technology transfer, and such feedback may not be forthcoming in cases where distance and institutional barriers hinder active information exchange and direct interaction. Personal relationships may also play a very important role in successful technology transfer and development operations.[8]

Furthermore, it is reasonable to assume that a business may become aware of a technological development that lends itself to commercial application at an earlier date when it is located in close proximity to a high-technology institution in a university research department, for example. This, it may be argued, should give it a considerable advantage in early technology exploitation. Furthermore, an enterprise's interaction with such an institution's highly skilled staff members may enable it to carry its thinking about the exploitation and further development of the original idea to maturity before its competitors can do it.

Having businesses and universities or research centres located in close proximity is no more than a necessary condition for successful technology transfer operations. Other factors have to be looked at with considerable attention. The transfer of technology from universities to small and medium-sized enterprises (SMEs) is frequently subject to impediments, including:

(a) Lack of awareness of business requirements on the part of academic staff and researchers;
(b) An underlying unwillingness to co-operate with business enterprise, often due to:

(i) The different value systems that govern academic research and business communities;
(ii) The pressures of academic life;
(iii) An inclination toward perfectionism;
(iv) Lack of practicality and hostility to compromise;
(v) Low regard for deadlines, profitability and confidentiality.

On the other hand, technology transfer from universities to businesses may occur even without direct contact between academic researchers and entrepreneurs. There have been countless cases where

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[7] A. Cooper, "The Role of Incubator Organizations in the Founding of Growth-oriented Firms," *Journal of Business Venturing*, 1 (1985), pp. 75-86, quoted in R. Ferguson, *Panacea or Let-down? Science Parks in the Literature* (Stockholm: Teknik Brostiftelsen, 1995), p. 7. http://www.ekon.slu.se/~richardf/scipklit/scipklit.html.

[8] Concerning the importance of personal contacts, university-SME contacts have often been the result of an entrepreneur's university experience and subsisting links with former professors or peers.

technological knowledge has been transferred from a university or research centre to an entrepreneur through an intermediary such as a consultant, technology broker[9] or specialized contractor.[10]

While this "hierarchical" form of technology diffusion may detract somewhat from the advantages inherent in the direct transfer mode, at the same time it may iron out some of its intrinsic difficulties (see the above list). At all events, hierarchical technology transfer should obviate the need for close proximity to a university or research facility.[11]

In general, SMEs in the developed countries have sought academic co-operation in pursuit of one or more of the following objectives:

(a) The acquisition of information and ideas about new products and services that:

(i) Constitute the focus of their commercial activity;
(ii) Complement their existing activities;
(iii) Afford prospects of improving their business strategies;

(b) The acquisition of reliable information about specialized technologies (such as measurement and control methodologies), including their potential, limitations, implications of their adoption and suitable implementation procedures;

(c) An improved public relations profile;

(d) The promotion of recruiting activity;

(e) The facilitation of employee training in specialized techniques.

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

F. CASE STUDY OF A LEBANESE TECHNOPOLE: BERYTECH[12]

The private sector in Lebanon has embarked independently on a number of technopole and incubation projects. One such projects is BERYTECH's Technopole established by Saint Joseph University. The BERYTECH project's aims and objectives are set forth in frame 3. The project is open to universities as well as businesses interested in contributing to the realization of its aims and objectives. Along with its educational role, BERYTECH incorporates a wider national and regional vision for socioeconomic development through new technology inputs. In addition, the project's initiator is seeking to create a socioeconomic dynamic that will increase competitiveness and attract high-added-value firms to the site. A primary function of BERYTECH is to provide the necessary environment and support services to help develop added-value activities. In this connection, BERYTECH offers the following outputs:

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9 A technology broker is essentially an organization in possession of skills for the assessment, patenting, licensing and implementation of technology.

10 This form of technology transfer is often referred to as "hierarchical diffusion".

11 Indeed, the lack of university-tenant linkages reported by some studies of science parks may be explainable, at least in part, by the hierarchical diffusion process, which enables one park tenant to receive technological knowledge from a university research team and then pass it on to other users.

12 Based on a paper by M. Asmar and F. Rahmé entitled *BERYTECH, a Technology Park in Lebanon*, presented at the Expert Group Meeting on Capacity-building Initiatives for the Twenty-first Century, ESCWA, Beirut, 1-3 November 2000.

(a) Assisting entrepreneurs in the creation of their businesses; this is done in an incubator, a nursery and a company hostel where projects are followed up until they mature into firms that are sufficiently well developed to be listed on the stock exchange;

(b) Hosting and development of existing local small firms; this can take place in a wider selection of settings, such as rented offices offering a variety of essential services at competitive rates;

(c) Acting as hosts to large local or foreign companies; this can be done through real estate services providing shared or sole-occupancy rentals or full ownership of premises;

(d) Providing specialized professional training; this requires specific means and well-defined environments.

Frame 3. Aims and objectives of BERYTECH

BERYTECH aims at:

1. Helping Lebanon regain its leadership in fields where knowledge and human talent form the basis of business.
2. Encouraging entrepreneurship in high-added-value fields, especially among young graduates.
3. Bringing newly created companies and small and medium-sized technology firms together at a single location in order to create a clustering effect and enhance competitiveness.
4. Encouraging the return of Lebanese expatriates.
5. Attracting foreign investment and foreign companies.
6. Maintaining the leading role played by Lebanese universities in the region by providing educational institutions in Lebanon with a tool that promotes creative thinking and helps transform fundamental research into applied research.
7. Widening the scope of the university's educational role by helping young graduates integrate into the business world more effectively.
8. Ongoing improvements to curricula to match the needs of today's businesses.
9. Anticipating the needs of the workplace of the future.

Source: Asmar and Rahmé, *BERYTECH*.

BERYTECH's activities are currently focused on fields in which competitive advantage, expertise and human resources are generally available in Lebanon. These include:

(a) Information technology;
(b) Communications;
(c) Multimedia and Web technology;
(d) Banking and finance;
(e) Water and environment;
(f) Energy;
(g) Health sciences;
(h) Food industry;
(i) Vocational training.

IV. TECHNOLOGY INCUBATORS

Technology incubators are essentially a special class of business incubators focusing on new enterprises with operations based on new or advanced technologies. Technology incubators came into vogue as a development policy tool in some industrialized countries in the late 1970s and early 1980s. A number of the OECD countries, including the United Kingdom, France, Germany and Italy, adopted technology incubation as a means of promoting job-creating innovative enterprises and the commercialization of university research. Several industrializing countries followed suit, and the numbers of technology incubators in some of them grew considerably during the 1980s and 1990s. In recent years, efforts at setting up technology incubators around the world have been characterized by a more clear-cut focus on the development and diffusion of specific technologies such as information technology and biotechnology.

Incubation initiatives are a development policy instrument of relatively recent origin. This accounts for the fact that rigorous economic analyses of incubation ventures are still sparse. Assessments of incubator performance in many parts of the world indicate that they may have a positive impact, mainly in terms of higher new firm survival rates. But the broader, longer-term economic impacts of technology incubators and their implications for innovation activity remain to be explored: the issue of the costs and benefits associated with public support for incubators, as compared to other measures for promoting the commercialization of knowledge-intensive enterprise and technology dissemination, are as yet not fully resolved.

A. OBJECTIVES OF INCUBATION SCHEMES

In general, technology incubators afford a means of enhancing overall economic growth and development, facilitating restructuring, technology diffusion and commercialization, and creating jobs.

Overall economic development: In seeking to revitalize economic development, incubators, particularly those located in universities, are able to play a dual role, acting as pilot facilities for the transformation of research results into commercial products and services on the one hand, and providing an environment for training incipient entrepreneurs on the other. In addition, incubators often play an outreach role, fostering the dissemination of technical skills in the local labour market. Finally, through networking with investment institutions, incubators can help strengthen the effective utilization of available capital. One outstanding benefit of incubation initiatives is the role they can play in strengthening public-private sector co-operation in overall socioeconomic development.

Economic restructuring: Apart from the concrete roles that incubators may play in the economic sphere and in technology dissemination and capacity-building, incubation initiatives have provided countries that are no longer in a position to afford direct subsidies for large declining industries with valuable opportunities for addressing local development. Indeed, restructuring has been the motivation for many local incubation initiatives. In the United States, technology incubation projects have been undertaken at the local and state government levels with a view to establishing clusters of technology-based firms in the hope of reversing the declining fortunes of certain industrial regions. Some earlier initiatives (during the 1980s) were driven by real-estate ventures. More recent efforts have focused on integrating technology incubators more closely into the surrounding innovation infrastructures and national systems of innovation. In the United States, the Advanced Technology Development Centre (ATDC), established in 1980, was also conceived as part of a State of Georgia policy initiative aimed at diversifying the industrial base, with emphasis on new technology applications, in response to foreign competition. In Italy, *Business Innovation Centres* (BICs) were established in the context of regional development policies in depressed areas of northern and central Italy, especially areas where lack of infrastructure impeded the growth of small firms.

Addressing specific economic development problems: Examples of incubators created to address specific economic challenges may be found in regional development policies in Japan, where initiatives of this kind have been launched at least partly with a view to promoting knowledge-based industries around major metropolitan areas. Similarly, the German Association of Technology and Business Incubation Centres (ADT) has helped to create new business opportunities in the eastern part of the country in support of the reunification process.

Creating employment opportunities: Job creation has been another important goal of incubation schemes in several developed countries. The *Centre d'Initiatives Locales* (CIL) in Saint-Nazaire, France, for example, was set up to help create new jobs[13] and diversify the local economy, which had always been largely dependent on large metalworking firms. In Israel, technology incubation was adapted to serve as an instrument for generating 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 has been challenged on the grounds that university research results are rarely of commercial value. On the other hand, the short-term demands of industry may compromise the longer-term goals and objectives of university research. In addition, universities often prefer to work with larger industrial firms rather than SMEs. Both considerations would appear to work against initiatives aimed at linking universities to SMEs.

From the standpoint of a commercial firm, even a fairly large one, proximity to industrially-oriented R and D facilities is likely to be more important than access to a university's educational facilities.

A factor that may remain somewhat hidden relates to long-term cultural interaction–making university staff more aware of industrial enterprise and allowing prospective academic entrepreneurs a first-hand view of the range of business skills required.

Incubators as property and real estate development ventures: Incubators can be lucrative property-based ventures. The success of the Italian *Business Innovation Centres* (BICs) in attracting investors, which has been referred to in an OECD study, illustrates this aspect. On the demand side, firms may often be keen to join a given incubator facility because of the associated tangible and intangible benefits.

There is potentially scope for conflict between the profitability of a property-based venture and longer-terms goals of technology and economic development. In a number of instances, such conflict has led an incubator's management to take on tenants among whom there is little synergy in order to maintain acceptable occupancy levels. In the United Kingdom, for example, an estimated 35 per cent of all technopole space is occupied by firms in the fields of accounting, insurance and financial services.[14]

Other benefits of incubator initiatives: Indirect benefits of incubation schemes include the encouragement of an entrepreneurial culture, the attraction of service industries employing semi-skilled and unskilled labour as well as skilled personnel, and the enhancement of property values.

B. Services Provided By Incubators

The start-up phase of an enterprise is generally clouded by uncertainty, regardless of the type of business activity in which it is engaged. The challenges facing fledgling enterprises include:

(a) Substantial entry costs;
(b) High fixed costs;
(c) Lack of access to equity capital;
(d) Lack of effective specialized technical support and infrastructures;
(e) Inadequate market information;
(f) Insufficient management skills.

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[13] Local unemployment was close to 17 per cent at the time of its inception.

[14] OECD, *Technology Incubators*, p. 7.

Even more commonly, new technology-based start-ups and spin-off enterprises originating in universities and large firms are confronted with problems relating to cash flow and access to basic services. Consequently, an incubator should not only provide its tenants with science and technology expertise and physical facilities, it should also facilitate their access to venture capital and various other business-related services in an effort to enhance their chances of survival in the early stages of their development.

Regardless of the objectives of the principal players in incubation initiatives, an incubator is a service-oriented business institution. A technology incubator, in particular, exists to provide specific high-value-added services. Since few incubators can provide a full range of such services, networking with other sources of public and private support is crucial. Locating incubators within larger, more complex facilities aimed at catalysing innovative activity is one way of doing this. Isolation is the enemy of technology incubators; networking is an essential means of helping tenant firms access technology and markets.[15]

The issue of networking has been carried to a higher level in Italy, in particular, where the National Research Council's *Consorzio Roma Ricerche* is helping link innovation centres, technology-oriented business innovation centres and technopoles in central Italy into a single network with the specific objective of helping SMEs access technology services and managerial know-how.

The need to tailor incubator support services to the needs of committed as well as prospective clients is an issue that must be addressed in the earliest stages of an incubation initiative. This is mainly due to the fact that specialized services required by technology incubators are not so readily available in a developing country as in a developed country in the case where an incubator in the first would be associated with a renowned technology institution in the latter.

C. Networking And Resource Policies In Incubator Management

The following presents a brief account of networking and resource policies that should be instituted in a technology incubator. In the first place, care should be taken 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. The building of linkages and networking with an incubator's socioeconomic surroundings and financing sources should be vigorously pursued.

With respect to resource policies, in particular, one important lesson that experience has taught is that incubators should seek financing from a variety of sources and rely on subsidies as little as possible.

D. 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. These generally serve two essential objectives:

(a) They are a cost-effective way of providing incubation services to small entrepreneurs in areas or application sectors lacking critical mass;

(b) They are a means of testing demand, possibly with a view to customizing future physical facilities more precisely to the needs of prospective clients.

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[15] OECD, *Technology Incubators*, p. 8.

V. RESEARCH NETWORKS AND CO-LABORATORIES

Today's large research projects require a firm interdisciplinary base involving the collaboration of a multitude of researchers, often widely dispersed over a geographic area that may be intercontinental in extent. Sustained collaboration among interdisciplinary groups of researchers, a hallmark of today's research work, is a necessity due to the immense mass of knowledge that has accumulated in the various fields of science and technology.

The classical structures of research institutes and university laboratories, however, are not always geared to interdisciplinary and collaborative work. In particular, traditional departmental boundaries and budget allocation are discipline-oriented, and the incentive system, which is essentially based on publications, does not promote collaboration across disciplines.

There have been various attempts to get around this problem by devising new structures, such as university-associated research centres, but these have tended to lead to the isolation of research staff and the distancing of teaching and research activities, aggravated by the relentless search for financial support.

The "research centre without walls" or "virtual research centre" concept affords a means of building multidisciplinary research teams that are geographically dispersed. Such a centre consists of networks of collaborating scholars from various institutions and disciplines working together on common projects. It is computer networks, and high-speed Internet links in particular, that make this possible. One important advantage of such networks is that they empower researchers in developing countries and enable disadvantaged nations to collaborate in international research.

Remote access to supercomputers, libraries, scientific instruments and other research tools has become a reality through Internet II technology, which affords a means of creating a constantly growing knowledge base and bringing together researchers from different institutions, disciplines or professions.

The explosion of communication speed and bandwidth, which is tripling every year, is opening many doors for scientific and technological collaboration and contributing to the proliferation of "virtual research centres". Several forms of these research centres have been instituted; some are relatively small inter- or intra-university research networks, while others are vast co-laboratories extending over continents. The following are some examples of virtual research centres.

A. Research Networks

As long ago as the late 1980s, the MacArthur Foundation created over a dozen experimental networks in the fields of mental health and human development.[16] Each of these networks consists of 12 to 15 researchers from different universities in a variety of disciplines such as psychology, sociology, anthropology, genetics, molecular and cellular biology and medicine. Each has a chairperson, an administrator and a core budget, for travel, telecommunications and preliminary research. Ambitious projects in need of large budgets are eligible for financial support from the usual funding agencies.

Members of a network commit themselves to a scientific problem area that defines the network, and to interdisciplinary collaboration. They choose a chairperson and meet four to six times a year, as they deem necessary. Critical questions facing members of the team are identified, together with an interdisciplinary agenda of research to address those questions. In spite of marked differences in network evolution, the following four explicit stages of organizational development have been found to be common to all networks:[17]

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[16] *The Scientist*, 8, 14 (11 July 1994), p. 1. http://www.the-scientist.com/.

[17] *The Scientist*, 8, 14, p. 1.

Stage 1 – Search for a common theme: Early meetings of networks show a familiar pattern of successive pronouncements that are more or less relevant. The underlying task at this preliminary stage is a search for a common theme, one that will be specific enough to attract members intellectually, yet general enough to leave them scope for exploration on their own terms.

Stage 2 – Conceptual modeling: Multidisciplinary collaborative work requires the identification of common concepts and common ground as a prerequisite for efficient communication. This is achieved through a process of conceptual translation from the vocabulary of one discipline to that of another by means of analogy and metaphor. By the end of this stage, a conceptual model common to all participants has been developed. This will serve as a basis for interdisciplinary collaboration, followed by joint research work.

Stage 3 – Collaboration: A high degree of mutual tolerance and readiness to collaborate emerges in this stage. This may lead to major collaborative efforts among members of the network, or at any rate intra-disciplinary discussions leading by degrees to more concrete collaboration between various laboratories.

Stage 4 – Joint projects: Maturity, in the form of joint research projects conducted by various members of the network, is usually reached after two to three years.

The results of this experiment in virtual research centres show that the network concept can work if a suitable environment is created and favourable circumstances are developed. In particular, commitment on the part of a funding agency is necessary, as is the careful selection of individuals on the basis of their expertise and enthusiasm for interdisciplinary investigation. Constant attention to the complexities of carrying out collaborative work across institutional and disciplinary boundaries is also a necessary condition for success.

Virtual research centres in the form of research networks enable scientists who are committed to ollaboration with colleagues from other disciplines, institutions and even cultures, to share in research that would otherwise be beyond their reach.

B. Co-Laboratories

Another form of virtual research centres is "co-laboratories". These are generally large virtual entities where scholars and research scientists work together, sharing funds and a work plan for the attainment of a particular objective. Each co-laboratory (abbreviated "co-lab") may have a different range of goals and objectives. But co-labs may be linked together for research on serious problems that require the combined efforts of international institutions in order to address problems affecting humanity.

In a co-lab, interaction among scientists in various disciplines who share instrumentation, data systems, and collaborate in teams is of the essence. Collaboration of this kind is several decades old. With the advent of high-speed communications, however, co-labs are becoming increasingly dependent on computer networks, which give them access to multimedia computer conferencing, simulation, modeling, graphics and gaming facilities, involving in some instances the remote manipulation of instruments in outer space or in the depths of the ocean.

Centralized data management is of the utmost importance for any co-lab, as are a support system for teamwork, networking for continuous thinking and planning together, and software tools for developing the methods and organizational structures of the co-lab itself. Interconnecting with other co-labs and research teams affords a means of tackling even the most difficult problems through the sharing of ideas, experiments and discoveries. By working together regularly and on an international scale, researchers can use their combined forces to take on problems that would otherwise be unmanageably complex and difficult. Thanks to co-labs, work can now be completed more quickly, efficiently and comprehensively than ever before.

Co-labs lead to global projects involving creative interaction across disciplinary, cultural and international boundaries. The International Centre for Genetic Engineering and Biotechnology and the Human Genome Project co-laboratory are two examples of co-labs where international collaboration is essential for the successful completion of the interdisciplinary activities they are involved in.

VI. CENTRES OF EXCELLENCE IN SCIENCE AND TECHNOLOGY

A. WHAT ARE "CENTRES OF EXCELLENCE"?

Centres of excellence in science and technology are institutions that aim at demonstrating excellence in selected fields, whether in education or R and D, including a strong relationship with industry. They may specialize in some specific discipline or cover several areas of S and T. They always represent areas of emphasis that will bring the institutions behind them special distinctiveness owing to their uniqueness, special nature or high quality. They also provide leadership at the national or even international level through research, high-level education programmes or resources in their fields of expertise.

Multidisciplinary teams are quite often involved in these excellence centres, where knowledge, applied research and technical assistance are used to strengthen and promote growth-oriented and technology-driven businesses.

As a rule, centres of excellence build partnerships with other centres and academic institutions through collaborative and exchange relationships, in order to complement each other and keep up to date with modern technology and best practices.

In many cases, a centre of this kind is established by, or constitutes part of, a university, in which case it serves as a doorway to accessing the capabilities of the university or developing new products based on advanced research that has been conducted at the university.

Commercialization strategies vary from one centre of excellence to another, and a customized approach is necessary, since there is no single solution. Centre directors are assisted by a consulting programme in the preparation and implementation of commercialization strategies. They use early market studies to determine the market segments that show the greatest potential and those product features that are of greatest interest to potential customers and licensees.

Quite often, the market study indicates that product alterations are required in order for commercialization to be feasible. The necessary modifications can then be made, whereupon the product can be validated, bringing in an early cash flow, expediting the centre's financial independence and enhancing the value of a production licence.

VII. COMPETENCE CENTRES

A. THE COMPETENCE CENTRE CONCEPT

Competence Centres are targeted to develop interaction between universities and industry. Their aim is to achieve greater impact and forms by creating vigorous academic research environments in which industrial companies participate actively and persistently in order to derive long-term benefits.

Competence Centres constitute a neutral place for industry to meet and discuss problems in scientific research and technological development. Activities are sorted into programs, which in turn consist of projects. A typical project involves graduate students, post docs from the universities, and application experts from the industrial partners. Graduate students often perform the main part of the work. The projects are motivated by industrial needs but must also be of academic interest in order to be a topic for a Ph.D. thesis. Other activities could include workshops.

More and more companies are realizing that a key factor to increase competitiveness is to invest in their human potential. Continuous learning processes as well as access to high-quality learning material and methods are key to a success in this field. Competence Centres provide support to companies in this whole process. Their aim is to spread excellence to companies, chambers of commerce, employment centres and trade and industry associations, creating alliances between these and network members, while dealing with professional learning tasks.

B. Industry Requirements

At a first level, industry partners will be involved to provide input and feedback on what the most important issues and expectations are from a business driven point of view. As a second step, a durable structure (the actual Competence Centre) will be implemented for the profit of industry requirements in various research areas. As a final result there will be company driven competence centres, chambers of commerce, employment centres and competence centres of trade and industry associations involved.
Some key issues the Competence Center would be dealing with:

- How can research results in technology-enhanced learning be effectively and efficiently disseminated to industry and trade?
- How can industry and trade communicate their requirements on access to research results to academia?
- How can research topics be compiled out of concrete requirements?
- How can research results be applied to different national and cultural contexts?

Industry requirements involve:

- Integrating the key issues in the different work packages defined by a competence centre's program;
- Gaining reference research activities for the benefit of economy (best practices);
- Strengthening the research institutes by focussing their basic research activities on areas relevant to the economy's needs.
- The aim at this level is to build up a sustainable structure to transfer R&D results from the competence centres to industry actors.

In order to achieve the above, it is necessary to develop business models that describe and tackle the main tasks of the competence centre.

VIII. CONCLUDING REMARKS

Various forms of S and T capacity-building initiatives have proved their effectiveness in developed and developing countries alike. Similar initiatives are needed in the ESCWA member countries in order for those countries to meet the socioeconomic challenges of the twenty-first century.

Although some initiatives have been launched in some of the countries in question, consistent, integrated strategies or plans for the propagation and multiplication of such initiatives are hard to find in the region. In fact, most of the ESCWA member countries still lack even a general S and T policy, let alone sectoral policies designed to fit into the general policy.

Concurrently with the formulation of full-fledged S and T policy initiatives in the ESCWA member countries, national and regional initiatives can and should be launched at all levels. In particular, the establishment of new institutional forms, such as technopoles, technology incubators and high-technology industry clusters, is a promising approach to the tasks of expediting technology transfer from R and D to industry and reforming education to serve economic and social development. These outcomes, in turn, are likely to foster the formation of national innovation systems that will upgrade standards, making products and services more competitive at the global level.

A framework for dealing with the key issues that arise in connection with the selection and launch of capacity-building initiatives in S and T should take into consideration the manifold differences among the ESCWA member countries in terms of their economic systems, development status and capabilities. It should also involve initiatives in the following categories:

(a) Policy and strategy initiatives for defining national directions in science, technology and innovation, leading to better co-ordination between existing systems, institutions and markets, the reduction of obstacles to the diffusion of technologies and increased spending on R and D;

(b) Initiatives aimed at revising and reforming legislative and regulatory frameworks to bring them into line with the ongoing process of global change, especially in the areas of industry, trade and technology;

(c) Initiatives aimed at facilitating technology transfer, especially through legislation and regulations designed to favour innovation-based entrepreneurship and the forging of strong links between R and D institutions and the business community;

(d) Initiatives designed to provide direct and indirect financial backing for technology-based institutional forms and start-up firms;

(e) Human resource development initiatives aimed at upgrading the competence of S and T personnel through education and training, inasmuch as skill formation aspects are crucial role to the success of other capacity-building initiatives;

(f) Programmes designed to provide assistance and guidance for the establishment of new institutional forms such as technopoles, incubation schemes and high-technology clusters.

These various types of initiatives complement one another. If undertaken in a consistent way, they will create synergy that will afford better prospects for success.

However, any given country's initiatives should be adapted to its scientific and technological maturity level, taking its national priorities into account and ensuring that return on investment is clearly favourable. Non-governmental organizations such as professional societies and chambers of commerce and industry, and academic institutions as well, should always be involved in the process of selecting and launching technological capacity-building initiatives.

Great care must be taken with the planning, design and implementation of initiatives relating to new institutional forms in order to avoid falling into the trap of land development without any substantive output.

This would defeat the purpose of the initiative in question and produce a negative effect that would be difficult to undo afterwards. Factual feasibility studies, careful design based on demand-side considerations and proper management involving private firms, partnerships and networking are all crucial elements in the emergence of successful technological capacity-building institutional forms.

Governments have a crucial role to play in creating an environment in which S and T capacity-building initiatives can flourish. They hold the main responsibility for adopting appropriate legislation and regulations that will effectively advance R and D, promote entrepreneurship and sustain technology transfer.

Civil society institutions also have an important role to play in the promotion of these initiatives, specifically by lobbying for a favourable legislative and regulatory environment, and helping firms overhaul their structures, procedures and human resource management practices while at the same time striving for innovation and collaborating with academic institutions.

Lastly, international organizations, and United Nations organizations and agencies in particular, should co-operate with national and regional entities involved with technology transfer, knowledge dissemination and enterprise development in order to develop frameworks for S and T capacity-building initiatives with a view to sustainable development. The "ESCWA initiative for technology parks, incubators and high-technology clusters" is one such framework, aimed at identifying and implementing schemes which are adapted to member countries.