1 The Concept of Cluster and the Cleverbio Project

1.1 The Concept of Cluster

Marshall (1920) was one of the first economists dealing with the concept of cluster, observing the creation of industrial districts. Marshall noted the apparent importance of industrial localisation while looking at English industrial regions of the 19th century, noticing the intangible dimensions of localisation, as evidenced in his famous comment about the secrets of industry being in the air. Though Marshall made reference to the technological dynamism of English industrial districts, he did not clearly distinguish between localisation as a means of reducing production costs under conditions of market uncertainty and localisation as an underpinning of the technological trajectory of an industry.

In earlier definitions, indeed, geographical concentration was not seen as a major characteristic of a cluster. Czamanski and Ablas (1979) refer to clusters as "a group of industries connected by important flows of goods and services".

Even Porter (1990) in his first contribution to this issue defines an industrial cluster as a set of industries related through buyer-supplier relationships, or by common technologies, common buyers or distribution channels, or common labour pools. Porter provides a simple definition of two types of clusters: vertical clusters and horizontal clusters. Vertical clusters are made up of industries that are linked through buyer-seller relationships, whereas

horizontal clusters include industries in which the other kinds of commonalities (market, technology, labour force, …) prevails. Geographic proximity emphasises advantages of industrial clusters but is not a prerequisite to their identification.

The geographic concentration as key feature in the definition of clusters appears later in the work of Redman (1994): "a cluster is a pronounced geographic concentration of production chains for one product or a range of similar products, as well as linked institutions that influence the competitiveness of these concentrations (e.g. education, infrastructure and research programs)".

Rosenfeld (1995) strengthened in his definition the concept of geographical concentration, identifying a cluster as "a loose, geographically bounded agglomeration of similar, related firms that together are able to achieve synergy. Firms "self-select" into clusters based on their mutual interdependencies in order to increase economic activity and facilitate business transactions".

Jacobs and DeMan (1996) present more in-depth discussions of the different definitions of industry clusters, although these authors also use the original definitions of Porter concerning vertical and horizontal clusters as the basis for their works. Jacobs and DeMan argue that "there is not one correct definition of the cluster concept … different dimensions are of interest". They expand from the definitions of the vertical and horizontal industry clusters to identify key dimensions that may be used to define clusters. These include: (i) the geographic or spatial clustering of economic activity; (ii) horizontal and vertical relationships between industry sectors; (iii) use of common technology; (iv) the presence of a central actor (i.e., large firm, research centre, etc.); and (v) the quality of the firm network, or firm cooperation. They consider the presence of a central actor as a key feature for a cluster. This represents quite an exception in the literature.

Again Rosenfeld (1997) adds further criteria in defining a cluster including the size of the cluster, the economic or strategic importance of the cluster, the range of products produced or services used, and the use of common inputs. He, however, does not encourage defining clusters exclusively by the size of the constituent industries or the scale of employment, pointing

out that many effective clusters are located in small inter-related industries that do not necessarily have pronounced employment concentrations. According to Rosenfeld (1997), an industry cluster is "a geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue, that share specialized infrastructure, labour markets and services, and that are faced with common opportunities and threats". Rosenfeld's definition clearly emphasizes the importance he places on the role of social interaction and firm cooperation in determining the nature of a cluster. Moreover, the latter definition introduces the importance of specialised infrastructures in creating the prerequisite for the establishment of a cluster.

Recent contributions (Porter, 1998; Swann, Prevezer and Stout, 1998; Cooke, 2000; Feser and Bergman, 2000) strengthen the feature of the geographic concentration, assuming a regional perspective to identify clusters.

To summarise, the key features which play a key role in a cluster are: (i) formal input-output relationships; (ii) buyer-seller linkages; (iii) geographic concentration of firms; and (iv) shared specialised infrastructures. Starting from this, in this work, we assumed as definition of cluster the following: "a geographical concentration of actors in vertical and horizontal relationships, showing a clear tendency of co-operating and of sharing their competences, all involved in a localised infrastructure of support".

1.2 The Advantages from Clustering

The definition of cluster itself suggests that clustering may lead to significant advantages for firms. They may take advantage of the strong demand in the location, the large supply of manpower (even high qualified and specialised), and the network of complementary strengths in neighbouring firms. Particularly in high technology industries, geographical proximity plays another pivotal role in the early stages of the life cycle of a product or technology, facilitating the use and transfer of tacit knowledge that is a key to successful development. Two literature contributions related to this issue need to be mentioned.

Porter in his Adam Smith Address (1998) identifies three kinds of advantages in clustering:

(1) *Productivity advantages*: due to the use of better and cheaper specialised inputs (components or services). These come from minimal inventory requirements and lower transaction costs as for the low distance and for the establishment of high trust relations among companies within a cluster. Moreover, joint purchasing services or shared infrastructures (particularly high-tech facilities) may reduce fixed costs for existing companies and initial investments for new ventures;
(2) *Innovation advantages*: proximity between customers and suppliers facilitates the transfer of tacit knowledge. Moreover, the proximity to knowledge centres offers a strong potential for innovation, allowing critical mass to be gained, particularly for pre-competitive activities (for example basic research). Finally, localised benchmarking among actors in the cluster and the great availability of a qualified labour market can strongly improve the capacity to innovate.
(3) *New business advantages*: due to better circulation of information about market opportunities and potential, barriers and risks for new firms can be lower for the clear perception of unfilled needs.

Another analysis on the clustering phenomenon is presented by Swann, Prevezer, and Stout (1998) in their book *The dynamics of Industrial Clustering*. The authors take in account both advantages and disadvantages of clusters, assuming two perspectives: (i) demand side; and (ii) supply side. Table 1.1 shows the results of their analysis.

Concerning the demand side, major advantages are the following:

- *input-output multipliers*: firms located in the same geographic area may take advantage by a strong local demand and/or stimulate induced activities (e.g. dedicated suppliers or services) as well as the demand by other areas, thus creating a virtuous circle that sustains the cluster growth;
- *hotelling*: the term refers to the theory by the economist Harold Hotelling (1929) concerning spatial competition. He provided the empirical evidence that the location of a new firm within a cluster allows to increase its market share thanks to the existence of incumbents;

Table 1.1 Advantages and disadvantages in clustering (source: Swann *et al.*, 1998).

	Demand Side	**Supply side**
Advantages	• Input-output multipliers • Hotelling • Search costs • Information externalities	• Technology spillovers • Specialised labour • Infrastructures
Disadvantages	• Congestion and competition in output markets	• Congestion and competition in input markets

- *search costs*: the presence of a firm within a cluster may increase its visibility to existent and potential customers allowing them to reducing searching costs;
- *information externalities*: informal relationships favoured by co-location may increase the transfer of tacit knowledge between people working within a cluster;

whereas major disadvantages concern:

- *congestion and competition in output markets*: an increased number of competitors in the same geographic area may reduce, accordingly to microeconomic theories, per-firm sales, prices, profits and growth. These effects, however, actually start to dominate demand side advantages when congestion becomes heavy, suggesting that there may be diminishing (and eventually negative) returns to locating in a cluster as it reaches its maturity.

On the supply side, major advantages are:

- *technology spillovers*: from widespread tacit technology transfer;
- *specialised labour*: the supply of high qualified labour within a cluster is mainly affected by two processes: (i) the ability to generate resources "internally" (favoured by a strong scientific base); and (ii) the ability to attract key people from other geographic areas (related to the visibility of the cluster itself and to the area attractiveness);

- *infrastructures*: the possibility of sharing common facilities, as for Porter, which reduces costs for firms within a cluster.

Disadvantages again refer to congestion and competition in input markets, whether it may be, for example, the cost of real estate or the cost of labour. It is expected that these effects come to dominate for new firms when the cluster reaches its maturity.

It is interesting to notice how both contributions look at clustering as a "spontaneous phenomenon". Possible actions by public actors to increase perceived advantages (e.g. through favourable industrial policies) or to reduce disadvantages (sustaining clusters in their maturity) are not taken into account. Literature contributions concerning the latter aspect, moreover, are rather weak. In most cases, however, particularly in the biotech sector, public interventions actually have been the trigger factor for the birth of clusters.

1.3 The Cleverbio Project: An Overview

This book collects the main results of the Cleverbio Project. "Cluster development and growth in bio-tech: enabling factors and best practices" (Cleverbio) is a project funded by the European Commission within the Fifth Framework Programme, within the topic "Quality of life and management of living resources", Thematic priorities "Research and technological development activities of a generic nature", area "Analysis of social and economic driving forces and of new opportunities in the bioindustries".

The project objective was to define a normative model for cluster approach in the biotech sector, which identifies key mechanisms to favour the growth and development of a cluster and the best practices in use to manage a cluster.

To achieve the above objectives the project has carried out:

- an in-depth study of biotech clusters, examining how they work and identifying the critical factors enabling the growth and development of a cluster in the biotech sector;

- a detailed analysis of dynamics, triggers, barriers and problems related to a cluster, in order to capture the best practices and provide key recommendations.

The concept of cluster is well known and, as we have seen above, there is a wide body of literature. However, most works concentrated on the description of the cluster: who takes part in the cluster, their roles, how the interactions take place, and what are the main advantages of creating and being part of a cluster. Much less attention has been paid to the dynamics of a biotech cluster: how the cluster had developed and continues to develop, which are the key factors enabling at the different stages the cluster to fluorish; and the main problems faced. The project aimed to give an answer to this aspect.

The empirical work consisted of the in-depth analysis of five clusters. They concerned five different countries in Europe: Denmark, Germany, France, Italy, UK. The clusters examined are at different stages of development:

- Cambridge in UK is the most important cluster in Europe and one of the strongest biotech areas at the worldwide level;
- Heidelberg is a major European cluster and one of the strongest in Germany;
- Aarhus in Denmark as well as Marseille in France are at early stages of development;
- Milano in Italy is at an embryonic stage of development but has the potential at both scientific and industrial level to have a strong development in the near future.

Moreover, other clusters have been analysed, such as Paris-Evry (France), Uppsala (Sweden), Biovalley (Switzerland/Germany/France), Bay Area and San Diego (US) to have a more comprehensive sample.

The work allowed to give a description of the cluster looking at the composition of the cluster and the actors taking part to the cluster, the role of each actor, the interactions between the actors, but also how the evolution took place, the main problems to face, and the key decisions taken. The project also examined how biotech clusters have started; what the process

of aggregation of the different actors has been; and how the network is working.

Therefore, the project results allow us:

- to compare the development process of the clusters;
- to identify the key stages of development of biotech clusters;
- to make a cross-country comparison at European level of the different working principles of the clusters;
- to make a cross-stage comparison at European level of clusters at different stages of development;
- to find similarities and differences between different cases and finally common practice to cluster approach which could be recommended to other cases.

The ultimate result of the project is therefore a normative model for cluster approach in biotech. The normative model includes the following aspects:

- the pre-requisites to cluster approach, i.e. the conditions which allow the cluster approach to be adopted;
- the driving forces for cluster growth and development, i.e. key mechanisms enabling the cluster to develop (they will be identified appropriate mechanisms in relation to specific phase of development of the cluster and in relation to specific local conditions);
- the best practices in cluster development and management (in relation to barrier removal, solutions to typical problems to be faced, etc.).

The project length has been 30 months. It started in January 2002 and ended in June 2004. The main activities and the milestones of the project are reported below (Table 1.2).

The first activity concerned the development of the framework of analysis and the definition of the methodology by which the clusters on field were examined (see the Appendix). The second activity was to conduct the empirical analysis. The third activity related to the development of a first version of the normative model for biotech cluster development. The fourth phase related to the pilot testing phase, aimed to test the normative model on field in different contexts. This phase led to the revision of the normative model. In this phase, a workshop was held in Heidelberg where

Table 1.2 The Cleverbio Project: activities and milestones.

Main activities	Milestones	Date
Development of the framework and of the methodology of analysis of the clusters	Framework and methodology of analysis	6 months
Field analysis	Report on the individual clusters	12 months
Development of normative model for cluster approach	Normative model	18 months
Pilot testing	Results from pilot applications and revision of the normative model	24 months
Dissemination	Workshop, symposium, book	30 months

representatives of clusters outside the consortium were invited (Uppsala and Paris-Evry). Finally, there was the dissemination phase, including an open symposium and this book.

Appendix

The Framework of Analysis

The framework of analysis used to conduct the empirical survey is summarised in Table A.1.

A detailed description of the framework where each section is further examined is reported in the Table A.2.

Consortium Members

University of Milano-Bicocca, Department of Biotechnology and Biosciences, Milan, Italy

The Department of Biotechnology and Biosciences of the University of Milano-Bicocca is composed of eight full professors, twelve associate

Table A.1 Framework of analysis.

Area	Sub-area
General information on the cluster	
Key organisations	
Major actors	Large companies Dedicated Biotech Firms Service Companies Universities and public research centers Financial context Incubators and Science parks
Forms of cooperation	Main collaborations Forms of industry — industry collaboration
Human resources	
General context factors	Governmental initiatives Legal environment General acceptance of biotech products Economic and financial context High-tech industry Other organizations and associations
Area attractiveness	
Performance indicators	

professors, ten assistant professors. The Department holds a Master Degree Course in Biotechnology.

It does both research activities and application works related to the application of biotechnology to industry (chemicals) and pharmaceutical (pharmaceuticals and diagnostics). The main areas concern bio-structures, bio-systems, and bio-processes. It also hosts the Centre of Excellence of the Lombardia region aimed to transfer results of biotechnological applications to SMEs in Lombardia. In addition, it is active in areas complementary to the research in hard sciences. Research is done on the management of biotechnological companies, including topics such as: management of research and development projects, financing of start up companies, investment evaluation of R&D projects.

Table A.2 The framework of analysis detailed.

Area	Sub-area	
General information on the cluster		Name or acronym Geographical area Starting year Orientation of the cluster Main fields of application of biotechnology
Key organisation(s)		
Major actors	Large companies	Number For each large company: — Sales and revenues — Employees — Core business — Year of establishment in the cluster — R&D expenses — Major biotech products — Supported biotech spin outs — Not supported biotech spin outs
	Dedicated Biotech Firms (DBFs)	Number Number and name of public firms Number of profitable firms For the most important DBFs: — Sales and revenues — R&D expenses — Employees — Year of foundation — Core activity
Forms of cooperations	Main collaborations (intra- and extra-cluster)	University–industry collaborations Industry–industry collaborations
	Forms of industry-industry collaboration (intra- and extra-cluster)	Project funding Alliances Joint ventures Outsourcing

Table A.2 (*Continued*)

Area	Sub-area	
Human resources		Availability of managers Training services and education Intra-cluster mobility Extra-cluster mobility (attractiveness for key people from abroad)
General context factors	Governmental initiatives	Funding to: — Basic research — Applied research — Technology transfer — Cluster development — Entrepreneurship Tax incentives
	Legal environment	Laws and regulations Intellectual property rights policies
	General acceptance of biotech products	
	Economic and financial context	
	High-tech industry	
	Other organizations	
Area attractiveness		Quality of life Access to transport means Traffic jams Availability of general infrastructures Availability of space
Performances indicators		Number of (profitable) companies Number of patents Number of new products Number of potential products in the pipeline Time-to-market Turn over Growth rate of employees

Team members: Vittorio Chiesa (coordinator), Matteo Barberis, Jonathan Brera, Elena Gilardoni, Davide Chiaroni, Simone Prandin, Matteo Conforti, Marco Pasqua.

Associazione Impresa Politecnico, Politecnico di Milano, Milan, Italy

The Associazione Impresa Politecnico (AIP) is a no-profit association founded in 1993 by the Politecnico di Milano aimed at enhancing the relationships among the Politecnico di Milano and companies. The main aims of AIP are seeking for research opportunities, seeking funds for developing research, managing research projects and promoting the related results.

Team member: Alberto Savoldelli (coordinator).

East Region Biotechnology Initiative (ERBI), Cambridge, UK

ERBI is an industry led initiative which was formally started in mid 1997 as an initiative of the local biotech community and local and national government officials. A grant was obtained originally from the DTI (Department of Trade and Industry). Now ERBI raises the vast majority of its financial requirements from private sources.

ERBI's aim is to enhance the growth and development of biotechnology in Cambridge and the East of England, thereby asserting the region as a world-renowned centre of excellence. To this end, ERBI promotes local, national and international networking; supports successful growth of new and emerging ventures, and ensures that the future infrastructure of the region allows seamless growth of the bioscience community.

Team members: Jeff Solomon (coordinator), Claire Skentelbery.

East Jutland Innovation, Aarhus, Denmark

East Jutland Innovation A/S was founded in 1998 by the Ministry of Business and Industry and is located in the Science Park of Aarhus. The shares of the company are owned by the following: the Aarhus University Research Foundation, the Science Park Aarhus A/S, Jyske Bank, INCUBA A/S, the

County of Aarhus, the Municipality of Aarhus, and the Freshwater Centre in Silkeborg.

East Jutland Innovation's mission is to commercialise new ideas and launch new business ventures. Its primary goal is to invest in ideas from researchers, students, and employees working in the research and development departments. Furthermore, East Jutland Innovation is the Technological Transfer Office for the Aarhus University Hospital, Aarhus University, and the Danish Institute of Agricultural Research with a well established network of entrepreneurial businesses.

Team members: Lars Stigel (coordinator), Gyda Bay, Joern Enggaard.

Heidelberg Technology Park, Heidelberg, Germany

The Technology Park of Heidelberg is an International Science Park with focus on Life Sciences. It is located close to the University of Heidelberg and to international research institutes, and acts in strong relations with them in the management of international research projects and the creation of an excellence pole for scientific and technological research and applications.

It works as a centre of a regional network of information and communication. Its main mission is: (i) to co-operate with the government, national and international institutions; and (ii) to co-operate with the ministries and with the major scientific institutes in Heidelberg.

Team members: Klaus Plate (coordinator), Marion Kronabel.

Ecole Superieure d'Ingegnieurs de Marseille (ESIM), Marseilles, France

Groupe ESIM is an establishment of the Chambre de Commerce et d'Industrie de Marseille-Provence, specialising in higher education and research in engineering services for industries. ESIM has 3 schools of engineers, with 750 students, a staff of 120 persons with 65 lecturers and engineers, and 6 departments for research and technology transfer. In addition to scientific core courses, Groupe ESIM gives a special attention to — and develops — management and communication courses. It is also accredited

to offer postgraduate courses (such as Technological Resources and Total Quality Management, Large Projects and Programs Management).

As a Chambre de Commerce establishment, Groupe ESIM has permanent relations with industries and specifically with SMEs.

Team members: Jean Laporta (coordinator), Françoise Perrin, Zilè Soilihi.