Biotechnology in Comparative Perspective

Edited by Gerhard Fuchs

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The biotechnology industry is an extremely important sector in the developed world's economies. This book, with contributions from an international array of experts, explains why biotechnology companies in different countries concentrate in a small number of locations and what accounts for the success some of these companies then go on to have.

This interesting book covers such themes as:

- the role of small firms in US biotechnology clusters;
- geographic clustering in the UK;
- case studies involving the sectors in a cross-section of European companies.

With such international contributions, this book will be of interest to students and academics involved in industrial organisation, innovation studies and business organisation. In addition, professionals with an interest in international business will also find this to be a very useful read.

Gerhard Fuchs is Deputy Director of the Department of Technology, Organisation and Work at the Centre for Technology Assessment in Baden-Württemberg, Stuttgart, Germany.

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Contributors

David B. Audretsch – Ameritech Chair of Economic Development and Director, Institute for Development Strategies, Indiana University, USA.

Tomas G. Bas – Ecole des Sciences de la Gestion, University of Quebec at Montreal, Canada.

Stefano Breschi – Libero Istituto Universitario C. Cattaneo, Castellanza and CESPRI, Bocconi University, Milan, Italy.

Philip Cooke – Centre for Advanced Studies, Cardiff University, UK.

Frederic Corolleur – Institut de Recherche Economique sur la Production et le Développement (IREP-D), Pierre Mendès University, Grenoble, France.

Christien Enzing – TNO Institute for Strategy, Technology and Policy (TNO-STB), Delft, The Netherlands.

Gerhard Fuchs – Centre for Technology Assessment in Baden-Württemburg, University of Stuttgart, Germany.

Gerhard Krauss – Centre for Technology Assessment in Baden-Württemburg, University of Stuttgart, Germany.

Stephane Lemarié – Institut National de la Recherche Agronomique (INRA)/SERD, Pierre Mendès University, Grenoble, France.

Francesco Lissoni – University of Brescia and CESPRI, Bocconi University, Milan, Italy.

Vincent Mangematin – Institut National de la Recherche Agronomique (INRA)/SERD, Pierre Mendès University, Grenoble, France.

Jorge Niosi – Department of Management and Technology, University of Quebec at Montreal, Canada, Researcher CIRANO and Chair of Management of Bio-Industries.

Luigi Orsenigo – Institute of Political Economy, and CESPRI, Bocconi University, Milan, Italy.

Martha Prevezer – Visiting Professor, Economics Department, City University, London, UK.

Gerd Schienstock – Work Research Centre, Research Institute for Social Sciences, University of Tampere, Finland.

Thomas Stahlecker – Fraunhofer Institut für Systemtechnik und Innovationsforschung, Germany.

André Torre – SADAPT, Institut National de la Recherche Agronomique (INRA), Institut National Agronomique Paris-Grignon (INA-PG).

Pasi Tulkki – Work Research Centre, Research Institute for Social Sciences, University of Tampere, Finland.

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1 Biotechnology in comparative perspective

Gerhard Fuchs and Gerhard Krauss

Introduction

Biotechnology is one of the new rising global industries. Companies are making decisions on where to place and support research activities worldwide. Knowledge is moving beyond national boundaries. Despite its global character the industry has a very specific regional flavour; it tends to concentrate in a few specific locations. The issue of regional concentration, however, has been overlooked in much of the more recent research on biotechnology, which covers industry trends, company behaviour and national strategies to promote biotechnology, the effects of national systems of innovation on the formation of the industry, etc. (see Giesecke 2001; Senker and Zwanenberg 2001). These studies have revealed great differences in patterns of innovation. Partial explanations for these differences are provided by the conceptual framework of a national system of innovation (NSI). National case studies confirm that the R&D system, the role of the public sector including public policy, interfirm relationships, the financial system, and the national education and training system are important elements of a NSI. These country-oriented studies also show that the strength of biotechnology companies in France, Germany and in the UK seems to be related to existing national strengths in the pharmaceuticals sector. These explanations, however, leave many important questions unanswered. What accounts for the spatial disequilibrium of biotechnology firms? To what extent are successful regional clusters mirroring or transcending established structures of an NSI? Which relationship actually exists between the pharmaceutical industry and the biotechnology industry, which still mainly consists of small and medium-sized firms and many university spin-offs?

The regional orientation, in addition, has become ever more a focus of public policy discussions. A number of countries (e.g. USA, UK, Germany) have recently started to promote the idea of supporting the development of regional industrial clusters. The OECD has also published important policy statements in this regard. The questions as to what drives clustering in biotechnology, what effects of this clustering can be observed, whether clustering is a sustainable process and whether it can be supported by public and private agencies is nevertheless still under-researched. In the context of regional and industrial development paths the question is whether new industrial sectors primarily develop in new growth regions or in mature industrial regions. So far analysis has provided a contradictory picture. In the extreme some regional planners seem to work on the assumption that clustering firms in the same neighbourhood will in itself trigger innovation. But, as various papers in this volume also suggest, clustering may simply heighten competition intensity and displace otherwise viable firms. Strong policy interventions may be required to shape a regional economy into an institutionally conducive environment for collective learning and business success. There is a growing literature on these issues which concentrates on a mantra-like reiteration of specific concepts such as networking and trust, but is short of detailed empirical analysis. This collection of chapters will try to fill this gap.

Discussing clusters

The book aims to explain why biotechnology companies in different countries concentrate in some few locations and what factors may account for the growth (or non-growth) of this industrial sector. Regional concentrations in North America (USA, Canada) and Western Europe (UK, Germany, Finland, Netherlands) will be analysed, offering truly comparative insights. The question the book then starts out with is the following: Do innovative activities in biotechnology tend to cluster in specific geographical areas? If the answer is positive, what are the determinants of these processes of agglomeration?

Definitions of clusters are abundant and various, yet have several elements in common: specialization, proximity as well as spill-over and synergies. There exists a widespread consensus about these elements as constitutive parts of clusters. Yet there is also a widespread consensus that these elements are open to interpretation, that other elements are also important, and that they imply further so far unresolved questions.

The discussion about clustering leads inevitably back to the seminal work of Alfred Marshall from the turn of the last century. He noted that most industry was concentrated in specific districts: cutlery in Sheffield, cotton in the Manchester area, lace in Nottingham, coal in Newcastle. Marshall also tried to provide an explanation for his observations. These insights were forgotten for a long time, but have received renewed interest over the last two decades. Marshall mentioned three characteristics for clusters which have been amended by a fourth in the more recent discussion:

- Economies of intra-industry specialization: a localized industry can support a greater number of specialized local suppliers of industry-specific intermediate inputs and services, thus obtaining a greater variety at a lower cost.

- Labour market economies: a localized industry attracts and creates a pool of workers with similar skills, which benefits both the workers and their employers.
- Ease of communication among firms: information about new technologies, goods and processes seem to flow more easily among agents located within the same area, thanks to social bonds that foster reciprocal trust and frequent face-to-face contacts. Therefore adoption, diffusion and innovation seem faster and more intense in geographical clusters than in scattered locations. That is, some 'knowledge spillovers' exist which are geographically bounded.
- Public intermediate inputs: local authorities may place a stronger than usual effort in providing support as soon as they recognize the importance of a specific industry for the welfare of the local communities.

The notion of so-called Marshallian districts has recently been challenged from two sides. There are those who claim that new Information and Communication Technologies and especially the Internet have undermined traditional notions of why and where individual companies settle. The Internet (theoretically) provides the possibility for every company to settle anywhere on the globe without losing contact with suppliers and customers and be excluded from a stream of valuable information.

A second line of argument says that it is true that we see agglomeration, but we still know little of what drives these agglomerations and under what conditions agglomeration acts as a beneficial or an inhibiting factor in further economic development in a globalizing world.

With respect to the third of the Marshallian advantages, Krugman insists that knowledge flows are invisible: 'They leave no paper trail by which they may be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that she likes' (Krugman 1991: 53). The co-operation of companies as an advantage, or at least a characterizing element, of clusters has also been put into serious doubt by some scholars, who could detect little actual horizontal co-operation in many of the highly acclaimed clusters. Some scholars like Zeller even state that 'spatial concentration does not necessarily imply the existence of a close network of input–output relations within a cluster' (Zeller 2001: 123). By selecting samples according to the dependent variable (i.e. district success and proximity), investigators have not been able to test the possibility that spatial proximity (1) may be important only under certain conditions, and (2) has variable consequences for firms and networks. The strengthening of global relationships and networking and the demise of some of the old clusters raise the question of whether this has not been the result of too much inbreeding within a crowded area. Parallel to the concentration of firms in a few regions, the creation and maintenance of global innovation networks has to be studied and reckoned with.

Tacit knowledge

The role of geographically bounded knowledge spill-overs is linked to tacitness. Tacitness implies that personal contacts, imitation and frequent interactions are tools which are necessary for knowledge transmission and which are clearly available at a lower cost for firms located within the same city or region. Regional economists have built upon such observation, and added many socio-economic features to the need for agglomeration. In particular, they have pointed out that the transmission of tacit knowledge requires mutual trust, a sharing of language and culture, as well as intense non-business relations. Thus social networks, such as those one can find in areas with a homogeneous social background, appear to be key carriers of tacit knowledge. However, very little is known about the precise ways by which knowledge is actually transferred among people located in the same geographic area.

These questions are particularly important for the case of biotechnology, which is usually considered as a strongly science-based technology and as such is – at least in principle – in large part dominated by the use of abstract and codified knowledge. Under these circumstances, knowledge should be theoretically available to everybody. So, what forces might lead to the agglomeration of biotechnology activities in specific clusters?

Part of the answer may lie in the observation that the mastery of biotechnology required (and still requires) a lot of complementary tacit knowledge. To the extent that the transmission of tacit knowledge is facilitated by geographic proximity, clustering may be a likely outcome. However, the diffusion of innovative activities in biotechnology does not seem to depend only on geographical proximity. So what other factors might be responsible? And is clustering a necessary condition for the development of biotechnology?

Some authors have argued that discoveries in biotechnology are characterized by high degrees of *natural excludability*, i.e. the *techniques* for their replication are not widely known and anyone wishing to build on new knowledge must gain access to the research team or laboratory setting having that know-how. In these circumstances, the discovering scientists ('superstars') tend to enter into contractual arrangements with existing firms (contract or ownership) or start their own firm in order to extract the returns from the fruits of their intellectual human capital.

Thus, it is still an open question as to what relationships actually exist between local and global knowledge links. The contributions in this book help to provide a more nuanced answer; the question of the interdependence of global and regional links is treated especially in the contribution of Gerhard Krauss and Thomas Stahlecker. The relationship between global and local connections also plays a role with regard to firms' market position. In fact, there are some indications that the firms in spatially concentrated and institutionally embedded networks (clusters) are exposed to international and global competition, which tends to be stronger the more the firms are 'high tech'. For that reason they particularly need the support from networks.[1] The question therefore is what form this support should take.

The entrepreneurial regime

Another aspect should be taken into account: unlike the more traditional and already developed or older industries, young high-tech industries are generally characterized by strong elements of what evolutionary economists call an 'entrepreneurial regime' (cf. Nelson and Winter 1982; Winter 1984). In other words, while young firms and start-ups play a minor role in the mature branches of industry, in the young developing and much more turbulent high-tech industries the innovatory contributions of young start-up firms are crucial (cf. Audretsch 1995). Thus these industries can be characterized by a high proportion of young start-up companies. On the other hand, the success of these young high-tech companies largely depends on their embeddedness in an environment of supporting institutions and organizations; the regional and local context is therefore of great interest. Here the study of biotechnology clusters offers the possibility of analysing in more detail the role of 'young' vs. 'old' companies, of global vs. regional/local networks, of competition vs. co-operation and, finally, of regional institutions. In contrast to most of the research on biotechnology, which essentially focuses on the level of the firm, we will study specifically the spatial aspects of this new industry and examine 'biotechnology clusters', each of which features a specific profile, characterized by a strong tension between competition and co-operation, as well as globalization and rationalization, and each of which occupies a specific position in the global economic space.

Particularities of the biotechnology sector

What are the further particularities of biotechnology? One could, first of all, refer to the fluidity of the innovation networks, to the great pace of innovation, as well as to the distinct technological and economic risks and chances. The technological knowledge in this field is radically new and it is therefore possible to open up completely new technological paths: 'Biotechnology represents a competence-destroying innovation because it builds on a scientific basis (immunology and molecular biology) that differs significantly from the knowledge base (organic chemistry) of the more established pharmaceutical industry' (Powell *et al.* 1996: 117). These new technological paths remain rather obscure, and the extremely broad spectrum of possible applications increases further the uncertainty under which biotechnology companies have to make their investment decisions. Due to the high technological risks it is likely that further development is influenced to no small degree by non-technical factors (cf. Tushman and Rosenkopf 1992). The complexity of the new biotechnologies seems to require, even more than in other domains, the systematic bringing together of disparate technological competencies and disciplines. That means that the generation of knowledge and its economic exploitation require intense science-based interactions between the actors, in order to bring together many, sometimes very different competencies. This presupposes a high degree of willingness to learn on the part of the actors. In some of the contributions the outstanding importance of star scientists in the context of the regional clusters and networks is stressed: the interaction between the young biotech firms and the academic scientific community turns out in practice to be crucial and the close coupling of technological progress and academic basic research following from it seems to be a very typical attribute of the young biotechnology industry.

In this context attention should be paid to the work of Audretsch and Stephan (1999) who showed that more than half of the start-up companies they studied were started by scientists having an exclusively academic trajectory and that another quarter founded their firm subsequent to a professional activity in the pharmaceutical industry. Of particular importance for the young biotech firms seems to be the direct, personal relationships to highly qualified and mature academic scientific personalities, who engage themselves for the young start-ups as advisers and/or associates. While it can generally be assumed that basic research is extremely important in the early stages in the development of any technological field, and will diminish in importance during later stages (Faulkner 1994), it can be stated that at present probably no other technological field shows an equally intensive relationship between purpose-free basic research and the research and development activities of young high-technology companies. Several of the contributions in this book consider this close interrelationship with science. The work of Lynne Zucker and Michael Darby is also of major importance in this respect; they conclude that the presence of star scientists is the decisive factor for success, while the role played by local venture capital industry is less important. Similarly, David Audretsch argues that the local presence of such star scientists is an important condition for the development of biotechnology clusters.[2]

In sum, this points out that the continuing access to fresh basic knowledge is vital for young technology firms, especially in biotechnology. In fact, many of the young biotech firms have the option to open up scientific know-how through social networks of academic scientists, because in general they have been founded by university researchers and recruit them as employees (cf. Liebeskind *et al.* 1996). These network relationships offer a number of advantages to the young firms: through direct and above all personalized relationships to academic scientists, information and new knowledge can be exchanged and acquired in the most efficient way. Such networks enable the firms to react more quickly and flexibly to new developments. Finally, networks also operate over substantial distances (Audretsch and Stephan 1996). A network of external experts enables firms to evaluate their own knowledge base critically and to adapt their strategies accordingly. Following Liebeskind *et al.* (1996: 432), it can be said that networking with a broad spectrum of external scientists, first, increases the probability of the company being the first with access to new knowledge and findings. Second, a young biotech company may be able to reduce its own costs, because it has immediate access to publicly financed top-class research, whereas mere market relationships would imply much higher costs. Third, social networks often offer better protection of intellectual property, since not all knowledge is always easily patentable (the appropriability problem). Finally, social networks may represent the only way for a young biotech start-up to access top scientific knowledge, since academic scientists would otherwise be unlikely to transfer their knowledge to the private economy.

The particularities of the biotechnology domain described so far have effects on the relationships between the main actors in the field. The generation of new knowledge that may result in the conception and production of new innovative biotechnological products and services, takes place in biotechnology according to a very specific pattern. The technology is extremely complex, its knowledge base expands continuously and knowledge and competence sources are often broadly dispersed, sometimes over wide distances (Powell 1998). As a consequence, interorganizational learning and cooperation networks develop on a large scale, in order to ensure access to new knowledge and specific competencies (Powell *et al.* 1996). Under conditions of fast technological change and fundamental scientific progress, a single company cannot possibly cover alone all the competencies necessary for technological and economic success. Thus there exists a strong incentive for the actors to co-operate. Inter-organizational cooperation is of existential importance for the actors, in order to gain rapid access to knowledge. This means that cooperation arises, to a great extent, from mere practical motives, since other options are barred for most of the time. Strong international competition, on the one hand, is paired with manifold types of cooperation on the other.

> The simultaneous systematic constraint towards cooperation results [. . .] from the extraordinary dynamic of the generation of knowledge, the close coupling of basic and applied knowledge, the fast technological change and the multidisciplinarity of biotechnological research and development projects, which for a long time it has been impossible to handle even in big enterprises purely through the building-up