What Does It Take to Build a Local Biotechnology Cluster in a Small Country? The Case of Turku, Finland

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ABSTRACT

There seem to be new biotechnology initiatives springing up in almost every country and every region, no matter how big or small. This is the case for both developed countries and many developing countries. At the same time, many studies seem to suggest that the industrial dynamics of the biotechnology sector strongly favor only a few globally important locations. These are characterized by well-established relations between small R&D companies and the presence of venture capitalists, big multinational corporations, and service providers. The tendency of biotechnology clusters to form in certain locations raises some questions. Can all these new initiatives be successful? Can biotechnology research clusters develop and prosper on a smaller scale? The aim of this chapter is to discuss ideas for building successful biotechnology clusters in less-developed places. Using the example of Turku, Finland, the chapter analyzes how public policy and local activity can "fill the gaps" in the innovation system, thereby facilitating the emergence of a biotechnology industry. Although this case study is from a developed country, many developing countries face similar challenges to those Turku has faced.

1. INTRODUCTION

The economic literature of the past decade has often argued that innovation is the most important source of competitiveness, especially for high-tech industries working within global markets. At the same time, it is widely known that particular industries tend to cluster in certain areas and that the clustering of knowledge is an important reason for this phenomenon.

Biotechnology, one of the most prominent new industrial sectors, is typically a very spatially clustered industry. Biotechnology companies are often located close to major universities, hospitals, and research centers, and are sometimes associated with supportive bigger companies interacting with small- to medium-sized enterprises. Moreover, the biotechnology sector usually makes extensive use of external services in R&D—testing, financing, and marketing—which also tend to be located close by.

Biotechnology activities also tend to concentrate strongly in specific areas of the globe. A few local concentrations (such as Cambridge, Massachusetts, and San Francisco/San Jose, California, both in the U.S.A.) are globally dominant.[1] In the past, biotechnology has been very much dominated by the United States and, to a lesser extent, by the United Kingdom.[2] But the past decade has seen a huge increase in biotechnology-related development in many other places. Countries, regions, and cities all over the world have realized that biotechnology is the next big thing following the success of information and communication technologies (ICT).

Previous studies have shown that the industrial dynamics of the biotechnology sector, especially in biopharmaceuticals, strongly favor only a few globally important clusters characterized by well-established relations between small R&D

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companies, venture capitalists, big multinational corporations, and service providers. It would seem to be at least difficult, and perhaps entirely impossible, to develop an industry when some or most of these factors are missing. Nevertheless, the biotechnology industry is growing in many places that may at first seem unfavorable: in developed countries like Finland, but also in many developing countries such as India, China, Brazil, and South Africa.[3]

This chapter analyzes how public policy and local activity can "fill the gaps" in the innovation system so that it is possible for a biotechnology industry to emerge and grow in seemingly unfavorable places. The basic questions I will answer are: What policies and institutions best support the knowledge generation and dissemination processes of high-tech industries in smaller, more peripheral, or less developed regions? In other words, what are alternative ways of developing a favorable environment for the emergence and development of a local biotechnology concentration? What sorts of relationships between local actors encourage the development process?

My argument is that it is possible, at least to some extent, to compensate for vital resources that may be missing in small economies and clusters. However, there seem to be several basic conditions for success. First, there has to be a substantial local knowledge base (often a university). Second, the national or regional innovation system must compensate for any missing resources (public venture capital, R&D funding, services, and so on). Third, a network of capable local actors (public or private) must develop and strategically direct a local innovation system.

To support the argument that it is possible to compensate for missing vital resources, the chapter analyzes the recent development of the biotechnology industry in Turku, Finland. The development of the biotechnology sector in Finland during the past fifteen years has been largely due to active national innovation policies. In terms of numbers of biotech firms, Finland ranks tenth in Europe.[4] The biotechnology industry in Turku has grown thanks to local activity, and Turku itself is home to the second-largest concentration of biotechnology-related activities in Finland.

The recent rise of biotechnology in Turku is largely due to the fact that it has drawn on decades-old capabilities across a variety of sectors in food processing, pharmaceuticals, and materials sciences. Furthermore, local development activities and a national science and technology innovation program have encouraged development.

It remains to be seen whether or not biotechnology will continue to prosper in Turku. However, this study finds that active policy measures can allow smaller, more peripheral places to attract the interest of biotechnology entrepreneurs.

2. THE BIOTECHNOLOGY INDUSTRY

In this chapter, "biotechnology" refers to a broad range of life sciences (biosciences) and their utilization in medicine, primary production,[5] industry, and services. Biotechnology is a set of powerful tools that employs living organisms (or parts of organisms) to make or modify products, improve plants or animals, or develop microorganisms for specific uses. The Organisation for Economic Co-operation and Development (OECD) defines biotechnology as "*the application of science and technology to living organisms as well as parts, products, and models thereof, to alter living or nonliving materials for the production of knowledge, goods and services.*"

The development of biotechnology can be divided into three phases. Early first-phase biotechnology includes traditional animal and plant breeding techniques, as well as the use of yeast in making bread, beer, wine, and cheese. The second phase started in the 1940s when biotechnology was introduced into modern industry. Modern, or third-phase, biotechnology includes the industrial use of recombinant DNA, cell fusion, novel bioprocessing techniques, and bioremediation. This phase started in the 1970s, when new tools for modifying the genetic structure of living organisms were introduced.[6]

Interestingly, new advances in the biosciences have blurred the boundaries between historically separate disciplines. Biology has begun to overlap with other fields, such as medicine, chemistry, informatics, and physics, thereby increasing the need for interdisciplinary research and bringing different industries closer to each other. Many new technologies developed for molecular biology research, such as high-throughput DNA sequencing, protein structure determination, and gene expression analysis on "DNA chips," are also used in ecology, agriculture, forestry, and the biotechnology and pharmaceutical industries.[7]

The nature of an industry greatly influences how it develops in any given location. Biotechnology is very demanding in terms of R&D. Bioscientific research is also time-consuming and requires methods and instrumentation that are rapidly evolving and expensive.[8] Because the cost of R&D is so high, funding becomes especially crucial for both universities and industry. Furthermore, many biotechnology innovations are based on basic research, which means that the time from innovation to market is very long.

Cooke[9] has observed that the focus of knowledge creation has changed. In the past, the world of pharmaceutical R&D was dominated by large multinational companies (MNCs). However, there is growing evidence that university or public laboratory research with associated spinouts and dedicated biotechnology firms (DBFs) are now responsible for most knowledge generation and exploitation, while global MNCs are specializing in distribution and marketing. The combination of two factors—spatially highly concentrated R&D and global marketing and distribution strategies—means that the innovation system in biotechnology has become both highly regionalized and highly globalized. The tendency of biotechnology activities to congregate means that local clusters of biotechnology activities are an important unit of analysis.

3. ON INDUSTRY CLUSTERING AND KNOWLEDGE

This chapter focuses on local concentrations of biotechnology-related activities. The first studies on the economics of territorial agglomeration were in the nineteenth and early twentieth centuries: the works of Marshall.[10,11,12] Traditional analysis of spatial clustering tries to analyze the advantages that firms get by locating near to each other (localization economies). According to Malmberg and Maskell[13] there are at least three factors that traditionally encourage spatial clustering:

1. Reduced costs of producing and maintaining a dedicated infrastructure and other collective resources
2. Well-functioning markets for specialized skills
3. Reduced interaction costs for co-located trading partners

In the last few decades, researchers have tried to explain the relationship between the spatial clustering of firms and the innovation process. Several different approaches have been developed, including innovative milieu, new industrial spaces, spatial clusters of innovation, regional innovation systems, and learning regions.[14] The topic has become more relevant in recent years because technological change and globalization have led to intrinsic economic changes.

Globalized markets, increased competition, and the development of information and communications technologies have forced companies to find new ways of increasing their competitiveness. Furthermore, new scientific developments are occurring all the time. This combination of external pressures and opportunities makes for a very turbulent corporate environment.[15] Companies respond to these pressures in two ways: by specializing and by innovating. They outsource in areas where they are weak and try to maximize the profits of their core competencies through innovation. Both of these strategies tend to create local as well as global connections. Many services and external functions have to operate locally. This is typically because of the economics of scale that local clustering of associated actors brings; economies of time and smaller transaction costs are generated by trust and easy face-to-face interaction. Firms can increase their competitiveness by sharing an infrastructure and by sharing supplier and service networks. In order to facilitate knowledge generation and transfer, companies locate themselves near knowledge sources and each other so they can make better use of local knowledge spillovers[16] and informal types of social interaction that form the basis for innovation and learning.

The fact that knowledge, learning, and innovation are important if an industry is to retain its competitiveness suggests a fourth advantage to spatial clustering:

4. Facilitation of knowledge spillovers, learning, and adaptation

   Local industrial structure with many firms competing in the same industry or collaborating across related industries tends to be dynamic, flexible, and innovative; the existence of a local culture facilitates knowledge transfer. The co-location of firms cuts the expenses of identifying, accessing, and transferring knowledge.[17] There are several reasons why innovation capability is related to spatial clustering:

   - **new knowledge**. Usually difficult to codify and therefore difficult to transfer. New knowledge is best transferred through repeated and frequent face-to-face contacts. Innovation is therefore facilitated by geographical proximity.
   - **knowledge exchange**. Can happen through knowledge spillovers. On the other hand, most actors are unwilling to share crucial information when there is a danger that it could end up in the hands of competitors. Knowledge exchange may happen as a result of long-term cooperation with universities and research institutions.
   - **the availability of a high-level workforce**. A very important requirement for innovation. The mobility of labor, especially in Europe, is lower than the mobility of other resources, and so labor tends to concentrate in certain regions.

All these knowledge-related factors are important because biotechnology typically has a much greater need for basic research and a highly educated workforce than does any other industry. It also tends to collaborate more with universities than do most other industries.[18]

This chapter also investigates the process of cluster formation and the conditions that enable a local biotechnology cluster to emerge and grow. Much of the conventional wisdom regarding successful industry clusters is based on studies of fully functioning innovation systems such as Silicon Valley.[19] However, the conditions under which mature clusters operate are not, in many cases, present at the creation of new clusters. The history of each cluster is unique, suggesting that cluster development is either path-dependent or heavily influenced by chance historical events.[20] The current economic strengths of a particular region are often based on developments and activities that took place over the course of several decades. Examples of this phenomenon are the Research Triangle Park in North Carolina, U.S.A.,[21] Silicon Valley, U.S.A.,[22] and Oulu and Tampere, in Finland.[23]

New clusters often develop thanks to pre-existing local expertise in related fields. Many places with ICT centers were founded in areas that already had expertise in electronics (for example, in Silicon Valley and Oulu). Therefore, it is important to understand both regional assets and the cluster formation process in order to develop policies that will support emerging clusters.

Feldman and Francis[24] have concluded that cluster formation appears to be characterized by three general stages.[25,26] In the initial stage, there are typically few, if any, spinout companies, but there are some needed assets such as large companies and universities. An exogenous shock that lowers the opportunity cost for entrepreneurship (such as a merger and acquisition or a change in the funding environment) tends to encourage active entrepreneurship and the subsequent appearance of new spinout companies.

The second stage is typically characterized by increased interaction between entrepreneurs and their environment.[27] In this stage, the cluster self-organizes in order to better serve its own needs. Various institutions may be created to support the cluster, and these institutions may, in turn, stimulate further innovation and promote localized learning.[28]

In the final stage, the success of the first spinouts and the synergy between them generate new possibilities for other firms in the same field. At the same time, an enhanced innovation environment develops around the cluster (consisting of universities, technology centers, local policy-makers, service providers, and so on). At this final stage of cluster formation, a critical mass of resources provides locational advantages.

4. INNOVATION AND INDUSTRY STRUCTURE IN BIOTECHNOLOGY

The geographical concentration of biotechnology is also the concentration of *knowledge*. Universities and R&D institutions are local concentrations of knowledge and expertise, and they can potentially provide a workforce for local firms. Many knowledge spillovers are local, either because they are based on tacit knowledge or because people are usually well informed about developments inside their own local knowledge base. For example, Jaffe and colleagues[29] show that most knowledge was used within a 50-mile radius of the university from which it originated. Also, the successful development of biotechnology, especially in the early phases, seems to require a considerable amount of tacit knowledge, which itself often relies on short-distance or face-to-face interaction.[30]

The local existence of high-level knowledge and research seems to have more of an effect on the development of biotechnology clusters than do local knowledge spillovers. According to Cooke and colleagues,[31] the biosciences do not typically make wide use of informal local tacit knowledge and face-to-face exchanges, informal networks, or other indirect region-specific assets that are often referred to as untraded interdependencies.[32] Because biotechnology techniques are so specific and specialized, there is typically not much knowledge transfer through social ties or networking between firms. In the early phases of the creation of biotechnology clusters, localization effects seem to be due to the so-called star scientists who are invaluable to R&D and tend to locate near their home universities.[33]

Another factor in the creation of biotechnology research clusters is the increasingly multidisciplinary nature of biotechnology R&D. In many cases, development work requires a heterogeneous set of cognitive skills and, therefore, a need for transdisciplinary network relationships that are most easily found within a larger concentration of related activities.[34]

What Cooke and colleagues call "exploitation knowledge"—that is, the knowledge of how to use basic research for practical applications—is found in clusters for several reasons. As small DBFs rely on research scientists to translate noncodified knowledge so that it can be further developed into commercial products or services, people with experience in both research and industry tend to be magnets for new companies.

In many cases, special services also play an important role. Business services and specialized expert services tend to locate close to key customers and thereby make these locations more attractive to new companies. I suggest that even if R&D companies trade very little knowledge with each other, they interact quite a bit with companies in fields like business expertise and services.

Biotechnology companies tend to be located close to major universities, hospitals, research centers, and sometimes supportive larger companies that interact with small- to medium-sized enterprises. At least initially, most new ideas and spinouts seem to originate from universities. However, Feldman argues that even though universities seem to be necessary for the development of biotech research clusters, the mere existence of a large knowledge base is not always enough.[35] Orsenigo argues that the existence of a strong scientific base does not guarantee that new companies will start up or that an industry will emerge.[36] There is also no firm correlation between the number of spinouts and either university financing or the number of patents applied for.[37]

As a biotechnology research cluster develops from the "science stage" to commercial application, the cluster may become dependent on a few bigger anchor firms. Larger companies can act as pools of skilled labor and demand special inputs such as specific products and services that may benefit smaller spinouts.[38] Large established companies can also act as sources for new entrepreneurial activity in the form of spinouts or outsourcing.

The mechanisms of co-location and spatial clustering seem to be especially strong in the biotechnology industry. However, the presence of favorable conditions (for example, a strong science base and a working labor market) is insufficient to explain why an industry develops in a particular region. Favorable conditions in a particular locale may encourage the establishment of an industry, but its growth is determined by other factors: its structure, technological change, economic factors, and changes in the institutional base and local development policies.

4.1 *Typical characteristics of successful biotechnology clusters*

Many studies and strategy papers have analyzed the factors that are needed for the biotechnology sector to prosper, and most of them have come to similar conclusions. They emphasize the role of a strong science base, a skilled workforce, supportive infrastructure, and the availability of services and financing. A British study[39] identified the following factors for successful biotechnology clusters:

- a strong science base
- an entrepreneurial culture
- a growing company base
- the ability to attract key staff
- the availability of financing
- appropriate premises and R&D infrastructure
- the close proximity of business support services and large companies in related industries
- a skilled workforce
- effective networks (for example, associations and cluster councils)
- supportive (national, regional and local) government policies

Although many industries benefit from the factors listed above, they apply especially well to biotechnology. Biotechnology is a science-driven business,[40] which means that clustering often occurs in close proximity to key knowledge centers, usually universities or public research institutes conducting top-level research. Because this knowledge is very often tacit and tied to individual researchers or research groups, effective utilization requires close interaction between actors and multilevel partnerships.

According to Cooke,[41] because research tends to concentrate near the key magnets (that is, universities or public research institutes), it favors the development of a localized "biosciences knowledge value chain." (Agglomerations that are more than mere clusters of commercial firms with some links to local knowledge centers are called "megacenters," which seem to be few and far between.) At the same time, the global "biotech boom" means that many countries and regions are investing in biotechnology. This leaves us with some questions: How successful can these initiatives be? Is it possible for smaller and more peripheral biotechnology clusters to survive?

The development of a smaller biotechnology research cluster in Turku, Finland, offers some answers to these questions. The primary data consist of detailed, interviews and analyses of industry statistics; the policy documents of national, regional, and city governments; and previous studies of the development of industrial activities in Turku, especially those conducted between the mid-1980s and 2004. Over a six-month period in 2002, 36 detailed semistructured interviews were conducted with academics (scientists), policy-makers at various levels, CEOs or R&D heads of companies, city officials, and actors in intermediary organizations, such as economic development agencies and hybrid organizations for sectoral growth.

5. THE CASE OF TURKU: DEVELOPMENT OF A SMALL BIOTECHNOLOGY CLUSTER

Turku is home to the second largest concentration (after Helsinki) of biotechnology activities in Finland.[42] Other regions with dedicated centers for biotechnology development are Oulu, Tampere, and Kuopio. There are also many Finnish universities engaged in biotechnology-related research and education. The period 1996–2000 saw the sharpest rise to date in the number of new biotech firms in Finland. Turku underwent a similar growth spurt, with most new biotechnology companies emerging during the 1990s.[43] Biotechnology companies that were started in the period 1998–2000 can be broadly categorized as biomedicine (37%), diagnostics (31%), biomaterials (13%), and "other" (19%).[44,45] However, during the past few years, industry growth has almost stopped, and the number of companies has remained relatively constant.

The Turku region is especially strong in biopharmaceuticals, but its firms are also involved in diagnostics, biomaterials, and functional foods. In March 2006, there were approximately 80 biotechnology-related companies in Turku, employing approximately 3,000 people. Two large pharmaceutical companies, Schering and Orion, conduct R&D in Turku, as do a number of smaller drug discovery companies, such as Tie Therapies, Hormos Medical (a subsidiary of QuatRx), and Juvantia Pharma Ltd. These firms, along with the universities and service companies, form a relatively tight drug-development network.

Although the growth of biotechnology in Turku has been very rapid, the roots of the industry are much older. The first drug companies (Leiras [a Nycomed Co.] and Farmos Ltd.) were established in the 1940s, as was Wallac Inc. (now part of the PerkinElmer group). These mid-sized companies cooperated with the universities when such cooperation was not common practice in Finland. A good example of this is the diagnostic company Wallac, which already cooperated with universities in the 1960s. Interactions with university researchers were institutionalized in many ways, and this culture seems to have diffused to other companies.[46] At the time Wallac also needed a steady supply of professional employees, and the university cooperation provided a good opportunity for them to develop this resource.

Older, larger companies have provided local expertise in business and development activities, as well as labor pools for new spinouts. In fact, many key people in the universities and the smaller companies have worked for these larger companies at some point. Many ideas have also been exported by individual workers leaving their jobs and establishing new start-ups or by dedicated spinout strategies of larger companies.

Several studies have noted that in biotech, the performance, strength, and width of the scientific base are perhaps the most important factors affecting industry development.[47] Indeed, Turku's scientific knowledge base did not emerge overnight: it has been developing since the 1960s or 1970s. Moreover, the level of scientific research in biotechnology-related fields has been on par with top research around the world. The establishment of spinouts owes much to strong academic links with the United States. When the molecular biology revolution occurred in the 1970s, many Ph.D.s and M.D.s from Turku did their postdoctoral research work in some of the best American laboratories. During their time abroad, they witnessed the birth of commercialized biotechnology firsthand and saw the many ways that academics can become involved in the business of medical biotechnology. A few leading researchers subsequently returned to Turku and became intimately involved in the establishment of both the Center for Biotechnology and several promising start-ups.

5.1 *Strong national support for biotechnology research and business*

The Finnish model for supporting biotechnology has been described as a "science-led strategy from above."[48] In Finland, the national innovation system has played a significant role in developing the biotechnology sector. Various government agencies support science-based and resource-intensive businesses. The Academy of Finland funds basic research: TEKES (the Finnish Funding Agency for Technology and Innovation) funds applied research, development, and knowledge transfer; VTT Technical Research Center conducts applied and contract research; and Sitra (the Finnish National Fund for Research and Development) used to provide venture capital funding for small high technology firms particularly in the 1990s.[49] Furthermore, public programs, such as the regional Centers of Expertise, coordinate and focus resources in key industries in many cities. Many of the institutions and organizations affiliated with the national biotechnology innovation system are located in the Helsinki region.

In the late 1980s, the Ministry of Education started the first biotechnology research program. Since then, public funding in the form of various research and technology programs (especially those provided to universities by The Center of Excellence) and public venture capital have all increased tremendously. Roughly 40% of the national R&D budget is spent on the biosciences. TEKES has invested some US$90 million, or 27% of the total amount spent on biotechnology in Finland. The Ministry of Education has also created new centers of excellence in universities. These efforts have paid off: in 2000, nine of the 26 most highly ranked university departments in Finland were in the field of biotechnology.

In Turku, the impact of the national science and technology policy has been remarkable. Partly because local actors have been active in national development programs, the newly dedicated university research units have received a lot of public funding. Public venture capital has also played a big part in the growth of new firms. However, in Turku, national institutions have been used as resources for local activity rather than initiating new activities themselves. Turku was not very visible in the biotechnology industry (compared with, for example, Helsinki) until the late 1980s. In 1987, the Ministry of Education launched a new biotechnology research program that was Helsinki centered, despite the fact that Turku had a biotechnology sector that was not much smaller than Helsinki's. The Turku research community protested this "injustice," and local informal initiatives, designed to increase the visibility of Turku's biotechnology activities, were instrumental in developing a local biotechnology cluster.[50]

5.2 *Local networks and local initiatives facilitate cluster building*

The development of Finnish biotechnology has been aided not only by national policies but also by the local efforts of actors in business, academia, university administration, and city governments. Individuals have promoted change, whether or not they had strategic support from their own institutions; this is important to note because the role of individuals as instigators of change has often been overlooked.[51]

The first changes in Turku's innovation network occurred in the mid 1980s. Particularly important was the first dedicated project for improving biotechnology research, the South-West Finland Biotechnology Project (SWB), started in the mid 1980s. At approximately the same time (1986), the Foundation of New Technology (FNT) was established. This was a very informal organization, composed of approximately 30 people, most of them drawn from industry and academia. The FNT was originally formed to establish Turku's first technology center, DataCity.[52]

The Turku Technology Center Ltd. regional development company is owned by the city of Turku (90%). It consists of two subsidiaries (100% ownership): Turku Bio Valley Ltd. and ICT Turku Ltd. The second stage of the technology center, BioCity, was built in 1989, after DataCity achieved some success. People with different needs joined for a common cause: the real estate business saw a new business opportunity; biotechnology firms saw an opportunity to gain more contacts and influence by cooperating with universities; and universities saw an opportunity to obtain better resources for research and education. Because city governments played a central role in planning five of the seven technology parks existing in Finland in 1989,[53] it is interesting that the city of Turku did not participate in the planning of BioCity.

BioCity has been very important to Turku's biotechnology cluster. It was not merely a physical structure but an ambitious new concept. Its founders wanted to create synergy between industry and academia by gathering a critical mass of researchers in various fields.[54] This critical mass was achieved by establishing new facilities and labs that were jointly administrated by the University of Turku and Åbo Akademi. The universities entered the project not so much because they shared the founders' vision but because they were suffering from a lack of resources. Today, the BioCity Turku research community consists of more than 50 research groups and more than 500 people working in different fields.

A recession in Finland in the early 1990s made local actors and the Turku city government look for new industries to develop. Compared with other mid-sized cities in Finland, like Oulu, Tampere, and Jyväskylä, Turku became active in the local economic development quite late. This was partly because of the local industrial structure—the impacts of economic restructuring in the 1970s and 1980s were not as severe as in many other cities. The Finnish recession and the collapse of the Russian markets, which were important for many local industries, also made local authorities pay more attention to economic development. Since then, the city of Turku has been very active in promoting new industries, particularly biotechnology, and investing in infrastructure. The government has encouraged life-sciences research and commercialization in Turku, partly because the city did not have pre-existing information-technology-related skills and industry like many other midsize cities in Finland.

Local authorities have supported the national Center of Expertise program, which organizes cooperation within the biotechnology sector in Turku. In general, local actors have taken advantage of opportunities provided by national and regional policies regarding science and technology. The use of biotechnology as a leading theme in city marketing should not be underestimated.

5.3 *Turku as a biotechnology cluster*

Turku has created a successful biotechnology cluster, but substantial efforts have been needed to guarantee its success. Below is an analysis of the aforementioned factors for successful biotechnology clusters, as they apply to Turku:

- **a strong science base**. In recent international evaluations, Turku's science base was highly rated.
- **an entrepreneurial culture**. Although many new companies have been created, there is no strong entrepreneurial culture.
- **a growing company base**. The company base has grown rapidly in many fields in the latter part of the 1990s, but there have not been many new DBFs in the past few years.
- **the ability to attract key staff**. So far, employees have come from within Finland. Many companies have noted that Turku is too small to be attractive.
- **the presence of investors**. Missing are MNCs and international venture capital (VC), though domestic VC (especially public) has made up for a lack of international VC. Recently, VC money has been less available and there have been substantial problems in attracting financing.
- **infrastructure**. Generally, the infrastructure for both research and business is very good. The public sector (especially the City of Turku) has recently supported the building of new infrastructure. This has been crucial, since university funding has been tight.
- **business support services and large companies in related industries**. Larger companies do not use local services very much. Many specialized services are in Helsinki and abroad. There are some good local services but the number is still quite small.
- **a skilled workforce**. The local universities have so far provided an adequate source of new employees. The region's traditional strengths in pharmaceuticals and diagnostics provide some experienced people, though not enough. The city is too small to provide an adequate labor pool. There is also a lack of local business expertise.
- **effective networks**. Local networks work effectively. Many of the networks arose voluntarily from local needs and have therefore been very active as opposed to policy-led network initiatives, which often turn out to be rather artificial. Networks linking Turku with the rest of the globe are quite extensive and important for research and commercialization.
- **a supportive policy environment**. National policy has been very important in providing financing for both research and commercial development. Local policy is increasingly supportive of infrastructure. University policies have neither helped nor hindered.

Turku has been able to overcome the weaknesses mentioned above for two reasons: strong national support and the ability of local actors to exploit both internal and external resources. The factors contributing to Turku's success can be summarized as follows:

(A) A strong science base with local and international networks
  - Expertise from older, medium-sized companies provided the cluster with the experience and skills that new university-based start-ups often lack.

- Early on, companies established long-term relationships with university researchers, thereby developing a culture of collaboration.
- Pre-existing scientific networks and cutting-edge research in medicine, biology, and chemistry compensated for the lack of local expertise and local institutions, such as business support services, banks, consultancies, and venture capital funds. Strong research ties to the United States, for example, have been very important.
- The difficulty of recruiting foreign employees has been at least partially compensated for by the expertise of Finnish researchers who have spent time abroad.

(B) National policies

- Extensive research funding and education supports the science base.
- The TEKES technology programs support R&D.
- Public VC partly compensates for a lack of foreign VC.
- Local centers of expertise facilitate networking.

(C) Local initiative

- Local initiative has led to improved infrastructure, as well as improved organization in universities and R&D firms.
- The success of Turku has been crucial in influencing national policy-makers to invest in biotechnology.
- BioTurku has brought various actors together, thereby improving the integrity of the local biotechnology cluster.

Despite its relative success in compensating for the missing success factors, Turku still faces problems. First, its small size makes it difficult to maintain local services. Lack of foreign VC is also a potential problem, because public support for biotechnology is limited. Technology transfer mechanisms are still underdeveloped, even though there are close connections between university researchers and companies. In addition, universities do not have a clear strategy for capitalizing on biotechnology research. The biggest problem, however, is that Turku lacks many parts of the value chain. There are few services, venture capitalists, and big MNCs with expertise in commercialization and marketing. This is a problem because external links are usually more difficult and costly to maintain than internal ones, especially for small companies.

6. DISCUSSION AND CONCLUSIONS

A small, peripheral biotechnology cluster can prosper under the right conditions. First, a strong local science base must already exist. Second, there must be a way to compensate for any missing links in the value chain. Turku has been fairly well able to provide adequate conditions for its biotechnology industry. Although its biotechnology cluster is young, quite small, and in many ways peripheral, its development has been successful because of the region's strong science base and well-established strengths in medicine and diagnostics. Both national innovation policies and strong local initiatives have been important in overcoming obstacles.

Several lessons can be learned from the Finnish experience. First, a good educational system is important. There are many ways to compensate for missing links in the value chain, but it is extremely difficult to build new entrepreneurial activity in biotechnology without a good local knowledge base.

Second, human capital formation (in the form of educated people and research groups) should be drawn mostly from the local pool, though it is often necessary to bring in experienced people to work in R&D. It is difficult for developing countries to compete with major research centers in Europe and the United States. However, biotechnology requires the best available scientific knowledge and expertise. If it is difficult to attract people from abroad, locals should go abroad to study, conduct research, and build international networks. It is easier to attract expatriates than it is to attract foreigners.

Third, the development of clusters is path-dependent and based on previous historical events and existing capabilities. It is extremely difficult to build new clusters from scratch. It is therefore advisable to match research activities and start-up formations to the existing strengths of the region. In many countries, this may mean concentrating on specific fields, such as agriculture or health care, in which local expertise is strong. A strong health care system is important for the development of biotechnology because it is a consumer of local products, a source of new ideas, and an environment for testing and clinical trials. It is also important to make good use of the R&D capacity and expertise of existing companies and universities. Many successful clusters in emerging technologies have been created around older but related industries. For example, the biotechnology industry was created around pre-existing food and medical industries in Turku, and the semiconductor industry was created around a pre-existing electronics industry in Silicon Valley.

Fourth, local and national policy support of emergent industries is important, especially if there are problems with the innovation support system. This support can take many forms: substituting public services for missing private services, supporting research, building up a working education and research system, creating a favorable legal and economic environment for new start-up companies, and working to prevent "brain drain."

Fifth, the role of individuals, especially in the early stages of cluster formation, should not be underestimated. The Finnish experience demonstrates that local networks of key individuals increase the capabilities of the cluster as a whole and help different actors achieve consensus. Support for key individuals in enterprises, universities, and research institutes is therefore important, and networking should be promoted.

There is indeed hope that smaller and more peripheral biotechnology clusters can prosper. However, it is also clear that strong, well-designed policy support is needed to overcome the various setbacks that these small clusters tend to face. Of course, there still remains the question of how this should be accomplished. So far, the "Finnish way" has worked quite well, but it is always difficult to determine how well policies and practices will work in the future or how well they will work in other institutional environments. There also remain the perennial questions of how much a government should invest, and how much it would be ready to invest, in a new industry sector such as biotechnology. Success in such endeavors is not guaranteed. ■

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1 Cooke P. 2002. Towards Regional Science Policy? The Rationale from Biosciences. Prepared for Conference on Rethinking Science Policy: Analytical Frameworks for Evidence-Based Policy, SPRU, University of Sussex, 21–23 March 2002.

2 Breschi S, F Lissoni and L Orsenigo. 2001. Success and Failure in the Development of Biotechnology Clusters: The Case of Lombardy. In *Comparing the development of Biotechnology Clusters* (ed. G Fuchs). Harwood Academic Publishers (forthcoming).

3 Thorsteinsdóttir H, U Quach, DK Martin, AS Daar and PA Singer. 2004. Promting Biotechnology in Developing Countries. *Nature Biotechnology*. vol. 22, Supplement.

4 Critical I. 2006. C*omparative study for EuropaBio*. Critical I Ltd. www.finbio.net/download/criticali-2006.pdf.

5 Primary production refers to agriculture, forestry and fishing.

6 Tulkki P, A Järvenisvu and A Lyytinen. 2001. *The Emergence of Finnish Life Sciences Industries*, Sitra Report Series. Helsinki.

7 Biotechnology in Finland. 2002. *Impact Of Public Research Funding And Strategies for the Future Evaluation Report*. Publications of the Academy of Finland. November 2002.

8 See *supra* note 7, p. 15.

9 See *supra* note 1.

10 Malmberg A and P Maskell. 2001. The Elusive Concept of Localization Economies: Towards a Knowledge-based Theory of Spatial Clustering. ISRN working

papers 2.10.2002. May 2001. www.utoronto.ca/isrn/working_papers.htm.

11 Moulaert F and F Sekia. 2003. Territorial Innovation Models: A Critical Survey. *Regional Studies* vol. 37 (3): 289–302.

12 Simmie J. 2001. Innovation and Agglomeration Theory. In *Innovative Cities* (ed. J Simmie). Spon Press. Taylor & Francis.

13 See *supra* note 10.

14 See *supra* note 11.

15 Schienstock G and T hämäläinen. 2001. Transformation of the Finnish Innovation System: A Network Approach. *Sitra Report Series* 7. Helsinki.

16 The concept of knowledge spillover is based on the notion that knowledge cannot be totally appropriated and, therefore, knowledge may spill over across organizations. This is especially true when different organizations work closely in the same fields or have shared networks. Labour mobility, close observation, and information leakages typically provide knowledge spillovers.

17 See *supra* note 11.

18 Cohen W, R Nelson and J Walsh. 2002. Links and Impacts: The Influence of Public Research on Industrial R&D. *Management Science*, 48 (1):1–23.

19 Feldman M and Francis J. 2004. Homegrown Solutions: Fostering Cluster Formation. *Economic Development Quarterly*, May 2004 18 (2):127–137.

20 Kenney M and U Von Burg. 1999. Technology, Entrepreneurship and Path Dependence: Industrial Clustering in Silicon Valley and Route 128. *Industrial and Corporate Change* 8:67–103.

21 Link AN. 2002. *From Seed to Harvest: The History of the Growth of Research Triangle Park*. Chapel Hill: University of North Carolina Press.

22 Sturgeon TJ. 2000. How Silicon Valley Came to Be. In *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region*, p.15-47. Stanford University Press: Stanford, California.

23 Sotarauta M and K Viljamaa. 2003. Mitkä tekijät tekevät kasvukeskuksesta kasvukeskuksen? In *Tulkintoja kaupunkiseutujen kehityksestä ja kehittämisestä. Kooste usean tutkimuksen tuloksista*. (Interpretations about development of city-regions: Compilation of several studies; eds. M Sotarauta and K Viljamaa). pp. 33–64. The Finnish Association of Graduate Engineers. TEK ry. Cityoffset Oy, Tampere.

24 See *supra* note 19.

25 Bresnahan T, A Gambardella and A Saxenian. 2001. "Old Economy" Inputs for "New Economy" Outcomes: Cluster Formation in the New Silicon Valleys. *Industrial and Corporate Change* 10:835–860.

26 DTI. 2003. *A Practical Guide to Cluster Development: A Report to the Department of Trade and Industry and the English RDAs by Ecotec Research & Consulting*. Department of Trade and Industry: London. www.dti.gov.uk/files/file14008.pdf.

27 See *supra* note 19.

28 Maskell P and A Malmberg. 1999. The Competitiveness of Firms and Regions, 'Ubiquitication' and the Importance of Localized Learning. *European Urban and Regional Studies* 6:9–25.

29 Jaffe A, M Trajtenberg and R Henderson. 1993. Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. *Quarterly Journal of Economics*, 108:577–598.

30 Zucker L, M darby and M Brewer. 1998. Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises. *American Economic Review* 88(1):290–306.

31 Cooke P, D Kaufmann and C Levin. 2003. The Biosciences Knowledge Value Chain and Comparative Incubation Models. Paper prepared for Regional Studies Association Conference on Reinventing Regions in the Global Economy 12-15 April 2003. Scuola Superiore Sant' Anna, Pisa, Italy.

32 Storper M. 1995. The Resurgence of Regional Economies, Ten Years Later: The Region as a Nexus of Untraded Interdependencies. *European Urban and Regional Studies* 2:161–221.

33 See *supra* note 28.

34 Orsenigo L, F Pammolli and M Riccaboni. 2001. Technological Change and Network Dynamics: Lessons from the Pharmaceutical Industry. *Research Policy* 30:485–508.

35 Feldman M. 2002. The Locational Dynamics of the U.S. Biotech Industry: Knowledge Externalities and the Anchor Hypothesis. Plenary Paper for DRUID's New Economy Conference, June 2002. 4.4.2003. www.druid.dk/conferences/summer2002/Papers/Feldman.pdf.

36 Orsenigo L. 2001. The (Failed) Development of a Biotechnology Cluster. The Case of Lombardy. *Small Business Economics* 17: 81-82.

37 See *supra* note 35.

38 See *supra* note 19.

39 Biotechnology Clusters. Report of a team led by Lord Sainsbury, Minister for Science. Department of Trade and Industry. August 1999. Internet Article 3.2.2003. www.dti.gov.uk/biotechclusters/bioclust.pdf.

40 Cooke P. 2003. The Evolution of Biotechnology in Three Continents: Schumpeterian or Penrosian? *European Planning Studies* 11 (7):757–763.

41 See *supra* note 1.

42 Part of this section is based on: Srinivas S and K Viljamaa. 2003. BioTurku: "Newly" innovative? The Rise of Bio-Pharmaceuticals and the Biotech Concentration in Southwest Finland. M.I.T. IPC Local Innovation Systems Working Paper 03-001.

43 Orava M, M Brännback, M Renko, S Suoniemi, S Söderlund and P Wiklund. 2001. Turun bioalan riskianalyysi [Risk analysis of the Bioindustry in Turku]. Innomarket, Turku School of Economics and Business Administration. FINBIO.

44 Finnish Bioindustries 28 November 2003. www.finbio.net.

45 Turku Biotechnology Strategy. 2004. Bio Turku. Unpublished policy document.

46 See *supra* note 42.

47 See *supra* note 2.

48 See *supra* note 1.

49 See www.research.fi for a more thorough description of the Finnish national innovation system.

50 BRuun H, M Höyssä and J Hukkinen. 2001. Networks of Ephemeral Empowerment: The Birth of a Biotechnology Centre in Turku, Finland, *Technology, Society, Environment* February 2001. Helsinki University of Technology Laboratory of Environmental Protection, 53–70.

51 Walcock SM. 2002. Analysing an Innovative Environmnet: San Diego as a Bioscience Beachead. *Economic Development Quarterly* 16 (2): 99–114.

52 See *supra* note 50.

53 Höyssä M. 2001. Teknologiakeskusta tekemässä. Biocity-hankkeen vaiheet ideasta osaamiskeskuksen osaksi. [Making a technology park] Unpublished study.

54 See *supra* note 50.

55 See *supra* note 44.