INNOVATION CLUSTERS IN LATIN AMERICA

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SUMMARY

Innovation clusters are critical for industrial and economic development in Latin America. They are groups of firms, research centres and investors which work together in close physical proximity to create new technologies, products and enterprises. They work on invisible networks of relationships in complex social settings where collective industrial activity is based on knowledge and learning. A literature survey, electronic conference, workshop and field investigations in six countries carried out by the International Development Research Centre allowed us to create a model of innovation clusters which is useful for guiding research and public policy intervention in Latin America. The model stresses the role of intangible factors like communication and culture as being equally important to tangibles like local markets and specialized infrastructure. Preliminary data gathered from the literature and our field studies tentatively showed there are no mature innovation clusters, but a significant number of protoclusters with potential to emerge. Typically missing are: risk equity finance; ready access to markets; integration of the stakeholders. Typically, public awareness about innovation and entrepreneurship, and broad support from social and cultural values are not strong, and in some cases limit the potential development of these emerging clusters. However, there are instances where community awareness and organized will to create innovation clusters is very strong – and starting to get results, for example in San Jose Costa Rica, Curitiba Brazil and Porto Alegre Brazil.

1. INTRODUCTION

Latin America is a major player in the world economy. It consists of Portuguese-speaking Brazil and 15 Spanish-speaking countries stretching from Mexico to Argentina[1]. Although there are numerous national distinctions, the countries can be thought of as a distinct region, sharing significant cultural, linguistic, political and economic characteristics. Brazil by itself is the eighth largest ecomony in the world, roughly equal in size to all the Spanish-speaking countries taken together. Mexico is one of the largest trading partners for the USA. There are large and modern resource, cultural, manufacturing, transportation and communications industries.

However, this region is typified as "developing". In industrial terms, this translates into a landscape where large firms are usually dependent subsidiaries of multinationals, technology-based innovation in small firms is very infrequent and the productive sector tends to be isolated from research and knowledge producing institutions. With significant exceptions, the region is characterized by deep-seated difficulties in creating locally-owned, innovative industries based on scientific and technological knowledge.

Developed countries are racing to transform themselves into knowledge-based societies, where industry is constantly innovating new technology-based products that form the basis of new, entrepreneurial companies competing in global markets. As part of this race, in countries like the US and Canada, it seems as though the Director of Local Economic Development of every medium sized city is thinking of creating a business incubator, wondering how to link the community college or local university better to small firms, or dreaming of a science park[2]. Larger cities or governments with more resources at their disposal are attempting to create "science cities" such as Japan's Tsukuba, or local versions of the classic innovation clusters: Silicon Valleys, Route 128, Research Triangle Park (Rogers and Larsen, 1984; Botkin, 1986; Voyer, 1997).

Why all this recent attention to local innovation clusters? At the heart of innovation clusters are new, entrepreneurial enterprises based on commercializing new technology. Altenburg and Meyer-Stamer (no date) show clustering benefits, as follows: "Clustering seems to enable firms, especially small and medium-sized enterprises (SMEs), to grow and upgrade more easily. SMEs may even become players in world markets if a high degree of interfirm specialization and their proximity to other firms performing complementary functions offset the disadvantages of being small. Clusters often create positive externalities which help managerial and technical learning. Empirical evidence shows that clustering is especially common among traditional small-scale and labor-intensive activities. Upgrading these activities contributes to a more balanced firm size structure and a more labor-intensive growth pattern" (p.1).

Innovation clusters create an image of success that instills a sense of dynamism, hope and future in their communities. They give jobs to young people in the community and attract new talent from outside. Clusters are strongly community-focussed, limited to distinct geographical areas, which

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[1] We include Cuba and Dominican Republic from the Caribbean but not the French, English and Dutch speaking countries of Belize, Guyana, Guyane Francaise, Surinam. This choice is made only to emphasize the linguistic and cultural commonalities of the Iberoamerican group for the purposes of this particular article.

[2] Tiffin (1987) has seen this field grow from the early '80s in Canada and the US. A typical early approach for building innovation clusters in small communities can be seen in his consulting study for the diversification of a nuclear research-based town in Canada.

means that the returns on public and private investment can be captured by the local investors. Marceau (2000) points out the critical importance of technology policy and management work that is oriented to takeup by the policy system and politicians. Local innovation clusters are not the only way of promoting economic development, nor is the local area the only one that is important for policy, but it is a very effective way for municipalities to be involved (OECDa, 1997). In contrast to the difficulty many national governments face, especially in complex federal states, in developing useful science and technology policy, municipalities can be extremely effective in promoting local innovation clusters.

In a detailed analysis of the two paradigmatic innovation clusters, Silicon Valley and Boston's Route 128, Saxenian (1994) shows that both have shown a rapid and sustained growth in terms of numbers of jobs generated and numbers of new firms created. Of critical importance is that these jobs and firms are in the advanced technology sectors, with enormous positive impact on the rest of the economy.[3]

	High Technology Employment		**Number of High Technology Establishments**	
	Silicon Valley	*Route 128*	*Silicon Valley*	*Route 128*
1959	17.376	61.409	109	268
1975	116.671	98.952	831	840
1990	267.531	150.576	3.231	2.168

"Silicon Valley is now home to one-third of the 100 largest technology companies created in the United States since 1965. The market value of these firms increased by $25 billion between 1986 and 1990, dwarfing the $1 billion increase of the Route 128-based counterparts.[...]. In 1990 Silicon Valley-based producers exported electronics products worth more than $11 billion, almost one-third of the nation's total, compared to Route 128's $4.6 billion" (Saxenian, p.2).

The positive benefits from industries locating close to each other has long been recognized in economic thought, beginning with Marshall, in his *Economic Principles*, 1890. His observations were based on a study of the uneven geographic concentration of firms involved in the English textile industry. For Marshall, there were several obvious positive externalities from this clustering:

- creation of a corps of workers highly specialized in the range of industry requirements
- provision of intermediate inputs to firms from local sources
- interchange of knowledge, information and ideas about improvements to production techniques and organizations.

By now there is a general consensus in the literature that clustering benefits firms' economic performance. (Cassiolato y Lastres, 1999; Echeverri-Caroll, 1997; Krugman, 1991; Malecki, 1997). The main reasons seem to be positive externalities (or knowledge spillovers, as Baptista and Swann state (Research Policy 27, 1998, p. 525-540)and the potential for the actors in the cluster to undertake joint action.There is another important factor, which Schmitz (1997b, p.3) stresses as joint action. The

[3] Both employment and number of establishments are refered to the following sectors: i) computing and office equipments, ii) communications equipment, iii) electronic components, iv) guided missiles, space vehicles, v) instruments, and vi) software and data processing.

combination of both gives what he calls "collective efficiency". Quandt (1999) sees the same concept of collective efficiency as describing the nascent cluster around his city of Curitiba, in Brazil.

Preliminary investigation in 1997 by one of the authors (Tiffin) at the International Development Research Centre (IDRC, a Canadian public corporation which funds research in technology and industry in Latin America), suggested that there was rather little awareness both in the public and private sectors about the importance of technological innovation and its role in the new knowledge-based economy[4]. In addition, there seemed to be no mature innovation clusters - groups of firms, universities and governments working together to create new technologies, new products and new enterprises. If innovation clusters are so important in developed countries, the obvious question is, how important are they in developing regions like Latin America? Can innovation clusters function in Latin America? Where are they? How do they work in this region? And most importantly, are they structures that will help to overcome some of the deep-seated constraints facing the conversion of Latin American industry to more knowledge-based forms?

These considerations led Tiffin to sponsor a feasibility study[5] on the topic to better understand the situation. Next came the hiring of a Research Intern (Bortagaray) to carry out a survey of innovation clusters in the region and run an electronic conference on the topic to locate researchers and bring the state of the art in Latin America to light. This paper reports on Bortagaray's survey work, placed within the broader context of the IDRC effort to develop a major research program in the area.

2. OBJECTIVES

There are three major objectives to this paper.

First, to create a definition of innovation clusters that makes sense for the Latin American context. Inputs for this definition come from the international literature and Latin American literature directly on this topic, and from literature on industrial innovation in Latin America. The definition must not only reflect the dynamics of what occurs in areas where innovation clusters work, but also highlight issues that are unique and critical for Latin America, at the same time.

Second, to use this definition to create a model of an innovation cluster that expands on the basic principles of the definition, allows the possibility of surveys and measurements and analysis on innovation clusters in Latin America to take place, using a concept that makes sense for the region.

Third, to use this model to examine available data in order to see where innovation clusters might be already in Latin America and draw any conclusions about how they are functioning. Key outputs would be a better understanding of how important innovation clusters might be to overcome the characteristic difficulties facing industrial innovation in the region, as well as how to support these structures by formal policy and management intervention. Given the very preliminary nature of the

[4] Recently, articles on the topic have begun to appear in the popular press. El Mercurio (1999) describes Chilean preoccupations, and a discussion in El Pais (2000) with the Dean of the Chemistry Faculty, Dr. Alberto Nieto, presents some important Uruguayan actions.

[5] Gibson, D., Conceiçao, P., Nordskog, J, Burtner, J., Tankha, S. and Quandt, C. (1999); and Quandt, C. (1999).

data we have at hand, we are likely only to be able to give a very preliminary assessment of the state of innovation clusters in Latin America, but future research will be able to go farther on this basis.

3. METHODOLOGY

This paper draws on concepts from IDRC-sponsored feasibility studies, mentioned before, as well as an electronic conference run by IDRC from February to April 1999, involving 73 people (30 participated actively) from 7 countries in Latin America, in addition to Canada and the United States. The electronic conference was followed up by a workshop held in Montevideo where 27 people met to discuss key aspects around innovation clusters for 3 days (Bortagaray, 1999). Next, Bortagaray undertook a literature search using the resources of the IDRC library and the Perry-Castañeda Library (PCL) at the University of Texas at Austin. Field trips were made to visit cluster sites in Buenos Aires (Argentina), Porto Alegre, Recife and Curitiba (Brazil), Montevideo (Uruguay), Havana (Cuba) and San Jose (Costa Rica). The concepts in this paper have been further refined in managing the development of a major research program on this topic which IDRC funded in 2000.

4. DEFINING INNOVATION CLUSTERS

What exactly is an innovation cluster? At present, there is no a single definition of what the term is and only limited consensus on its meaning. It practice, it seems to be used interchangeably with technopoles, science cities, incubators, industrial clusters, science parks, networks and systems of innovation. In Latin America, the word cluster is usually used without translation, and is preferred to aglomeración-aglomeração, or conglomeración-conglomeração, which would be more exact translations. It is necessary to try and clarify the basic concepts, in order to move ahead to make a practical model and then test it on real data. Obviously present in the term are two basic concepts: industrial production in organized groups; and knowledge, learning and technological change. We examine what the literature has to say about these concepts.

Industrial Production in Organized Groups

There is a large literature dealing with **Industrial Districts**. The basic consideration is as expressed by Lerer (1979, p. 82) as: " un área de terreno delimitada y convenientemente localizada, subdividida por la planificación, y en el cual se encuentran dispoinibles medios y condiciones necesarios y favorables a la actividad industrial". Here the emphasis is on a sharply defined geographical space where firms are physically present. The concept has evolved considerably since, now emphasizing the "social environment of the ideal-type industrial-district" in terms of a common culture, frequent face to face relations, and "norms of reciprocity acompanied by relevant social sanctions" (Dei Ottati, 1994, p.530 in Schmitz, 1997b, p.9). Altenburg and Meyer-Stamer (no date) define it as: "...those local business networks in which a dense social fabric based on shared cultural norms and values and an elaborate network of institutions facilitate the dissemination of knowledge and innovation...".

A great deal of investment has been made by local governments to create **Industrial Parks**. These are physical spaces created to supply the basic infrastructure that firms will need, often with subsidized conditions, such as tax exemptions, to encourage them to locate in the district. A study of industrial parks in Latin America defined them as " aglomeraciones industriales conjuntamenete planeadas y

equipadas con una infraestructura complete [y] además una serie de servicios decentralizados" (Jonas, 1979, p.16). In this sense, the Industrial Park is a recreation of the original concept expressed by Lerer above, with an awareness of the importance of the need to promote links among the firms in the park. Jonas (1979) says that the proximity between firms " permite el desarrollo de relaciones interindustriales con costos mínimos de transporte. También permite la concentración de varias funciones empresariales y su manejo a través de compañiás especiales de tipo cooperativo" (p. 16).

Saxenian (1994) emphasizes the value of the relationships which form and characterize industrial districts, which she refers to as ***Regional Network-based Industrial Systems***: "In these systems, which are organized around horizontal networks of firms, producers deepen their own capabilities by specializing, while engaging in close, bu not exclusive, relations with other specialists. Network systems flourish in regional agglomerations where repeated interaction builds shared identities and mutual trust while at the same time intensifying competitive rivalries" (p.4).

Schmitz (1997b) focuses explicitly on ***Industrial Clusters***, meaning "...a sectoral and geographic concentration of firms". Ramos (1998, p.5) emphasizes that industrial clusters generate significant advantages of "...exernalidades, economías de aglomeración, 'spillovers' tecnológicos e innovaciones que surgen de la intensa y repetida interacción entre las empresas...". Altenburg and Meyer-Stamer present a very useful summary of the various attributes of an industrial cluster:

- positive external effects emanating from the existence of a local pool of skilled labor and the attraction of buyers;
- forward and backward linkages between firms inside the clusters;
- intensive information exchange between firms, institutions, and individuals in the cluster, which gives rise to a creative milieu:
- joint action geared to creating locational advantages;
- the existence of a diversified institutional infrastructure supporting the specific activities of the cluster;
- a sociocultural identity made up of common values and the embeddedness of local actors in a local milieu which facilitates trust".

They define a cluster as follows: "... is a sizeable agglomeration of firms in a spatially delimited area which has a distinctive specialization profile and in which interfirm specialization and trade is substantial. This excludes agglomerations of the EPZ-type [Export Processing Zones], as these do not build upon intensive linkages" (p. 3). Porter (1998) also defines a cluster as a"...geographic concentration of interconnected companies and institutions in a particular field".

Knowledge, Learning and Technological Change

Baptista and Swann (1998) introduce a new concept to the industrial cluster, of the formal knowledge component "... a strong collection of related companies located in a small geographical area, sometimes centred on a strong part of a country´s science base" (p.525). This emphasis on scientific and technological knowledge is taken up by Magalhaes Tavares (1998, p.312) for a structure he calls a ***Technopolis***: "Enquanto paradigma, a tecnópolis consiste en três zonas integradas, uma zona industrial compreendendo indústrias, locais de distribuição e setores administrativos; um núcleo de universidades, centros de pesquisa públicos e privados; e zonas residênciais para os pesquisadores e suas famílias". Gómes (1999) uses the term ***Science Park*** to include technopoles and industrial clusters that are based on science and technology, and describes them as: " arreglos institucionales mediadores, que se proponen ejercer un papel de articulación-gestión política-operacional en favor de los intereses-necesidades de empresas de base tecnológica localizadas en un espacio geográfico, normalmente dispersos en el ámbito de una ciudad" (p.205).

There is also a large literature on ***National Innovation Systems***, which puts the aspects of knowledge and learning in a distributed context of multiple actors as the core concern. An OECD report (1997a) summarizes this research and the key contributors. This concept is like an industrial system except that it deals with the interrelated organizations producing, transferring and using knowledge:
i) "the networks of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987)
ii) "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge...and are either located within or rooted inside the borders of a nation state""(Lundvall, 1992)
ii) "a set of institutions whose interactions determine the innovative performance...of national firms" (Nelson, 1993)
iv) "the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country" (Patel and Pavitt, 1994)
v) "that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies" (Metcalfe, 1995).

In large countries with multiple layers of governments, López y Lugones (1999, p.2) point out that there are multiple and very different systems of innovation, national, local and sectoral. Obviously, there are also regional systems which act at the supra-national level as well.

Use of the term ***Innovation Cluster*** is much more recent and so far, more limited scope. An innovation cluster, according to Voyer (1997), who has had the benefit of working with this topic for many years as an academic, a policy manager and a cluster promoter in the private sector, is "regional or urban concentrations of firms including manufacturers, suppliers and service providers, in one or more industrial sectors. These firms are supported by an infrastructure made up of universities and collegues, research institutes, financing institutions, incubators, business services and advanced communications/transportation systems" (p. 2). Voyer (1997[a]) presents a list of 8 factors which the consulting industry tends to use when contracting to local development authorities on the liklihood of creating an innovation cluster in their community[6]. These factors are important to highlight the main characteristics of an innovation cluster as seen by professional practitioners, and they stress:
"1. the recognition of the potential of knowledge-based industries by regional/local leaders;
2. the identification and support of regional strengths and assets;
3. the catalytic influence of local champions;
4. the need to have an entrepreneurial drive and sound business practices;
5. the availability of various sources of investment capital;
6. the cohesion provided by both informal and formal information networks;
7. the need for educational and research institutions; and most importantly,
8. the need to have "staying power" over the long term" (p. 4).

Lundvall (1994) stresses that innovation clusters feature processes of interactive learning and collective action. In this regard, Porter's definition of clusters emphasizes the importance of 'willingness to cooperate' and 'closely knit social-cultural links' (1990).

[6] Researchers sometimes criticize the creation of simple lists which describe critical factors for building local innovation clusters, alluding to the complex and so-far poorly understood processes involved. However, these lists are very popular with policy professionals and cluster managers, because they give them some anchor and direction which is better than none.

Gibson et al (1999)[7] use the term **Learning & Innovation Pole (LIP)** defined as: "...an evolutionary improvement to the concept of technopolis [which "interactivily links technology commercialization with the public and private sectors to spur economic development and promote technology diversification"(p.1)] that is more attuned to the needs of developing countries" (p.2). They analyze the importance of the environment in the development of technology-based regions. For them, this "... environment consists of regional networks of talent, technology, capital, and know-how that provide support essential to successfully commercializing innovations and new technology...".

Definition

Given the above discussion, it seems most useful to conceptualize an innovation cluster as a special kind of industrial cluster where the core is technology-intensive or knowledge-intensive firms, and scientific and technological knowledge drive the development of new products and firms. An innovation cluster is quite similar to the concept of local innovation system as well, except the emphasis is on firms rather than on technology. Innovation clusters are local structures focussed on geographically-indentifiable communities, as opposed to sectors or networks, which may spread out over an entire country. Innovation clusters should be found within science parks, which are administrative structures that are supposed to promote their development (focussing on the most technology-intensive types of industries). Given the predominance of the literature on industrial clusters and the fact that the term cluster is already in popular use, we therefore choose to call these structures clusters (as opposed to local systems), but distinguish them from industrial clusters with the word "innovation".

We suggest the following definition:
an innovation cluster is an organizational structure that creates new products and enterprises by means of collective industrial production within restricted geographical boundaries, based on high concentrations of knowledge exchange, interactive learning and shared social values.

It must be stressed that an innovation cluster is not something that can be easily seen or touched; the physical components work together with invisible information exchange networks, or communities of people with shared values. The tangible components of a cluster – university, a new technology-based firm, an incubator are elements of a cluster, but not the cluster itself.

An innovation cluster is obviously a continuum of structures which range from those that are not innovative, or involved with science and technology, to those that are so closely bound up with R&D that they drive the scientific and technogical frontiers forward. This suggests the following typology, which will be important to apply when considering the Latin American situation.

Cluster Type	Description
Dependent or truncated	Composed of branch plants, which are installed from another region or country and specialize in very limited activities, eg assembly (maquiladora) or resource extraction and processing. Technology is mature and arrives in fully packaged form of installed process equipment.
Industrial	A group of firms working together, focussing on producing mature goods and services. Very limited engagement of knowledge sources except for maintaining routine quality control and hiring skilled graduates. Limited entry of new firms.
Innovative industrial	An industrial cluster with strong product upgrading, quality improvements, creation of new enterprises and seeking of new markets. Routine engagement with

[7] idem footnote 5.

	local consultants, labs and universities to inject new knowledge into the cluster.
Proto innovation	An innovative industrial cluster which is aware of world markets, the need to be at international best practice levels, is focussed on rapid acquisition of cutting edge technology to create new products and supports a limited growth of new knowledge-intensive firms. Some key stakeholders typically missing and not clear if will continue to develop in medium term.
Mature innovation	A cluster which defines the social structure of the community it is in, creates a dynamic, expanding group of firms based on cutting edge scientific knowledge, sucks in talent from around the world, generates venture capital and drives the pace and direction of scientific and technological research.

5. INDUSTRIAL INNOVATION IN LATIN AMERICA

A review of the Spanish-language literature on Latin America shows that there has been relatively little formal attention to innovation clusters. The literature in Portuguese about Brazil, however, has a good number of studies on structures very close to innovation clusters. Fortunately a good deal is known about industrial innovation in the region. These sources allow us to get a strong image of the constraints facing industrial innovation based on science and technology in Latin America. From this survey, we can see if it provides any guidance on what local characteristics innovation clusters must have in order to maximize their chance for success.

To start, it appears that a major feature of the innovation landscape in Latin America may be what Sutz (1998) calls innovation circuits, "entendiendo por tales a los...procesos donde se generan innovaciones tendientes a resolver situaciones de importancia clave para problemáticas productivas específicas" (p.33). Industrial innovation does occur, but it is not self-sustaining – let alone growing. Clients request specific innovations from specific firms. This is the innovation circuit, which produces the innovation, but then disappears after the one-off task is complete. This "encapsulated" type of innovation plays an important role, but it does not generate the kind of broad industrial benefits that innovation systems create. Sutz' work is based on a detailed analysis of industrial innovation in Uruguay, but this may be a widespread phenomenon in Latin America.

Gómes (1995) has carried out a survey of science parks and techology poles in 5 cities in Brazil: São José dos Campos, São Carlos, Campinas, Campina Grande and Florianópolis. He notes a great deal of variation in terms of the regulation and management of these structures, as well as the support from state governments, but does find some strong commonalities in terms of : the low degree of knowledge the park management has of the industrial and economic profiles of the technology firms involved; the scarcity of venture finance (with the exception of Campina Grande and the Fundo Constitucional de Desenvolvimento do Nordeste-FNE); the difficulty of involving universities and research institutions in a formal way; and the low capability of the park management for mobilizing and coordinating its members. In short, Gómes is remarkably sceptical as to whether these initiatives have any real substance in terms of what we are calling innovation clusters in this paper. He qualifies these initiatives as fragile and vulnerable to changing political whims often based more on abstract speeches rather than real links and outputs.

Gómes' view is not the last word, fortunately. With a shift in optic from the science parks to the more organic form of bottom-up cluster, Quandt (1997) also studied Campinas and came to very different conclusions about this predominantly microelectronics-informatics cluster: "...its specialization in technology-intensive industries combines endogeous efforts by the region´s institutions and entrepreneurs with equally significant initiatives from extra-regional sources such as outside

companies and the federal government.[...] There is a strong correlation between the regional specialization in high-technology industries and their interaction with top-level universities and other organizations that support high-technology industrialization, such as R&D centers, research institutes and industrial associations"(p.13).

Now, we turn to the much larger literature on industrial innovation, and point out the highlights. A major difficulty in establishin g innovation clusters is the generally low level of investment in research and development, almost an order of magnitude less than in the leading developed countries, as the following table shows.[8]

Country	**% total of R&D in relation to GDP in 1998**
Argentina	.42
Bolivia	.33 a
Brasil	.76 b
Colombia	.41
Costa Rica	1.13 b
Cuba	.86
Chile	.62
Ecuador	.08 c
El Salvador	.08
Mexico	.34 b
Nicaragua	.12 b
Panama	.34
Perú	.06
Canada	1.61
Estados Unidos	2.61

a. data for 1996
b. data for 1997
c. data for 1995

Not only is the public sector a minimal investor in R&D, the percentage of the overall investment carried out by firms is much lower than in developed countries, as the following table shows, also from RICYT (1999).

Country	**Spending on Science and Technology by Financing Sector (1998)**				
	Government	**Firms**	**Educación Superior**	**Non-profit Private Organizations**	**Extranjero**

[8] Data taken from Red Iberoamericana de Ciencia y Tecnología (RICYT, 1999). Note that data come from several recent years.

Argentina	42.8	27.4	24.5	2.2	3.0
Bolivia[a]	30.0	24.0	12.0	22.0	10.0
Brazil	64.0	31.8	4.1		
Colombia	65.0	14.0	17.0	4.0	
Costa Rica[a]	53.4	17.4	14.8	4.5	9.9
Cuba	55.3	44.8			
Chile[b]	70.7	15.2	7.6		6.5
Ecuador[c]	39.8	32.5		4.9	22.9
El Salvador	51.9	1.2	13.2	10.4	23.4
Mexico[b]	71.1	16.9	8.6	.9	2.5
Panama	40.2	0.0	2.5	1.3	56.1
Venezuela[b]	31.5	44.8	23.7		
Canada	13.1	62.0	23.7	1.2	
Estados Unidos	7.7	75.1	14.1	3.1	

a. Data from 1996
b. data from 1997

There are good reasons for this, of course. Much of Latin American industrial infrastructure is oriented to the production of natural resources. The typical dynamic for a natural resource-based economy is to export raw and semi-processed materials, and import the sophisticated equipment to do the basic extraction and transportation operations. In developed countries like Canada, there is significant investment in new technology on the extraction and processing, but this tends to be done predominantly by the public sector. Innovation clusters in these areas are more constrained to working in a few areas (although important) like environment, surveying, prospecting and instrumentation. This truncated pattern can be broken, but only a few exceptional countries – like Finland and Sweden – have managed to do this (Tiffin, 1989). Agriculture is perhaps more amenable to local innovation cluster development, but even here, the control of global markets by a few chemical and biological multinationals constrains action.

The heritage of decades of forceful public policies promoting import substitution has also left its mark. The following comment by Perez (1989) about the inability of Brazilian firms to innovate, due to the import substitution heritage, is very telling. "A maior parte das empresas não foi constituida para evoluir. A maioria o foi para operar tecnologias maduras, supostamente já otimizadas. Não se esperava que as empresas alcançassem competitividade por elas próprias. A lucratividade era determinada por fatores exógenos, como a proteção tarifária, subsídios á exportação e numerosas formas de auxílio governamental, em vez de capacidade de a própria emepresa aumentar a produtividade o qualidade. As empresas não são conectadas [tecnicamente] ... [e tem sindo] difícil a geração de sinergias nas redes e complexos industriais"[9]. Or as Sutz (1996a) puts it, "La producción moderna de bienes y servicios y la producción de conocimientos nació así divorciada..." (p. 9). It is not import substitution per se that is the problem, it is the conjunction with other forces such as low investment in R&D that causes this serious basic problem of "enterprises not being designed to evolve".

Industry, government and university tend to operate very separately throughout much of Latin America. This problem was pointed out by Jorge Sabato in the 1970's, and the "Sabato Triangle" model, with the three groups occupying each a corner, has not been significantly changed in the intervening 3 decades. At a recent Triple Helix conference in Rio de Janeiro (the Triple Helix being a

[9] Pérez, C.(1989), in Lastres and Cassiolato, 1999 p.14) "The present wave of technical change: implications for competitive restructuring and for institutional reform in developing countries", text prepared for "Strategic Planning Department of the World Bank", Washington D.C.,: The World Bank, p.32.

rediscovered image of the Sabato Triangle), many authors noted the continuing mutual isolation of the three essential partners to innovation.[10]

Tiffin, Couto and Bas (2000) have pointed out the impact on creation and growth of new technology-based firms from the extreme lack of venture capital throughout most of Latin America. Not only professionally-managed venture capital is missing, so is the early stage, informal angel or seed capital. A study on technopoles, technoparks and incubators in Brazil (Medeiros et al, 1992, p. 231) said the following about venture capital: "De todas a pré-condicoes necessárias para florescimento dos pólos científico-tecnológicos, a menos presente tem sido o capital de risco,… Ausente este instrumento, as empresas de base tecnológicaa usualmente ficam numa espécie de limbo financiero: por serem do setor privado nao tem acesso a finaciamentos a fundo perdido; por nao possuírem um capital que sirva de garantia real, nao conseguem empréstimos junto ao sistema financeiro". Recent events related to the craze for investing in electronic commerce companies have sparked a boom in venture capital in Brazil, but looking at the early signs of this boom, the reality still shows some disturbing trends. According to one observer partly responsible for a national Brazilian program in venture capital (Baptista, personal communication, 2000), the capital is almost wholly of foreign origin and it is oriented only to internet investments whose business plans show payoff in less than two years. This is very different than venture capital associated with local innovation clusters, and in a sense a repeat of previous history in Brazil of foreign-managed resource booms and busts.

Enterprises in Latin America seem to have a culture that limits their ability to cooperate, according to some authors. Albuquerque (1995, in Borges Lemos, M. y Campolina Diniz, C., 1999) describes this for Brazil and Sutz (1996b) points out the same thing for Uruguay. "...la escasa configuración del sector empresarial como actor colectivo, frente a actividades que requieren, para ser eficientes, de la disposición de los destinatarios a sumar voluntades y capacidades". This makes innovation more difficult, as close relationships among suppliers, innovators and customers are critical for success.

In circumstances where enterprises have difficulty working together and the Sabato triangle (or Triple Helix is not linked up), it is obvious that the role of the state in promoting this communication becomes greater[11]. Unfortunately, as a general rule in Latin America, the state tends not to send clear, long term signals favouring the need for innovation and sponsoring the elements that make it happen. Gómes (1999) refers to this problem in his study of science parks in Brazil: "...la inserción de estas entidades en la agenda política de los gobiernos es sin excepción dependiente de actores políticos individuales que en un momento dado deciden apoyar tales iniciativas.... No existen políticas públicas consistentes, con instrumentos de aplicación general, dirigidas a apoyar las entidades gestoras de los polos tecnológicos y sus empresas. Existen proyectos y obras en marcha, pero pueden sufrir paralizaciones en cualquier momento, en función de las condiciones político/partidarias vigentes"(p.206)

Various authors signal a common problem about sharing information. Latin America tends to have a culture where information is hoarded, not shared. This results in a duplication of efforts, underutilization of available resources and a mismatch between supply and demand. A Brazilian

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[10] The Endless Transition: Third Triple Helix International Conference. Rio de Janeiro, 26-29 April, 2000.

[11] We are not stating, however, that the state has the only responsibility for this, or can do it very effectively; all stakeholders are responsible to different degrees. Tiffin visited a large technology transfer exhibition in Mexico City in 1998 at which there were dozens of excellent booths with eager, competent staff, all public sector organization trying to promote transfer and linkage, but virtually no visitors were present – a telling metaphor of the difficulty of state promotion.

federal government official states “Brasil invirtió mucho en tener centros de información tecnológica sectorial pero la información no es usada por los empresarios”[12]. Villaschi Filho (1999, p.240) states “...o principal fator inhibidor/minimizador de potencialização da capacidade de inovar no SCI é a quase total desarticulação entre seus diversos componentes. No desenvolvimento deste trabajo foi marcante a falta de informação mínima que as diversas organizações têm sobre os trabalhos desenvolvidos em outros componentes del sistema”.

Obviously, from the preceding discussion, industrial innovation in Latin America faces significant and deep-rooted difficulties. Our interest in the topic of local innovation clusters is not only because they are important to create a knowledge-based economy, but because they may be structures that offer a way around some of the deep-seated innovation difficulties. For example, if national governments have trouble articulating innovation policies, a focus on clusters may help avoid this being a problem, because clusters are an extremely local phenomenon. Municipal governments and community business associations can step in and play a much more effective role. The next chapter takes these characteristic limitations into consideration, in designing a model of innovation clusters that makes sense for Latin America.

6. A PRACTICAL MODEL OF AN INNOVATION CLUSTER

In this chapter, we elaborate a model of an innovation cluster. This model is based on the previous discussion of literature, the prior experience of Tiffin working in this field and IDRC’s workshop on the topic. Like all models, it is a simplification of a complex reality. It highlights the elements that are problematic for Latin America, as well as the basic elements found in a mature cluster in a developed country. The model consists of a list of stakeholders and their interactions. It will be tested in the next section to see how well it helps us measure innovation clusters in practice[13]. Note that some other stakeholders are involved in clusters, like the stock markets and industrial research funders, but these do not need to be local. In most cases they are supplied quite effectively from a single national source, or even international, so they do not show up in our discussion below.

Our model stresses both tangible and intangible elements. The tangible elements are:

- knowledge-based firms
- knowledge inputs
- specialized consulting services
- specialized inputs
- markets
- cluster support
- financing.

The intangible elements are:

- supportive social climate
- links and interactions among individuals and organizations
- quality of life for people working in the community where the cluster operates.

[12] Joao Bosco from Brazilian Science and Technology Ministery, at the Innovation Clusters in Latin America Workshop, IDRC, Montevideo, May 1999.

[13] The model as presented here is static and pictorial only. However, it should be able to be greatly extended through mathematical techniques in ecology and systems analysis.

6.1 Tangible Elements

Knowledge-based Firms

At the core of any innovation cluster is the group of new knowledge-based firms. The firm is the core element because it produces goods and services to sell, as well as innovating new goods and services. However, the firm is also a major actor helping the innovation cluster to evolve as a system in its own right. As Kozul-Wright (1995) points out, "... the firm is in a position to fulfill a number of critical conditions for innovation: (i) by acting as an organization for storing knowledge (including tacit knowledge); (ii) as an enduring institution which can reproduce that knowledge and inculcate it in new entrants or share it with other firms, and (iii) as a social agent which can establish trust and cooperation".

There are several different kinds of firms involved at the core. They include the much-desired "anchor" firms, which are large sources of technology, markets and expertise (like Bell Northern Research in Ottawa or Dell Computers in Austin). There should be a swarm of small firms and a constant flow of spinoffs and startups coming out of the large firms and the technology centres (labs and universities). These firms must be located close by their suppliers as they need to have close relationships in the innovation process understanding and modifying the technical inputs. Large firms often act as miniature innovation systems in their own right, supplying incubation space to employees, financing their startups, providing technical expertise, product specifications and initial markets. Large firms also provide a steady flow of trained people which the small innovating firms can hire.

Knowledge Inputs

The knowledge that the firms base their new products on comes from universities, public R&D labs and other sources of technology, either as publications or "on the hoof" from skilled individuals. These elements represent the main knowledge inputs that innovating firms draw on. The more they are available locally, the easier will be the lines of communication and transfer of knowledge from the sources to the innovating firms. In a more complex model, we could distinguish between the stock of knowledge, the institutions that produce it and the institutions that train and educate people who create, diffuse and apply the knowledge. Since Latin America, as a whole, has a mature educational and training system, this is not such an important point to make and we prefer for the current purposes, to focus more on the groups that produce scientific and technological knowledge for this model.

Consulting Services

Spinoffs and startups tend to focus on the technology innovation and research aspects first, then incorporate incrementally other areas of expertise as they grow. Therefore, the roles of a whole range of specialized consulting services is critical to the functioning of a cluster. Even for large firms, many specialized functions are still outsourced to consultants. Some of the most important ones are:

- technology: transfer and commercialization
- legal services: patents, trademarks
- accounting for small firms
- industrial design for creation of new products
- industrial engineering, focussing on devising new production processes and scaling up current ones
- marketing, both local and international
- business associations which act as clubs providing moral support, pressure to public sector agencies and a source of contacts.

Most of these service providers operate independently of each other, coming together in business association meetings which aim to support the development of the cluster. They will also get to know each other through the contracting activities of the individual firm that hires them. Generally speaking, these services are well available throughout the industrial areas of Latin America, with the possible exception of industrial design (and fashion, when dealing with garment and leather industries).

Specialized Inputs

Every innovating firm needs inputs of materials, instrumentation and equipment. For some industries, this is fairly universal (eg, computers or Internet). For others, there may be an outstanding requirement to locate next to a laboratory with a unique facility. Easy intercommunication of staff between the input companies and the innovating firm will make the innovation more successful. In some cases, the labs or specialized materials inputters will even participate in the innovation itself as they need to modify specifications or improve their own products to match the specifications of the new innovation. Because the inputs required can be so specific to each type of firm, it is difficult to make any general remarks about the strength or weakness in Latin America.

Cluster Support

Many cities have created organizations to promote the creation and management of local innovation clusters. These organizations typically have a very small staff of 1 to 3 professionals, whose coordination and promotion roles are critical. They will orchestrate the connections with their peers in the business incubator, public sector regulators at different governmental levels, technology transfer agents and business associations, to promote effective development of the cluster. In addition, they will promote linkage among all the other stakeholders.

Most developed countries have networks of technology transfer agents that also work to promote the functioning of local innovation clusters. In Canada, the IRAP (Industrial Research Assistance Program) network maintains hundreds of scientists and engineers to serve innovating firms throughout the country. In addition to the technology transfer services they offer linking to federal R&D labs, these agents also have at their disposal industrial research grants (essentially allowing them to act as early stage angel capitalists), and they provide advice on product design, marketing and suppliers. A major part of their work is to liaise with other cluster support agents, including those who run local business clubs and innovation support networks in the private sector.

From time to time, these public and private innovation support agents will deal with regulators in the public sector, on specific issues that need resolution to assist groups of innovating firms to mo ve ahead. For instance, in biotechnology, restrictions on importing live cultures can seriously impede product development. If the cluster promoters work actively with the government regulators early on, these legal problems can be more quickly resolved.

The other major element in this group of cluster support agents is the incubator. Attention is lavished on this element of specialized infrastructure, which in far too many cases is mistaken for the innovation cluster itself. It is typically attached to a university, where it serves a double role: to facilitate the incorporation of professors and senior students into entrepreneurial business; and to provide the physical facilities and specialized services (often at a deep discount) to help startup firms learn how to stand on their own during the first critical years of their creation. “Incubators [...] can act as a laboratory for commercialising the ideas of academics and provide a training ground” for entrpreneurs” (OECD, 1997b, p.7).

Incubators serve as a meeting place between the university, the productive sector and the state, and because of this and the fact that they are obvious physical symbols of rather intangible, often esoteric

activities, they have enormous symbolic power in the community. Incubators are symbols of modernity, progress, community pride and hope. In Latin America especially, they may provide a unique source of low-cost, low-risk, high potential value investment prospects for venture capitalists, thus acting as the focal point for a small cluster[14].

There is a debate, however, as to the direct importance of incubators in local innovation clusters. There are many "horror stories" about investments in incubators that have been unproductive[15]. In most cities of Latin America, there are already many choices for new firms to find physical premises. While there is no denying the need for minimum levels of infrastructure, and the need for superb infrastructure of specialized types (eg fiber-optic communications for software development), a concentration on the visible physical often leaves support for the links and social relationships unanswered. Ruffiex (1987) (cited by Gómes, 1999) states that the "...a mera criação de infra-estrutura é insuficiente para promover uma eficiente rede de comunicação e relacionamento entre as empresas, e de cada uma delas com a universidade" (p. 15). As with the incubators, we are in the midst of a critical reassessment of the utility and efficiency of investments in more complex infrastructure like technopols , science parks and science cities. Gómes (1999) presents an exhaustive discussion of the literature on this topic.

Markets

The innovation processes also involve the customers, as they define the performance requirements of the new products and test them out. Having lead customers immediately at hand is a critical support to a firm creating a new product. In a vibrant cluster, the firm's technical and managerial people may even move across the boundaries between the customer-and supplier- companies rather easily. Governments have a key role to play as purchasers of new products to provide large markets for risky new products. Many knowledge-intensive products aim for global markets from the outset or very early on, hence it is usually very important for the local cluster to have communications and transport facilities to world customers.

Financing

Seed capital, venture capital and knowledge-based banking are essential local elements in an innovation cluster. A paper by Tiffin, Couto and Bas (2000) surveying venture capital in Latin America gives a good summary of the current situation. Seed capital is typically very small sums of equity (ie, for the purchase of shares in a company, not loans), supplied by private individuals, sometimes working together in informal groups. Seed investing is nearly always only within the community. Venture capital is required later on by the growing enterprises, in much larger amounts (typically from $500K to $2M). It comes from professionally managed firms, which typically will only invest in enterprises up to an hour to two hours travel time distant. Venture capital firms too usually invest in groups. It is well known that angel and venture capitalists not only supply money, but equally

[14] Jose Pimenta-Bueno, closely involved with the PUC-Rio incubator in Brazil has commented that this seems to be a key service to venture capitalists, and is thinking of packaging and marketing its firms explicitly to further lower costs and risks to investors.

[15] As one example, the University of Calgary, in Canada, created a beautiful building with a wide range of services to incubate firms, just a few years before an economic crash in the city slashed the cost of office rental space. As costs of accommodation fell in the city, the incubator rapidly found its tenants leaving to cheaper office space downtown. David Gibson, associated with the innovation cluster at Austin Texas, through the university's IC2 Institute, tells a story of a neighbouring city which built an incubator, equipped it and then found no "tenants" showing up.

importantly, expert management services in the form of contractual relationships with the new firms and via informal mentorship. These management and related technical services from experienced investors are worth their weight in gold to the new firms. Information about deals often flows from one group to the other, and then to the bankers who are becoming more involved with early stage corporate loan instruments. This area is called Knowledge-based Banking, and is one of the growth areas for banks. They try to move "upstream" as far as they can with traditional loan instruments, and always want to be involved with information about growing firms, from early stages on. The knowledge-based banking is also a very local phenomenon.

6.2 Intangible Elements

Culture

The cultural values held by the local society that spawns the innovators, as well as the values of the innovators and entrepreneurs themselves are a central example of the intangibles that allow innovation clusters to work. As well as an underlying favourable business climate, there must also be a broadly held social mindset that understands, values and rewards small business, competitive cooperation, risk-taking, research, innovation and entrepreneurship (Pérez, 1990). Underling all this, is the sociocultural environment in the surrounding community that values novelty, insists on quality and promotes education and learning. Popular magazine articles portray these powerful, eccentric and novel cultures well.[16] It is difficult, perhaps impossible, to create innovation clusters in societies that are not open to innovation. While the state can not single-handedly create an "innovative society", it can put in place a system of education and economic and symbolic rewards that encourage the other key actors to participate in the long term transformation.

While not all the characteristics associated with successful innovation clusters may be positive to all people – there is a dark underbelly of compulsive consumption and display of wealth, destruction of established values and personal relationships that are important to society – no one can deny the immense social and symbolic power of these innovation clusters. Once sleepy, grey government towns, Austin and Ottawa have been transformed in a few decades into some of the most dynamic, creative and wealthy parts of the world by their innovation clusters.

Integration

Integrating the visible organizations mentioned in section 6.1 above are the invisible community links. Flows of information, money, technology, people between firms are intense and ceaseless in mature innovation clusters. Most important, and hardest to measure, is that innovation and learning are occurring not just at the individual level or the firm level, but in some way, at the overall system level of the cluster as a whole. Face to face contacts and personal relationships facilitate this learning and impose limits of distance and size, which we do not yet fully comprehend, on the geographic nature of the cluster. A great deal of the knowledge that is interchanged among the stakeholders of an innovation cluster is tacit, as opposed to formal knowledge.(Wilson, 1998). Integration and explicit community self-awareness are essential constituents supporting innovation. In the words of Castells, an innovative environment is a "…sistema de estructuras sociales, institucionales, organizativas, económicas y territoriales que crean las condiciones para una generación continua de sinergias y su inversión en un proceso de producción que se origina a partir de esta capacidad sinérgica, tanto para las unidades de producción que son parte de este medio innovador como para el medio en su conjunto"[17]. In a knowledge-based economy, firms seek interactions with other firms to develop

[16] Silicon Valley: Droles d'indigenes! GEO, No. 247, Sept. 1999, pp.36-50.

[17] Castells, 1984; Andersson, 1985a; Aydalot, 1986a; Hall, 1990, citado en Castells , Manuel y Hall, Peter: *Las tecnopolis del mundo. La formación de los complejos industriales del siglo XXI*, Alianza Editorial, España, 1994.

learning strategies which allow them to reduce costs and risk related to the innovation process, access new research results, acquire key technological components of a new product or process, and share costs of production, distribution and marketing (OECD, 1996, p. 16).

Geographical proximity of the organizations favours this interchange of formal and tacit knowledge, by formal and informal means. It is important to note that dense interchange of information implies a set of social relationships where there is a community value promoting a balance of cooperation and competition. This is especially important for small firms. Trust in group processes, sharing of information and openness of communications are critical to form working clusters. Public and private agents specializing in this information exchange are equally important to ensure it happens.

Quality of Life

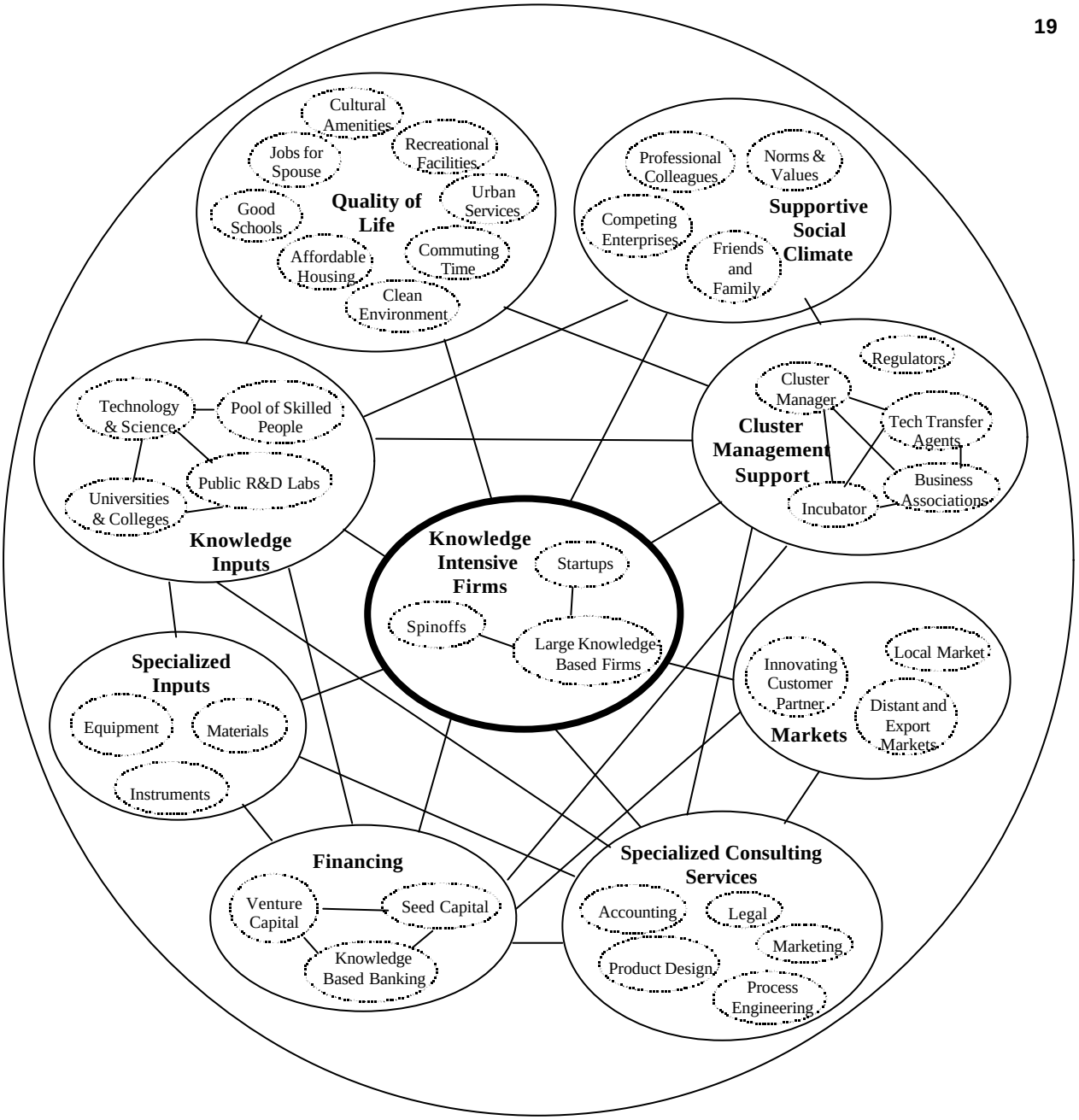
This is a somewhat controversial element of a cluster. The literature seems to show quite clearly that cities where the quality of life is perceived as high, can more easily attract the mobile, highly educated people who are innovators and entrepreneurs, as well as the skilled professionals who support them in consulting roles and the researchers and educators who create the pools of trained staff and new technical discoveries. However, quality of life is something that is to a significant extent dependent on the individual's unique perceptions; one person may value a bustling city environment, but another may detest it. In the literature on Latin American clusters, this debate has not seemed to surface at all so far. It is significant, though, that business magazines are picking up on this issue, for normal business location decisions. A recent edition of EXAME magazine (2000) had a feature article on the best cities in which to do business in Brazil, in which various indices of quality of life featured prominently.

The indicators are rather obvious, that should be considered in measuring quality of life. Housing costs are a key. This has been stated as one of the key reasons for the rapid growth of second-tier clusters like Austin Texas – its housing prices are significantly below those in the Silicon Valley area![18] Other factors to consider that are measurable include: cultural amenities; recreational facilities; urban services; commuting time; clean environment; good schools for children; jobs for the spouse, usually highly educated as well. This element may become much more important in Latin America.

6.3 Visual Representation of the Model

The following diagram summarizes the previous discussion on a practical model. It is made up of two elements: the circles represent stakeholders, participants or critical factors; the lines repesent flow of goods, ideas or money. A more detailed representation could show the lines in terms of thickness to represent the intensity or importance of a specific flow, along with the direction. Within each of the large circles lie a number of smaller ones, to represent more detailed elements. Some of these detailed elements are also interlinked by flows: for example, we represent the Financin g circle as being made of up seed capital, venture capital and knowledge-based banking, all of which need to be in constant communication with each other. Around the whole model is another circle indicating that the cluster is restricted to a small geographical area. In the form presented, this model is amenable to computer modelling, which might be a useful step, once more firmly elaborated, to display the "ecological" dynamics of a local innovation cluster.

[18] Personal communication from David Gibson, IC2.



7. INNOVATION CLUSTERS IN LATIN AMERICA

The model we have generated arose from a combination of literature analysis and field trips in the region. Since the data on innovation clusters in Latin America are very fragmentary, and come from different and non-comparable sources, it is not possible to claim the results presented in this chapter are anything more than very preliminary. It is highly likely they are biased according to where there are

researchers interested in the topic. We are likely, for example, to be overemphasizing Brazil, and within Brazil, skewing the data to cities like Rio and Campinas, which have strong university teams with doctoral students involved with clusters and innovation policy. Still, there are no better data at a Latin American level that have been brought into a single document, and a bias towards Brazil has good reasons to exist. For example, Brazil has made a huge investment to promote innovation clusters, by means of creating incubators. There are now more than 100 incubators (52 technology-oriented, according to the public information, and maybe 20 or so really doing this, according to one incubator manager) in that country.[19] In addition, one of the biggest universities in Brazil, the Federal University of Rio de Janeiro, has land which it is proposing to develop as a science city[20].

7.1 Field Studies

Bortagaray visited Porto Alegre (Brazil), Buenos Aires and San Jose (Costa Rica), and studied Uruguay in some detail, to gather preliminary impressions about the potential of clusters in these cities. In the course of routine IDRC work, Tiffin gathered opportunistic data on clusters during visits to Havana, Monterrey (Mexico), Recife (Brazil) and Curitiba (Brazil). Innovation clusters in these cities are discussed in varying degrees of detail as follows.

Porto Alegre

This city, capital of the southernmost state in Brazil, is well known for the excellence of its urban planning and management, with a strong emphasis on democratic participation of local communities and improving the quality of life of the urban and regional environments. In 1995, the Proyecto Porto Alegre Tecnópole was initiated with a mission to transform the metropolitan region to a knowledge-based economy. It is led by the Universidad Federal de Rio Grande do Sul and the Prefectura Municipal de Porto Alegre. There appears to be strong and frequent dialogue among the promoters and the local stakeholders, many of whom are working together on other projects. The personal relationships are said to cut through bureaucratic obstacles.

The project has several distinct and clearly articulated components:

- the *Tecnópole a domicilio* program which is basically a technology extension service for small enterprises
- a linkage among the technology-based business incubators in the region
- a series of specific investment projects (electronics-informatics, health, a science-technology campus and the linkage of the two main universities with the city industrial park)
- a *teleporto descentralizado* project which is extending the fibre optic cable network throughout the city.

There are 3 incubators focussing on new technology-based firms:

- Centro de Emprendimientos de Informática, created in 1996 as part of the Instituto de Informática of the Universidad Federal de Río Grande (UFRGS)
- Centro de Biotecnología do Estado do Rio Grande do Sul, at the UFRGS
- Incubadora Empresarial Tecnológica de Porto Alegre, created in 1991, which is managed by the city government and linked to a variety of universities and organizations (UFRGS, PUC/RS, ULBRA, PROCEMPA, IEL/FIERGS, FUNDATEC, CIENTEC, BANRISUL, PETROBRAS,-REFAP, CNPq).

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[19] ANPROTEC "Panorama 99. As Incubadoras de Empresas no Brasil", 1999, taken from http://www.anprotec.org.br. The number of incubators is continually rising.

[20] Personal communication from Geddes, Director of the UFRJ Incubator, 1998.

Porto Alegre has the distinction of being one of two cities in Brazil with a private – and successful – venture capital firm, the Companhía Riograndense de Participações. However, it does not appear that the CRP is closely linked to the formally planned elements of this cluster, preferring to work independently with prospective enterprises.

We looked more closely at the health industry cluster being promoted. Here, the situation seems identical to the broad outlines: very strong and clear communication links among the main players; a clear sense of mission and shared goals; a feeling that the goals will be accomplished with hard work and commitment for the long term; an impressive science base which is oriented to practical outputs in the private sector; a close linkage between the researchers, the specialized inputs community and the markets, mediated by formal cluster managers and strong incubators.

Costa Rica

Costa Rica has worked consistently over the past decades to develop, based on its democratic traditions, social harmony and high levels of primary and secondary education. Since the 1970s, Costa Rica has not only been synonymous with environmental tourism, it has managed to set the standards for this new and rapidly growing industry. As a study financed by CEPAL clearly shows (Acuña, Villalobos and Ruiz, 2000), the environmental tourism industry has attained the complexity of a robust tourism industry cluster. Field work by Tiffin found important elements relating to the development of a strong set of management and research services oriented to tourism, principally located in INCAE, the university in San Jose with strong links to Harvard, and the numerous NGOs working there. In addition, a number of local and regional venture capital companies have set up (such as Empresas Ambientales de Centroamerica S.A.), as well as other regional banks, focussing on the environmental business and technology areas (Tiffin, Couto and Bas, 2000). With these related elements, we might be seeing the development of a tourism innovation cluster and that of an environmental services and management innovation cluster as well. These two clusters, being focussed on services instead of products, may require a different way of viewing the model elaborated before.

However, the country has managed to lay the basis for yet another innovation cluster in the last decade, based on microelectronics and software. The anchor for this cluster is, of course, capturing the INTEL plant investment in San José, which has acted as a spark and catalyst for much more cluster development not just in terms of infrastructure and companies, but in terms of institutional and social transformation. In the words of one senior university administrator (as recorded by Bortagaray in April 1999): "Entonces trabajamos muy duro, ellos [Comisión de INTEL] vinieron en las vacaciones y nosotros sacamos a todos los profesores de las vacaciones y los pusimos a trabajar con INTEL y comenzamos a generar un compromiso muy fuerte. Y así actuaron muchas de las instituciones de alrededor que tenían que atender la electricidad, agua, etc.. Todo el mundo trabajó muy orquestadamente para poder lograr que INTEL se viniera, porque sabíamos que INTEL es INTEL, e INTEL provoca un montón de empresas más y una serie de condiciones que nos ayuda a mejorar una serie de cosas internamente".

For several decades, Costa Rica had been capturing small but important investments as a maquiladora in the textiles area, principally. But the national government, industry and university leaders engaged in formal and informal discussions about the future of the country and how to develop new industry based on the human resource potential of the nation. The installation of the INTEL plan is seen as a watershed, drastically changing the self-confidence and the image of the city and surrounding region, that has acted to intensify the cooperation and imagination of the communities involved, to continue pushing for further development of the knowledge components of the informatics industry, with INTEL as the anchor point. The following interview carried out by Bortagary in April 1999 illustrates this point clearly:

"Y hubo una época en donde una inversión, hace unos doce, diez años, de algunas empresas en el campo electrónico, como Motorola por ejemplo que se instalaron en Costa Rica, en ese momento encontraron atractivo en el asunto sin que hubiera toda una facilidad de diferentes formas. De eso al día de hoy ha pasado mucha agua bajo el puente, y ahora se acaba de modificar la ley de Zonas Francas, se está tratando de regular la economía y de regular los trámites para hacer más sencillo al inversionista, se han instalado ventanillas únicas tanto para exportación como para importación, de manera que el trámite esté en un solo lugar, en vez de que le hagan ir a veinte lugares diferentes. Se han ido buscando esos mecanismos de agilidad, se ha ido buscando integrar también la industria local con la industria internacional o que viene a estos regímenes de Zonas Francas para ir creando también integración industrial vertical y horizontal. Y se empezó a trabajar en un concepto, bueno estudiemos qué sectores podrían ser atractivos para que Costa Rica pueda promover la inversión tomando en cuenta también qué ofrecemos, qué recurso humano hay, qué infraestructura, qué capacidad y se hizo un primer análisis como estrategia del gobierno donde salió un grupo de áreas que podrían ser interesantes para el país [...] qué podía Costa Rica ofrecer en el campo, por qué promover la Industria Electrónica y que ventajas y qué cosas estaban pasando, qué compañías, qué países estaban llevándose la atracción, por qué, entonces se hizo un estudio muy interesante que nos permitió tener muy claro y empezar a buscar industrias en ese sentido. Y ahí se inició un programa muy fuerte de atracción de inversiones cuya corona de oro para ese programa fue el poder capturar a INTEL. ¿Por qué? Porque era la primera vez que uno de los dominadores de un área tecnológica como es los microprocesadores, estaba buscando un sitio que no fuera Asia o los Estados Unidos o Israel en donde normalmente tienen plantas, o Irlanda del Norte. Y resulta que entonces en ese concepto logramos demostrarle a INTEL que nosotros éramos el país apropiado y tomó la decisión".[21]

In 1994, the Instituto Tecnológico de Costa Rica set up an incubator, under the management of the Escuela de Administración y Negocios. The project took shape with the support of the Ministerio de Ciencia y Tecnología and the italian group Zeta which was managing the industrial park on the outskirts of San José. The incubator's tenants are all working either in the informatics or biotechnology sectors at the time of Bortagaray's interviews. Cooperation among established firms based on R&D is promoted by the Cámara de Empresas de Base Tecnológica de Costa Rica, which was set up in 1992. Growth of some local firms in some instances has been spectacular: Bortagary interviewed at one software firm set up in 1993 with 4 staff which now employs 90. With this kind of development Costa Rican software exports jumped from 10-20 M$ to 70-80 M$ over the last 3 years, making Costa Rica the largest exporter per capita of software in Latin America.[22]

Despite the striking achievements in recent years, we do not see any of these areas as yet representing a mature innovation cluster. Costa Rican industrial and technological development has taken off from a very limited base, in a very small country quite a distance from markets. The venture capital recently located in San Jose tends to be more regional in scope, focussing on traditional investments, as opposed to local high-tech startups. For these firms, our field work showed both a shortage and an absence of techology-oriented venture and angel funding. The incubators find it a hard task to fill their space, and need to spend a great deal of effort selling their facilities. Entrepreneurs need a lot of specialized training (like everwhere), but the only place to do it is in the incubator itself. There is a shortage of many specialized inputs and consulting services still.

[21] Interview carried out by Bortagaray at the Centro Nacional de Alta Tecnología, CENAT, Costa Rica, April, 1999.

[22] Personal communication from Ricardo Aguilar, Vice Rector, Research and Extension, Instituto Tecnológico de Costa Rica.

Recife

Recife is a mid-sized Brazilian city in the extreme north east coast. Historically basing its industry on sugar cane, the region is managing recent growth based on rather traditional industries and services, such as a modernized port and transportation facilities from the interior, for raw materials and agricultural products. One of the raw materials available for technology-intensive transformation is a very diverse supply of plants that can provide alternative inputs to the local pharmaceutical industry. The state of Pernambuco has 33 firms producing pharmacochemical products, corresponding to 47% of the total Northeast region of Brazil[23]. Most of this output goes to the Northeast region market.

In recent years, there has been a considerable change in the production technology and products of this industry, spearheaded by interaction with research teams at the Federal University of Pernambuco. A government research institute called LAFEPE is working with the university and a private pharmaceutical firm HEBRON, to develop new products based on local biological inputs. The initiative now underway is to see how this kind of work can be increased and formalized by working with other state agencies centred on Recife, and local industries to link the pharmacochemical industry backwards into local biological resource production. This is an incipient innovation cluster, with strong support from a variety of local stakeholders in university, industry and government.

Curitiba

Curitiba is the capital city of the southern Brazilian state of Paraná. Long overshadowed by massive Sao Paolo just to the north, Paraná has a tradition of agricultural base and a small population. Dynamized by a charismatic mayor a decade ago and a population highly receptive to organized change, Curitiba has surged to a leadership position in Brazil in terms of urban planning, environmental awareness and university development. Researchers, politicians and public managers from all over the world now come to the city to see how it has developed and expanded its urban management systems, principally transportation. The lead in creating an innovation cluster centred around environmental management and software-informatics, however, seems to have been taken by the state government. One of the key leaders is the top civil servant in the science, technology and higher education ministry, Ramiro Werhaftig. He has a technical background and maintains active links with one of the best "think-do tanks" in the United States where cluster research and promotion is done, the IC2 Institute at the University of Texas at Austin. In addition, there are numerous other industrial leaders who move back and forth between the private sector and the public programs like Softex that support the growth of technology-based industry. They work closely together in the state of Paraná, promoting this growth in a highly effective and efficient manner.

More recently, the main universities have begun to follow the lead of government and industry to support the quickening of the links between knowledge and enterprise. In Curitiba, the main private university, the PUC, has begun to implement a strategy to transform itself into a research-based university instead of a teaching enterprise. One of its steps is the creation of a graduate specialty in Knowledge Management.

There is a well-established incubator, but it does not seem a central actor in the emerging technopol, as it is focussed so strongly on its immediate role of supporting technology startups. There is no venture capital, but negotiations have begun recently to set up a branch of an established vencap firm in the city.

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[23] Information for this industry comes from ADM&TEC (2000), a research proposal prepared for IDRC on innovation clusters.

Curitiba is recognized as the city in Brazil with probably the highest quality of life and is extremely active in promoting this status to attract environmentally-friendly industries and knowledge workers. Partly as a result, Curitiba is the fastest-growing city in the country. The influx of new, high-technology skills can be imagined to be rapidly filling the previous gaps in specialized consulting services.

Buenos Aires

Located in Buenos Aires is the Polo Tecnólogico Constituyentes (PTC), made up of several large and powerful institutions: Comisión Nacional de Energía Atómica, the Instituto de Investigaciones Científicas y Técnicas de las Fuerzas Armadas, the Instituto Nacional de Tecnología Industrial - INTI, the Servicio Geológico Minero Argentino and the Universidad Nacional de General San Martín. The pole is intended to generate and transfer scientific and technological knowledge among its members, within Mercosur and around the world, as well as promoting linkage with this knowledge to the private sector. It emphasizes the signing of formal protocols with other technology poles around the world to project and develop the national scientific and technological systems of Argentina.[24].

Its principle lines of work are said to cover: materials, environment, energy, transport, support to regulatory bodies and public services, quality control, instrumentation and monitoring industrial establishments, developing human resources and technical information, as well as the development of basic and applied research projects in biotechnology. There are plans to create a program for stimulating new enterprises based on technology, which include an incubator, courses in entrepreneurship, entrepreneurship competitions and the offer of technical assistance.

In the brief time available for our field work, we were not able to get much information on how this group is actually working, but it appears that it is more a "technopol" than a cluster in the sense we use the term in this paper. The emphasis is strongly on technology transfer out of large government research labs, and the seeking of relationships with the private sector. The group proposes to develop more elements of an innovation cluster, but the lack of technical focus and the continued need for public sector push from the research side, leaves us doubtful of its long term economic potential without other, major, intervening transformative factors.

Uruguay

Snoeck (1998) has carried out a detailed study of the wine industry in Uruguay. While this is a small cluster, and specialized around a single agricultural product, it seems to show some characteristics that could metamorphose into an innovation cluster. The firms at the centre of the cluster are wineries. As agricultural enterprises, they show few of the characteristics of knowledge-based spinoffs, but in Uruguay, a significant segment of the industry has converted itself over the past decade into specialized, export-oriented companies producing small quantities of high-quality wines. Faced with financial ruin after several decades of stagnation, a group of firms in the industry decided to work together to implement radically new and different strategies, based on continuous quality and knowledge upgrading, inputs of best-practice technology and close links with customers for developing specialty products. Overall, this industry has achieved significant success in the last decade.

In terms of our model, Snoeck points out the following:

- Strong integration and a highly supportive social climate, including the creation of limited time and function consortia
- Strong support from regulators, technology transfer agents, business associations
- Transfer of skilled people, technology and science

[24] http://www.unsam.edu.ar/polo/espa.htm

- Purchase and application of best-practice process technology and genetic stock
- Utilization of specialized bank credits.

On the other hand, it should be pointed out that there was virtually no support from the national school set up to train enologists, and that the main university only very recently has begun to link with the producers in terms of research and development. Most of the specialized consulting services and the technology and equipment inputs seem to come from foreign sources. In terms of our categorization scheme set up in Chapter 4, this would be an innovative industry cluster.

In Chapter 5 we mentioned Sutz (1998) concept of innovative circuits. She studied 4 in Uruguay: animal health, bioengineering, wool-textiles and informatics. The first two of these are worthy of mentioning in a slightly more detail. The animal health circuit revolved around a national lab (EUBSA) which was producing a vaccine against aftosa fever. There were both local and international clients in the public and private sectors participating in the innovation. However, work came to an end when a legal injunction stopped EUBSA from producing the drug.

The second circuit, bioengineering, related to the production of electronic pacemakers by the firm CCCU (Centro de Construcción de Cardioestimuladores del Uruguay). Sutz says this circuit "...tiene varios de los componentes que cualquiera puede imaginar como importantes: tradición de investigación de calidad en los dos polos cognoscitivos extremos del circuito -medicina clínica e ingeniería-; tradición de enfoques mancomunados de ambos polos para la resolución de problemas; construcción concreta de dispositivos en estadio de experimentación desde el punto de vista de la aplicación y de prototipo a nivel de fabricación; empresa exitosa nacional e internacionalmente, de fabricación de dispositivos muy sofisticados de bioingeniería" (p.39). However, it was difficult for this firm to generate other links and markets.

Neither the government of Uruguay nor the city of Montevideo have an effective policy policy recognizing or promoting innovation clusters. While there has been sporadic talk over the past decade about science parks and incubators, it is only now that one incubator may finally be getting off the ground (El Pais, 2000). The discussion still focusses on the need to create physical infrastructure of the science park type. The national technology lab system LATU is leading a consortium to establish a technology-oriented venture capital fund, with support from the BID, but it is not clear if this long-standing project is moving ahead and if it will be led from the private sector, which is essential. The most important strengths in Uruguay are a highly-educated populace, but social norms and values do not favour entrepreneurship and innovation; the society as a whole is extremely conservative and has not moved significantly from its old vision of living off the rent of agricultural produce which brought such prosperity early in the century. From this we could conclude that it will be some time before an innovation cluster takes shape in Uruguay.

Havana

On the outskirts of the capital city of Cuba, Havana, the national government has made enormous investments to create biotechnology research and product development capability. This investment was originally made as part of a commitment towards excellent, universal health care, with an emphasis on valorizing local pharmaceutical raw materials and herbal traditions (Tancer, 1995). Estimates are that in the period from 1959 to 1991, the government has invested about $300 million US in this pharmaceutical-medical-biotechnology system. There are now about 7 major research centres, employing some 1,131 research scientists and technicians.[25] It does not appear, however, that this set of laboratories is able to convert itself into an innovation cluster because of the extreme difficulties in

[25] Data compiled from Yo rk Medical information circulars. Tiffin explored the possibility of IDRC investing in Cuban biotech commercialization with York Medical and the Canadian Medical Research Council in 1998.

commercializing products in a communist regime. There is no ability to create startup firms, few specialized business services and many restrictions on marketing and sales activities. In addition, the severe financial and regulatory restrictions on access to the internet makes it difficult for researchers to participate in cutting edge bioscience.

However, several laboratories are acting as a partner in an international innovation system with Canadian venture capitalists and basic research labs. A venture capital company in Toronto, York Medical, has created a venture capital fund which pays for teaming up the Cubans with Canadian researchers to commercialize new drugs. The Canadians excel in basic research; the Cubans in applied research, and this work seems to be generating a fruitful partnership. The drugs will be commercialized in Canada and the Cubans paid royalties under this scheme. The difficulty may be that the easily-commercialized drugs are rapidly exploited while there is insufficient continuing investment maintaining the upstream supplies new products from research.

The Cubans are making strenuous efforts to extract commercial benefits from this prodigious investment, within the limitations of the castrist system, including the export of many highly-trained physicians to Latin America and the licencing of drugs and related medical techniques to biotechnology companies in the region. Overall, this export is reported (Nash, 1996) to be bringing in over $100 million US per year.

Monterrey

This booming industrial city in the northeast of Mexico has great potential for creating innovation clusters in a number of areas. Conditions are very favourable: it is close to one of the most successful innovation clusters in the US, Austin, and enjoys close industrial, cultural and educational ties. Foreign high-tech investment is pouring into this maquiladora centre. One of the biggest and best technical universities in Mexico– and Latin America – the Instituto Tecnologico de Monterrey is located in the city. It is a central point in training, research, consulting and testing, with ambitious plans to expand its reach and depth in the community, and as well its influence internationally. However, as a 30 year debate on branch plants and innovation in Canada attests, it is not at all clear that a maquiladora strategy leads to an innovation future. There is much literature to show that it can be a dead end, trapping the community in a dependent, truncated position. There seems to be no venture capital available in the urban region for new technology-based ventures. In addition, the social climate is still promoting employment in large firms, not entrepreneurship in startups. The research base seems to be currently oriented to testing and trouble-shooting with the local industrial community. This is an excellent first step, but only time will tell if the technological and business structures come together in a deeper partnership to form an innovation cluster.

Summary

The following table summarizes our interpretation of the innovation cluster status of these cities. We use a scale of asterisks with 5 being the rating of a mature innovation cluster and 1 having some few basic elements. This is a highly personal and preliminary rating, but does give a more complete picture at a single glance of all the above clusters.

Location	Quality of Life	Knowledge Inputs	Supportive Social Climate	Cluster Management Support	Specialized Inputs	Markets	Knowledge Intensive Firms	Specialized Consulting Services	Integration	Finance	Relative Strength
Porto Alegre	****	****	****	****	***	**	***	**	***	****	1
San Jose	*****	**	*****	*****	**	**	***	**	***	****	1

Curitiba	*****	***	****	****	***	**	***	**	***	*	2
Monterrey	***	****	**	*	***	*****	***	****	***	**	3
Buenos Aires	***	****	**	*	****	****	***	****	*	*	4
Recife	***	**	**	**	***	***	**	**	**	**	5
Havana	***	*****	***	*****	**	*	*	*	***	*	6
Uruguay	*****	**	*	*	**	**	**	***	*	*	7
Relative Strength	1	2	3	3	4	5	6	6	7	8	

The subtotal of points awarded to each location give some preliminary and very rough measure of how we think the regions may compare to each other and to a fully mature cluster. Note how the individual elements show much variation and that there is little consistency for each city. For example, Havana gets a very high rating for its investment in knowledge infrastructure, but very low for business- related potential. On the other hand, Buenos Aires has a very strong service infrastructure, but extremely weak support for an innovation cluster. We rank the cities in terms of relative strength. The cities that appear strongest score about 2/3 of what we might consider the score for a mature innovation cluster, indicating a respectable potential to emerge. Community will to succeed can make a huge difference in these scores, even if the industrial base is small, as in the case of San Jose, Costa Rica. Despite the imprecision of these preliminary data, it is interesting to note that the numbers for Curitiba and Porto Alegre generally coincide with what some business investors agree in terms of the highest growth areas in Brazil and the best places to do business (EXAME, 2000).

In terms of the different cluster elements, it is interesting to note that finance comes up as the weakest element overall, followed by weak integration and then a probable lack of support from specialized consulting services and lack of market support, both local and access to global. On the positive side, some cities have a respectable quality of life. This of course is measured in terms of the amenities available to those with jobs and education, as many of these cities suffer from exteme income disparities in different neighbourhoods. As well, knowledge inputs score high, reflecting the mature and significant investments the public sector has made in education and research over the past decades.

Our tentative conclusions from this exploratory field work? No mature clusters. Significant potential in a variety of countries and cities. The model should be useful if expanded further, for more detailed questionnaires and research.

7.2 Additional Data from the Montevideo Workshop and Literature

Several innovation clusters were named during the electronic conference and discussed during the Montevideo meeting. The participants in the workshop made additional suggestions in a session on the topic, based on criteria elaborated in the first day. These criteria stressed: geographical focus; industrial innovation as the underlying goal; scientific and technical knowledge being the basis for

innovation; invisible social relationships as critical to define the feeling of a community with shared values; the dense interchange of tacit knowledge.

The following list was not discussed afterwards by the group, so it is presented here to show very preliminary and tentative suggestions only. In this list, we add some references to clusters mentioned in the workshop where there has been an academic study, and as well, a few more clusters which the literature discusses, which were not mentioned in the workshop. (We do not repeat references to studies already discussed earlier, eg Uruguay.)

In the workshop, the Argentinian participants indicated that there were no organized clusters, although there have been isolated attempts to create and grow them. In retrospect, we feel they were being far too modest relative to the Brazilian participants, and using criteria much stricter about what should be counted as a cluster. In discussions with the Argentinian participants afterwards, it became obvious that they were referring to fully mature clusters. Therefore, we have added the two for which we found literature analyses, Rafaela and Mar del Plata. It is clear these data are skewed to countries where the participants came from: with no participants from Columbia, Peru, Chile and Venezuela, these countries simply do not appear, unfortunately, in this preliminary list. In addition, this list obviously includes entries that are too small, too weakly innovative or too weakly focussed in a geographical sense to be considered real clusters. For example, the previous section discusses in some detail the three suggestions for clusters in Uruguay, and concludes that both biotechnology and software innovation exist, but they are characterized more by Sutz' model of transitory innovative circuits. The wine industry definitely has some elements of innovation cluster, but it is very new and very small, as well as missing some key elements. For several entries, such as Oceanography in Ensenada Mexico, we have no additional data to give us a better understanding, but we accept this as possible, given the close proximity to the world's largest such cluster, Scripps at La Jolla, California.

Country	City/Region	Focus
ARGENTINA	Mar del Plata[26]	chemistry
		metal-mechanical
	Rafaela[27]	food (agroindustrial)
		metal-mechanical
BRAZIL	Bahia[28]	petrochemicals
	Belo Horizonte	biotechnology
	Cachoeiro de Itapemirim, NovaVenécia	Metal-mechanical, marble and granite
	Campinas[29]	microelectronics
		computer science
		telecommunications
	Curitiba[30]	Telecommunications
		Environmental industries
		software
	Espírito Santo[31]	software
		automation engineering

[26] Gennero de Rearte et al, 1999.

[27] Bosherini, 1999.

[28] Rodas Vera Filho, 1999.

[29] Gomes, 1999; Voyer, 1997.

[30] Krüger Passos, 1999.

	Linhares	furniture
	Londrina	agrobusiness
	Maranhao	Cultivation and processing of soya
	Novo Friburgo	garments
	Paraiba and Ceará	textiles and garments
	Pernambuco State	tropical fruits
		tourism
	Porto Alegre and region	Leather and shoes
		Auto parts
		Farm machinery and implements
		health
		software
	Porto Real	software
	Resende/Porto Real	Automotive parts
	Rio de Janeiro[32]	Deepwater drilling for offshore petroleum around Petrobras
		Electricity technologies around CEPEL/Eletrobrás
		Audiovisual entertainment around Red Globo de Televisión
		Software
	Santa Catarina[33]	Electro-metal-mechanical
	(Florianópolis and	Frozen foods
	region)	Textiles and garments
		Ceramics and tiles
	Santa Rita do Sapucaí[34]	electric-electronic
		Fiat network of automotive parts suppliers and the associated metal mechanical complex
	São Carlos	advanced materials
	São Francisco	tropical fruits
	São José dos Campos[35]	aeronautics
	São Leopoldo	computer science
COSTA RICA	San Jose	biotechnology
		software
		ecotourism, environmental technologies & management
CUBA	Havana	biotechnology
MEXICO	Cuernavaca	electronics
		environment
	Ensenada	oceanography
	Guadalajara	electronics (known locally as the Mexican Silicon Valley")

[31] Villaschi Filho, 1999.

[32] Melo, 1999.

[33] Ramos Campos et al, 1999.

[34] Lemos and Diniz, 1999.

[35] Gomes, 1995; de Souza and Garcia, 1999.

	Mexico City	pharmaceuticals
	Monterrey	informatics
	Tijuana	communications
URUGUAY		biotechnology
		wine
		software

7.3 Analysis

Here we consider all together the results of the field studies, the web conference and the literature. Since these data have been presented in a way that errs on the side of being inclusive rather than exclusive, future research should investigate the cases signalled before as having potential for being or becoming innovation clusters. Now we should look at the same set from a more limited, exclusive viewpoint and see what a tighter application of our model will portray. The categorization scheme used is the one developed in Chapter 4.

We categorize all natural resource industrial clusters as dependent or truncated. While they may be functioning industrial clusters, it is our estimation that they have relatively few of the fundamental characteristics that enable them to transform easily into innovation clusters. In earlier research by Tiffin (1989) comp aring innovation strategies in the Canadian mining industry with Finnish strategies, it was seen that the latter was clearly able to create a dynamic innovation cluster, but the Canadian industry was dominated by a strategy promoting import of machinery and equipment from abroad. To our knowledge, this is the strategy overwhelmingly followed by the Latin American resource industries of mining, forestry, oceans and to a lesser extent, agriculture. In both the Canadian and the Latin American cases, the industries are dominated by multinationals using Latin America to produce relatively simple raw materials. More recently, the Canadian industry has been able to create clusters around management, control and instrumentation aspects of resource exploitation, as well as pollution mitigation systems, but it seems doubtful to us that this is happening in Latin America at present, although we stand to be corrected by future research.[36]

In agriculture, there may be noteworthy exceptions that we are ignoring. We therefore considered wine clusters. However, innovation clusters that focus on lower quality wines for mass markets are in our opinion less likely to be the first breeding grounds for transformation to innovation clusters than those that focus on fine quality, specialty products, where knowledge of markets, design, quality and constant innovation are fundamentals instead of low cost, large scale production. Hence our interest in reviewing the Uruguyan case, where this is the niche strategy followed. In the absence of any studies on this topic in Chile and Argentina, we are left not including wine clusters in either country, unfortunately. However, it is very likely that there are candidates for agroindustry innovation clusters, for example in Londrina, southern Brazil, where in addition to the strong agro-industry cluster, there is a committed community will to create a technopol[37]. It would not be realistic to assume that a single crop, however important like soya, could be the basis for an agroindustry cluster,

[36] IDRC is planning to sponsor further research in this area. Personal communication from Dr. Andres Rius of IDRC, Montevideo.

[37] There is a Londrina Techapolis project, created in 1998, and the city is now into its 7th Jornada Tecnológica Internacional de Londrina conference and exhibition. (www.adetec.org.br is the address of the managing group, the Associacao do Desenvolvimento Tecnoógico de Londrina.)

so we exclude this category mentioned in Section 7.2. Brazil's specialty tropical fruit production is so new that, although there is great promise here, we reluctantly choose not to include these entries either at the present time. Smale scale and newness also caused us to remove the Recife initiative in pharmaceuticals, despite its promise for the future.

Automotive parts could be either industrial clusters or dependent-truncated clusters. In our understanding, these sectors, although highly technology-intensive, tend to be largely branch plants controlled by foreign firms, using technology implanted by the head office, much of it significantly off the technological frontier. There will be many small firms involved, under local ownership and management. Ho wever, recent research in this sector by Katz (2000) claims that much of the potentially innovative capacity of small, locally-owned firms has disappeared with the opening of national markets to international competition. In addition, much of this production is not generated within a distinct and limited urban environment, but often involving many different cities and even countries. We include this as a marginal case of an innovative industrial cluster.

There is frequent mention of metal-mechanical innovation clusters. We feel these may be very dynamic industrial clusters of considerable economic importance, with a strong local content, so label them innovative industrial clusters.

Similarly with textiles and garments, leather and footware. Although working with limited knowledge, we do not see the fundamental role of knowledge, science and technology, venture capital, the creation of new products and the integration of new production technology with new products. Mature innovation clusters are definitely possible in these areas, as many studies of the industry in Italy have shown, but to us, these are currently, overwhelmingly, innovative industrial clusters.

Tourism is mentioned several times. Two detailed studies sponsored by CEPAL (Acuña, Villalobos and Ruiz, 2000; Barbosa and Zamboni, 2000) on tourism clusters show they are both industrial clusters in our terminology, and even the mature Costa Rican cluster lacks many elements of an innovation cluster. Therefore, we exclude all the tourism clusters mentioned except for the Costa Rican case, which seems to have very strong stakeholder will and resources to continue to advance, giving it the status in our eyes of a proto innovation cluster.

The Polo Tecnologica Constituyentes in Buenos Aires, we do not consider an innovation cluster, from the limited data at hand. It is based too much on public research institutions trying to find industrial applications and customers, and is not focussed enough. New, technology-based firms do not seem to have a strong presence yet. Obviously, this organization has potential for creating innovaton clusters in a variety of fields over the long term (eg 2 decades of concerted, consistent effort).

The most difficult cases are those where we have insufficient data to make any judgement. Here we have relied on the quality of the source of the data. For instance, in the Mexican cases, the data were supplied by the Montevideo workshop by several Mexicans who were expert in the field and were working on very similar definitions of innovation clusters to what this paper proposes. Therefore, we include them, except for Tijuana, which we feel is more like Monterrey; dynamic, but currently more industrial innovative in character. We label the clusters as shown in the table below as either proto or innovative industrial (Inn.Ind.).

Note in the following table that none of the entries classify as mature innovation clusters. There are a good number of protoclusters, which have some of the most significant elements of an innovation cluster and they have potential to develop farther. Their principle limitations seem to be:

- Extremely limited to non-existent risk equity funding
- Weak and intermittent social interaction and integration
- Lack of specialized consulting services.

Country	City/Region	Focus	Category
Argentina	Mar del Plata	Chemistry, metal-mechanical	Inn. Ind.
	Rafaela	food (agroindustrial), metal-mechanical	Inn. Ind.
Brazil	Bahía	Petrochemical	Inn. Ind.
	Belo Horizonte	biotechnology	Proto
	Cachoeiro de Itapemirim, NovaVenécia	Metal-mechanical, marble and granite	Inn. Ind.
	Campinas	microelectronics computer science telecommunications	Proto
	Curitiba	Telecommunications Environmental industries software	Proto
	Espírito Santo	software automation engineering	Proto
	Linhares	furniture	Inn. Ind.
	Londrina	agrobusiness	Proto
	Novo Friburgo	garments	Inn. Ind.
	Paraiba and Ceará	textiles and garments	Inn. Ind.
	Porto Alegre	Health, software	Proto
	Porto Alegre region	Leather and shoes Auto parts Farm machinery and implements	Inn. Ind.
	Porto Real	software	Proto
	Resende/Porto Real	Automotive parts	Inn. Ind.
	Rio de Janeiro	Deepwater drilling for offshore petroleum around Petrobras Electricity technologies around CEPEL/Eletrobrás Audiovisual entertainment around Red Globo de Televisión Software	Proto
	Santa Catarina (Florianópolis and region)	Electro-metal-mechanical Frozen foods Textiles and garments Ceramics and tiles	Inn. Ind.
	Santa Rita do Sapucaí	electric-electronic Fiat network of automotive parts suppliers and the associated metal mechanical complex	Inn. Ind.
	São Carlos	advanced materials	Proto
	São Francisco	tropical fruits	Inn. Ind.
	São José dos Campos	aeronautics	Proto
	São Leopoldo	computer science	Proto
Costa Rica	San Jose	Software ecotourism, environmental technologies & management	Proto

Cuba	Havana	biotechnology	Proto
Mexico	Cuernavaca	Electronics, environment	Proto
	Ensenada	oceanography	Proto
	Guadalajara	electronics	Proto
	Mexico City	pharmaceuticals	Proto
	Monterrey	Informatics	Inn. Ind.
	Tijuana	communications	Inn. Ind.
Uruguay		wine	Inn. Ind.

To give a visual impression of where the protoclusters are located in Latin America, we present them on a map, each with a star. Note the close correspondance with existing industrial centres in Mexico and Brazil.

8. CONCLUSIONS

1. It is important for Latin America to consider innovation clusters. They seem to grow more firms, grow them faster and make them more profitable than can be done elsewhere. Innovation clusters are seed beds out of which the new knowledge-based economy takes root. Local governments can make successful policy interventions to promote these structures.

2. Although the data are very preliminary and incomplete, it seems likely that there are no mature innovation clusters in Latin America.

3. There are innovative industrial clusters and protoclusters that exhibit a significant number of characteristics that a mature innovation cluster would have. The concept of an innovation cluster is not black and white, on or off; industrial communities evolve and integrate knowledge in many different forms. The leading communities discussed in our report are what we call protoclusters, illustrating not only some of the important characteristics of mature clusters, but most importantly, potential to evolve into mature clusters.

4. With the previous conclusion in mind, we stress that investing in physical infrastructure is not as important as investing in the mechanisms that promote the invisible parts of community and integration. Large scale projects to create science parks and technopols should be approached with great caution as the past experience is so ambiguous about their success and the potential for using up large amounts of scarce resources in an unproductive manner is so high.

5. Innovation cluster development can be stimulated by community will and the will of individual champions. In this sense, we see the potential for growth of innovation clusters in some areas of Latin America as high in the short and medium term future.

6. One of the most obvious strategies to create local innovation clusters is to work with existing industrial clusters. Increasing the availability of venture finance, community integration and linkage with the local science and technology institutions could be a quick and low-cost way of making these structures be more knowledge and innovation-intensive. However, overcoming social barriers limiting cooperation among businesses and linking to universities may prove difficult for some countries.

7. Conversely, it may be difficult to create an innovation cluster in a city without the existence of a strong industrial cluster – except, of course, in areas where the science and technology involved are sufficiently revolutionary that they create remarkably new industrial possibilities, and the markets tend to be global.

9. A DIRECTION FOR FUTURE RESEARCH

It would be appealing if we could conclude with the remarks above, pointing out simply that with more research along the lines already undertaken, we would be well on our way to improving the functioning of public and private investments for innovation clusters. However, there might be a significant technological event intruding on the current situation which will rapidly alter the local nature of innovation clusters as we know them today – the diffusion of Web and Internet. Thus we are obliged to conclude with the following caveat, opening up still more questions.

Ernst (1999) has begun to pose some important questions about how national systems of innovation are beginning to reshape themselves under the simultaneous influence of forces promoting globalization, regionalization and localization. As communications infrastructure rapidly becomes cheaper, better and more widespread, the balance of tacit and codified knowledge exchange and development may shift significantly. Some of the requirements for proximity may weaken dramatically as virtual exchanges on the Web grow.

In a report on this topic to IDRC, Gibson et al (1999) ask: "A key question for the proposal research project for the 21st century, therefore, is how necessary and sufficient is the regional development of

'smart' infrastructure in all its aspects (i.e.talent, technology, capital and know how) or physical infrastructure (i.e.science parks, incubators, and high tech corridors) in the emerging internet-based economy where the movement of knowledge is increasingly through ICT? And it may be asked, which sectors or components of this infrastructure must be physically co-located or digitally networked at different stages of a firms becoming globally competitive."

Lalkaka (1998) ilustrates the potential of the World Wide Web to strengthen the links between different components with the "Netcelerate Web Site" at The Georgia Institute ofTechnology (Atlanta). "This is a virtual community of companies inside and outside the incubator, mentors and accredited investors. It offers selected participants entry to discussion groups, information library, directories of qualified accountants, lawyers and consultants, and access to potential angel-investors" (p. 7). The University of Texas at Austin's IC2 Institute has recently set up a Global Business Accellerator, which is working to provide services from the innovation cluster at Austin to international startup firms; a partial concretization of the concepts elaborated by Gibson et al (1999) about virtual innnovation clusters.

In addition, clusters may be moving into a more complex global environment, as they begin to interact more directly with other clusters and take on complementary or specialized roles. Both Ernst and Saxenian suggest this[38].

[38] "The concept of global production network (GPN) allow us to analyze the globalization strategies of a particular firm with regard to the following four questions: 1) Where does a firm locate which stages of the value chain? 2) To what degree does a firm rely on outsourcing? What is the importance of inter-firm production networks relative to the firm´s internal production network? 3) To what degree is the control over these transactions exercised in a centralized or descentralized manner? And 4) how do these different elements of the IPN hang together?" (Ernst, D. 1999, pp. 13).

Saxenian states the following: "the creation of regional clusters and the globalization of production go hand in hand, as firms reinforce the dynamism of their own localities by linking them to similar regional clusters elsewhere" (Saxenian, pp.4).

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