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Biotechnology and Multimedia: Cluster Dynamics in New Industries

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Abstract

The analysis of structures and processes of spatial agglomeration of new firms in the innovative sectors of biotechnology and multimedia seems to be a promising field for listening to the “background noise” of the regional concentration of economic activities. This paper is analysing the differences in the agglomeration tendencies of two economic sectors. Whilst new biotechnology firms are essentially dependent on science and research infrastructure, linkages to the market matter for newly founded multimedia companies. It is argued that differences in the innovation processes bring about distinct requirements for networking and thence lead to diverse forms of firm formation processes. The characteristics of interaction and networking in the early stages of firm foundation and sector evolution have a fundamental influence on the different spatial patterns of economic activity in the two examined sectors.

1 Introduction

Biotechnology and multimedia are newly rising global industries whose specific knowledge base is moving beyond national boundaries. However, despite of this obviously global orientation, the new firms of these industries tend to agglomerate in certain locations, giving it also a specific regional flavour. Looking closer, one may observe that the firms of these newly emerging sectors generally do not concentrate in the same locations. This means, the processes of agglomeration also seem to be driven by sectoral characteristics.

During the past two decades spatial agglomeration and clustering of economic activities have been intensively discussed in economic geography, economics and the social sciences. The cluster concept as used by Michael Porter has received a lot of popularity even beyond the scientific

arena. It has been frequently used in empirical studies as well as in policy deliberations and as a guiding concept for developing new policies (Martin/Sunley 2003). A number of countries (e.g. USA, UK, Germany) started to promote the idea of supporting the development of regional industrial clusters with the aim to improve their regions' competitiveness. The OECD supported this movement by a number of policy statements (OECD 1999, 2001).

The elements, however, leading to the emergence and development of the spatial concentration of economic activities in the mentioned as well as other high-tech sectors, their effects, sustainability and, last but not least, the possibilities of stimulating and supporting clustering by public and private agencies remain still somehow diffuse and continue to be an object of heated discussions (Benneworth et al. 2003, Malmberg/Maskell 2002, Martin/Sunley 2003). It is also debated whether economic clustering and agglomeration will still be matter in the future given the obvious trends of globalisation and the often quoted "death of distance" as a result of the widespread use of new information and communication technologies.

Nevertheless, the spatial concentration of economic activities is an empirically observable fact and there has to be some kind of glue making some places "sticky" in a more and more "slippery space" (Markusen 1996). The research on the spatial concentration of economic activities examines two basic questions (Malmberg/Maskell 2002, Moßig 2002): The first one – *how and why do agglomerations emerge?* – refers to the origin and evolution of the spatial concentrations. The second one refers to the internal structure and dynamics within spatial agglomerations and tries to give answers to the question *which are the advantages for firms located inside agglomerations?* The second one is also the more "classical" question in economic geography and economics related to concepts like agglomeration economies and clustering.

For an understanding of the spatial concentration of economic activities it is important to look at those two aspects. A purely static analysis of existing industrial clusters is not enough. In order to describe, analyse and influence the concentration of industrial activities in certain loca-

tions, a structural view must be paired with an analysis of the dynamic processes of clustering activities as well as the underlying relations and interactions between firms and other actors within the clusters. In order to be able to do this, a comparative examination of two newly arising industries – biotechnology and multimedia in our case – seems to be a promising approach to study agglomeration processes:

- Due to the novelty of the two sectors the processes of spatial concentration are very recent – consequently, one may observe not only the development, but also the originating factors of these processes.
- The sectors of biotechnology and multimedia are rather well researched providing thus a broad vision of their internal structures and characteristics. The issue of regional concentration, however, has been overlooked in much of the recent research.
- The rapid (technological, and accordingly spatial-economic) development is allowing almost real time insights into development *processes* of the two industries in question.
- The two sectors have been (and still are) the object of many policy initiatives in Germany and elsewhere during the last few years.
- Last but not least, the comparison between the two sectors may shed light upon some of the most important factors for the development of spatial agglomerations: the observation that the firms of the two sectors tend to concentrate in different locations may help us understand some of the constituting factors of the spatial concentration itself.

This paper is based on an analysis of the regional development of the biotechnology and multimedia industry in Germany and elsewhere conducted by the authors over the last few years (Braczyk et al. 1999, Fuchs/Wolf 2000, Buhmann et al. 2002, Fuchs 2001, Fuchs/Krauss 2001, Fuchs 2002a, Fuchs 2003).¹ The overall project included an econometric

¹ The empirical research on which this paper is based was funded by the Centre for Technology Assessment (Stuttgart) as part of the project “Multimedia and Regional Economic Restructuring” and by the German Research Foundation as part of the project „Foundation of enterprises under high uncertainty: The prob-

study of the locations of multimedia companies in Germany, two standardised surveys of multimedia-companies in Baden-Württemberg, expert interviews and case studies.

We have structured our contribution as follows: We will first give a review of existing approaches dealing with the clustering of industrial activities, focusing not only on the development, but also on the origin and emergence of clusters (paragraph 2). The aim of this discussion will be to clarify our conceptual approach. In paragraph three the most important characteristics of the two sectors in question will be established and the processes of clustering in the two sectors will be analysed using results from our empirical research. The emphasis will be put on showing the different requirements and development paths of the two sectors (chapter 4). By doing this we want to account for the spatial disequilibrium in the location patterns of firms in these sectors, discuss whether new industrial sectors primarily develop in new growth regions or in mature industrial regions and argue against a popular belief that clustering firms in the same neighbourhood will in itself trigger innovation.

lem of the development of new economic sectors". Furthermore a series of international workshops addressing the issues discussed here were held at and sponsored by the Centre for Technology Assessment.

2 The Agglomeration of Economic Activities in New Industries

2.1 Spatial Agglomeration as a Multi-Dimensional Process

Looking at a map showing the spatial allocation of economic activities, it becomes obvious that there are more or less unbalanced patterns of these activities at almost every geographic scale (Alecke et al. 2004). The explanation and analysis of those spatial patterns are at the very heart of economic geography. Notwithstanding the continuous research activities throughout the 20th century, the subject has undergone some kind of revival during the last two decades. Important milestones have been for example the rediscovery of Marshall's ideas about industrial districts and its empirical application (Belussi/Gottardi 2000, Markusen 1996, Pyke/Sengenberger 1992), network and milieu approaches (Camagni 1991, Fromhold-Eisebith 1995, Maillat 1998), the concept of "Regional Innovation Systems" (Braczyk et al. 1998, Iaksen 2001) and the concept of regional clusters (Martin/Sunley 2003, Porter 1990, 1998, Steiner 1998). The common ideas behind these concepts are that

- (1) locating inside a spatial agglomeration of related actors brings certain advantages for firms, and
- (2) especially the interrelations and interactions between actors matter for the shape and efficiency of the agglomerations.

Regarding the first assumption – agglomeration is normally advantageous –, regional scientists have stated that spatial agglomeration and the co-location of firms bring important benefits to actors (agglomeration economies). Malmberg/Maskell (2002:432f) mention three mechanisms for the existence of those benefits: First, firms can “share the costs for certain collective resources” resulting in “reduced costs for producing and maintaining a dedicated infrastructure and other collective resources.” Second, the labour market will be better equipped if many firms are drawing upon its resources (human capital). Third, firms can reduce “interaction costs for co-located trading partners”. In the study of agglomeration economies there has been a gradual shift of attention since its introduction from the reduction of transport costs via analysing the benefits of buyer-supplier interactions onto an emphasis of studying informal linkages between the different co-located actors in more recent publications (Bathelt/Glückler 2002:128).

However, the concept of agglomeration economies has a fundamental problem. By taking agglomeration simply as a given fact and disregarding its emergence and evolution, its explanation is frequently based on a circular approach (see fig. 1): The emergence of spatial agglomerations is explained by agglomeration economies which themselves are being explained by spatial agglomeration (Krugman 1995:52). This shortcoming shows the importance of regarding not only the beneficial aspects of spatial concentrations, but also the how and why of their evolution.

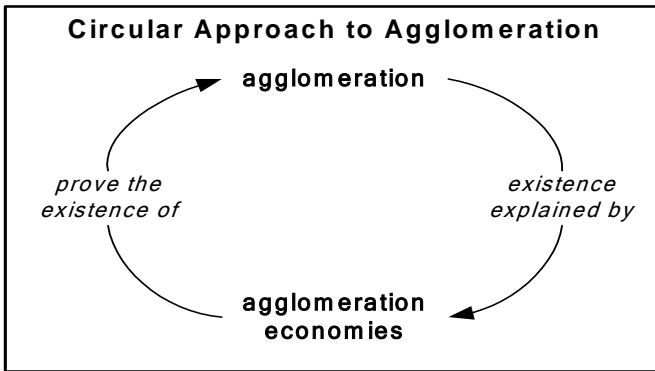


Fig. 1: Circular approach to agglomeration

Several more questions still remain unresolved in the discussion about spatial clustering. There is a problem of scale. What appears to be a spatial concentration on the national level may be, for example, well disappear in space on a regional level (Weterings/Boschma 2002:6, Feser 1998:26). Another problem is measurability – agglomeration per se is not difficult to measure, but it is difficult “to investigate the degree of agglomeration across groups of firms which are related along some other dimension” (Malmberg/Maskell 2002:443). The reason for these problems may be grounded in the serious question about the role and the evolution of spatial agglomerations: Are they a pre-condition for the advantageous development of the actors inside them or are they rather an outcome of underlying social, economic and institutional structures and relations between the actors?

To analyse this question, it seems reasonable to distinguish different dimensions of clustering. Feser (1998) is suggesting to differentiate between an economic dimension, referring to the economic relations between firms (e.g. value chains, buyer-supplier-relationships, cooperation) and a geographic dimension, referring to the spatial relations between the firms. Feser’s systematisation tells us that spatial proximity

does not imply automatically economic proximity (in the sense of relatedness of actors), and that conversely even economically closely related firms must not always locate in spatial proximity. A more detailed perspective can be found in Bathelt/ Glückler (2002:212f), who distinguish the following dimensions of spatial clustering:

- a **horizontal dimension** referring to **similar firms** at the same level of the value chain. This dimension is emphasised especially in the industrial district concept (Markusen 1996).
- the **vertical dimension** of a cluster refers to a concentration of **related firms** along a value chain. Characteristic for this dimension are buyer-supplier relations and user-producer relations. This dimension is regarded to be of crucial importance in theories based on agglomeration economies (Crouch et al. 2001). Input-output relations between firms, undertaking “dissimilar but complementary activities” are in the focus of interest (Malmberg/Maskell 2002:438).

Two things are thus important to consider when analysing clusters: First, spatial concentration of economic activities is rather a *result* of underlying social, economic and institutional structures, processes and linkages than a necessary *pre-condition* for these. This has consequences for the analysis of spatial concentrations of economic activities. What has to be investigated are those underlying structures, i.e. social, economic and institutional linkages of actors. Methodologically, it is important to analyse spatial agglomerations also on the micro-level of the single actor/firm. Second, and subsequently, the processes leading to the evolution of clusters have to be distinguished from those constituting the internal advantages of an existing cluster. In this context, to understand the spatial patterns of economic activity it is essential to investigate the origin of these patterns (Moßig 2002).

2.2 The Emergence and Evolution of Agglomerations

Especially in new industries, studying firm foundations and their spatial context is a promising task for understanding the spatial pattern of economic activities. As industrial structures frequently are highly persistent, the spatial patterns evolving in the early times of the development of an industry often pre-determine its future path. Three concepts are first of all used to address the emergence and evolution of spatial agglomerations (Malmberg/Maskell 2002:431):

First, classic location factors play a certain role in the initial development of the spatial pattern of economic activities. Even if Weterings/Boschma (2002:11) hold that new industries “are confronted with hardly any stimulus from the existing environment. They need new types of specific knowledge, skills, capital, markets and inputs etc. which existing organisations [...] cannot provide. The specific inputs the new industry requires are not yet available in space, because the specific characteristics of existing regional conditions [...] are strongly oriented towards previous technologies”, the assumptions of traditional location theory may not be totally irrelevant. For example, for biotechnology, the existing regional labour market is of relevance regarding the supply of qualified personnel (Niosi/Bas 2001); similarly, for the multimedia sector the availability of clients in spatial proximity is important because of the close producer-client interaction schemes in this industry (see e.g. Brail/Gertler 1999).

The core of the **second** line of explanation is the introduction of some kind of “chance” for the initial location of related or similar firms in a region. This is what Storper and Walker (1989, chap. 3) have further developed into their “theory of geographical industrialisation”. Their basic assumption is that a new industry can originate in a certain location due to the opening of “Windows of Locational Opportunity” (e.g. Silicon Valley began like that). During the times of “open windows”, firms of the new industry have a certain freedom of choice for the location to

start production. After a more or less short period, as firms settle down in a determined area, the windows close. After the windows have closed, the new industries are beginning, according to Storper and Walker (1989), to create their own location factors (like the establishment of a specially trained labour force, common facilities etc.).

The **third** line of explanation is emphasising the foundation of new firms as a central factor for the emergence of agglomerations. Firstly it is assumed that firms and persons, once located at a certain place rarely relocate, even when founding a new firm and having the theoretical opportunity to chose a new location (Malmberg et al. 1996:87; Litzenger/Sternberg 2004). Usually there is no “location scanning” – especially not in the early times of an industry.² Moßig (2001) has shown in a study on the German packaging machinery industry in an impressive way that the firms of this knowledge intensive sector became concentrated mainly in two German regions because of local spin-off processes. Most firms in this sector were founded by a former employee of another firm of the sector using specialised knowledge or already developed products. Spatial concentration emerged as the majority of the founders did not relocate to other regions but stayed at their actual place of residence.³ This phenomenon gets even more surprising by the fact that the founders of the new firms rarely formally co-operate with other actors inside their region.

There is an additional aspect: Unlike the more traditional and already developed or older industries, young high tech industries generally are characterised by strong elements of what the evolutionary economists call an “entrepreneurial regime” (cf. Winter 1984, Nelson/Winter 1982). In other words, while young firms and start-ups play a minor role in mature branches, the contribution of young start-up firms in young developing and much more turbulent high-tech industries for innovations are crucial (cf. Audretsch 1995). Thus these industries can be character-

² There are certainly exceptions to this observation: the foundation of subsidiaries, for example by big firms will be mostly based on “rational” decisions.

³ A study reaching similar conclusions is the one by Dahl et al. (2002).

ised by a high proportion of young start-up companies. On the other side the success of these young high tech companies depends very much on their embeddedness in an environment of supporting institutions and organisations, and therefore the regional and local context is of such a great interest.

The above-mentioned high importance of young and newly founded businesses with regard to innovation is noteworthy. Biotechnology as a young (cross-sectional) technological domain and as a developing industry shows a high share of newly founded and young firms. According to the high importance of non-routinely generated knowledge for innovation, the new biotechnology firms may have innovation advantages vis à vis established enterprises. For that reason, the economic exploitation of new knowledge in many cases is initiated first by start-ups, which, to a great extent, are founded by scientists. Only in a later step, the globally operating large incumbents then will become central for the further development of the technology. This does not mean at all that the big established companies would play a minor role. Actually they must take an interest in the new technologies promoted by the new comers and be prepared to assimilate them. And the young firms themselves have a stark interest in establishing relations to incumbent companies (cf. for instance Walker et al. 1997).

In multimedia things look at first sight similar. Most companies claiming that multimedia is their core competence in the second half of the nineties were new foundations. Bigger companies (from media, publishing etc.) with an interest in multimedia had very often created new independent subunits solely concerned with multimedia products and services. With the growing maturity and sophistication of the market many multimedia firms have been in-sourced into bigger units again and the rate of new firm foundations has gone down dramatically.

2.3 Innovation, Learning and Spatial Proximity

After we have outlined some of the factors relevant for the emergence and evolution of spatial agglomerations it is necessary to have a closer look at existing agglomerations and the ongoing processes within them. Particularly in new industries, it is especially promising to analyse factors of knowledge, innovation and learning and the processes promoting them.

Evolutionary models of innovation and technological change are no longer looking at the process of innovation as a linear sequence from basic research to production and diffusion. Rather, innovation is understood as an interactive process including feedbacks between different actors in production and research. Within this process, knowledge diffusion and learning play important roles. The creation of new knowledge and new technologies is rather seen as the outcome of continuous learning processes resulting from the interaction between various actors during the entire production process and not as the more or less automatic outcome of systematic research. For a single firm, it is thus not only important to be technologically competent, but also to be able to interact and learn (Cantwell/Fai 1999).

These learning and innovation processes involve – to a considerable extent the exchange and transmission of tacit, non codified knowledge. As the exchange of tacit knowledge is frequently threatened by opportunism trust, confidence and reputation become important factors. Due to a higher probability of interaction and face-to-face contacts, spatial proximity enhances these processes (Moßig 2002, Sorenson 2003). Therefore, to the extent that the transmission of tacit knowledge is facilitated by geographic proximity, clustering may be advantageous for innovation processes and learning. Subsequently, most scientists agree that clustering is most significant in newly emerging sectors and/or those sectors depending crucially on tacit and informal knowledge, often in pre-commercialisation stages (Audretsch 1998, Martin/Sunley 2003:22).

The transmission of tacit knowledge requires mutual trust, a sharing of language and culture, as well as intense non-business, mostly informal relations. Thus social networks, such as those one can find in areas with a homogenous social background, appear to be key carriers of tacit knowledge. Very little is known, however, about the precise ways by which knowledge is actually transferred among people located in the same geographic area.

As a consequence a considerable number of new and modified explanations for the spatial concentration of economic activities were developed. Most of the new concepts are moving beyond purely economic and quantitative models and are considering quality-based ideas linked particularly to concepts like evolution, innovation, knowledge, learning or social capital (Malmberg et al. 1996:89; Sorenson 2003). In the focus of the majority of the concepts are the social and economic relations between regionally embedded actors.⁴ This means, the region or the location is not any longer regarded as a container embodying a collection of location factors, but it is rather regarded as “a milieu for collective learning through intense interaction between a broadly composed set of actors. The milieu is both a result of and a precondition for learning...” (Malmberg et al. 1996:91).

In more detail, knowledge accumulation is composed of three interlinked processes: the innovation process as such is requiring repeated interactions between firms, intermediates and users. Face-to-face contacts are important. There are significant barriers to the diffusion of locally embedded knowledge. Insiders have better entry to this knowledge. Third local accumulations of knowledge exert a certain attraction

⁴ The most outstanding concepts are the “New Industrial Districts” (Harrison 1993, Markusen 1996, Pyke/Sengenberger 1992), “Innovative Milieux” (Camagni 1991, Franz 1999, Fromhold-Eisebith 1995), “Regional Innovation Systems” (Braczyk et al. 1998, Isaksen 2001, Wiig/Wood 1995) “Regional Clusters” (Steiner 1998, Feser 1998, Malmberg/Maskell 2002, Moßig 2002, Porter 1990, Porter/Sölvell 1998) and the “Learning Region” (Asheim 1995, Morgan 1997, Hassink 1997).

on outsiders because of their success (Malmberg et al. 1996:93; for an overview of empirical evidence see Tappi 2000).

Usually it is argued that between the companies concentrated in spatial proximity competitive as well as co-operative interrelationships are enhanced by the co-presence at the same location. Malmberg/Maskell (2002) partially doubt that fact and contribute the existence of agglomerations of similar firms also to advantages of *variation* (which not necessarily implies *co-operation* or even close *interaction*), which is “fuelled by the differences between independent firms”. The authors suggest that this variation implies processes of mutual observation and comparison which can initiate learning processes. Indeed, empirical studies on the significance of interaction and learning processes inside regional agglomeration indicate contradictory results and unclear causal relationships so far (Benneworth et al. 2003, Martin/Sunley 2003, Staber 1999).

During the development of agglomeration structures, an institutional landscape emerges “as a response to the special requirements of the activities performed by the firms making up the cluster” (Malmberg/Maskell 2002, p. 441). A specialised mode of learning inside the cluster more or less suited to its requirements is working. This mechanisms tends to “reduce cognitive distance *within* the cluster [and] to increase the cognitive distance *between* clusters” (Malmberg/Maskell 2002:441, accentuation in original). At this point a regional concentration of economic activities can reach the crossroads between beneficial specialisation or detrimental ossification and lock-in.

Indeed, the problem of the spatial agglomeration of economic activities is far from being resolved. There remains a number of shortcomings concerning the theoretical foundation of the concepts as well as their empirical justification. The mere quantity and diversity of concepts examining the same phenomenon may be just an indicator for the unresolved theoretical questions and empirical deficiencies, encroaching also upon the political sphere often applying policy actions based on the new

concepts (Martin/Sunley 2003).⁵ Finally it has to be added that regional agglomeration and cluster studies deal in a variety of forms with the favourable impact of proximity. Most studies, however, treat firms as black boxes and do not link internal organisational learning processes to the external environment. Insofar the dominant meso-perspective in the literature should be linked with a micro-perspective, which is often used in organisational research, which again usually does not account for the role of proximity (cp. Caniels/Romijn 2003).

⁵ There is also a number of articles analysing these shortcomings in detail (see, for example Martin/Sunley 2003, Staber 1999, Malmberg/Maskell 2002).

3 Spatial Agglomeration in Biotechnology and Multimedia

Biotechnology and Multimedia are two of the most widely discussed new technological and economic fields. They are important carriers of hope regarding the labour market, innovations and competitiveness. In the following, we will compile empirical material concerning some of the “background noise” of spatial concentration in these two sectors.⁶ We will first give an overview of the general characteristics of the studied sectors and thereafter go into detail by portraying innovation processes, characteristics of firm foundation as well as interaction and network structures and processes in a comparative manner. We will consider structural as well as evolutionary factors in our analysis. This compilation will lead us to a discussion of the determinants of the spatial patterns of economic activities in new industries.⁷

Both the biotechnology and the multimedia sector are characterised by a highly dynamic development of technologies, firms and markets. Within the last ten to fifteen years, there has been a high number of firm foundations, mainly based on technological innovations. At the same time, above-average firm failure rates indicate the economic risks in these new markets. Recently, the beginning processes of market consolidation have been further supported by the overall economic development. Firm

⁶ The majority of the empirical studies referred to in this chapter were conducted by the authors between 1996 and 2001 (see bibliography). Research concentrated on newly founded firms in the two sectors.

⁷ We are aware of the fact that a comparison between two different sectors is not trouble-free (cf. Swann/Prevezer 1996). Weterings/Boschma (2002:3) even point out the difficulties in analysing the ICT-sector which is in itself highly heterogeneous. For the case of Multimedia we apply a rather narrow definition for the companies analysed (see below).

foundation rates are declining, a lot of previously successful companies have disappeared from the market. At the same time, an increasing spatial concentration of companies in the two sectors is observable, with some places left behind and others growing constantly. Not only in Germany numerous public initiatives were established in order to support the development of new firms and to enhance technology transfer and innovations in these sectors.

However, the two sectors show some significant and important differences in their structure and development, which we will highlight in the following.

3.1 Biotechnology

Biotechnology can be seen as a future-oriented, highly interdisciplinary sector, opening new technological and economic potentials to many other sectors, like pharmaceuticals, agriculture and ecology.⁸ As sources of innovation and differentiation, firm foundations play a crucial role for the development of the sector (Audretsch 2001). Start-ups are able to open new technological paths and to create innovations, which may become integral parts of overall innovation processes. Firm foundations in the biotechnology sector are risky undertakings. They are characterised by high financial requirements⁹, time consuming research and development processes and a high uncertainty regarding the success on the market. The biotechnology sector is thus, even more so in its early

⁸ In this chapter, we concentrate on the so called “red biotechnology” (medicine and pharmaceuticals). The most frequently mentioned further “branches” are green biotechnology (agriculture), grey biotechnology (environmental technology), and, most recently, blue biotechnology (maritime applications).

⁹ Due to long-term and costly product development processes, the quality of the venture capital market is an important factor for the evolution of the biotechnology sector.

stages, characterised by frequent product and firm failures (Dolata 1999:134).

The global evolution of the sector has been highly dynamic over the last years, driven by an increasing economic and societal significance of biotechnological products and processes. However, on a global scale one can observe significant regional differences concerning the economic development of the sector. In the U.S., biotechnology already has entered a somewhat consolidated stage of development with e.g. bigger and older companies and less dynamism (in terms of firm foundations and failures) than in Europe. Inside Europe, the biotechnology industry is characterised by a somewhat lower maturity with more volatile markets, younger and smaller companies and much more firm fluctuation. Germany has recently replaced the UK in hosting the biggest number of biotechnology firms inside Europe. But also in Germany, 2002 was the first year with a decreasing number of firm foundations. The latest biotechnology report for Germany from Ernst & Young (2003) is titled "Time of Probation", thus hinting at the actual processes of market consolidation.¹⁰

¹⁰ Recent statistical data concerning the development of the sector in Germany may be found in <http://www.vci.de/dib> and in Ernst & Young (2003).



Fig. 2: Spatial distribution of Core-Biotech-Companies in Germany 2003 (Source: Ernst & Young 2003)¹¹

¹¹ With friendly permission from Ernst & Young AG Wirtschaftsprüfungsgesellschaft, Mannheim.

Biotechnology firms are concentrated in certain places. This is observable in various regions (see the numerous examples reported in Fuchs 2003 and Fuchs/Krauss 2001) and also on different spatial scales. On a global scale, it is the US and Europe gathering the largest number of biotechnology firms. Inside Europe, Germany and the UK are hosting the majority of biotech companies. And, at the national level in Germany, a majority of firms are concentrated in Munich, Berlin and in the Rhine-Neckar-Triangle (Heidelberg/Mannheim/ Ludwigshafen, see Fig. 2). Further important locations in Germany are minor cities like Tübingen, Freiburg, Regensburg – all of which have powerful science faculties and/or public research facilities. Companies are not located predominantly in metropolitan areas.¹² In the UK, for example, the largest concentration of biotechnology firms is located in Cambridge, which cannot be called a global city. Comparing the development during the last few years, one can observe that spatial concentration is increasing (cf. Ernst & Young 2000, 2002, 2003).

In the biotechnology sector, linkages to the existent economic structure do not play an important role. In its early stages, the location of biotechnology firms seems to be more influenced by (public) research infrastructure than by strong economic actors and/or potential customers (Audretsch 2001, Reiß/Koschatzky 1997:77). For example, Cambridge has no industrial tradition, the big pharmaceutical firms in the Rhine-Neckar-Triangle have not been interested in the biotechnology sector for a long time, and even the centre of biotechnology in the Rhine-Neckar-Triangle – Heidelberg – is far from being an industry-dominated location. The majority of new firms in biotechnology originate directly or indirectly as spin-offs from university research (Niosi/Bas 2003). As a matter of fact, many biotechnology firms are situated in technology centres with close linkages to research facilities.

Most locations with concentrations of biotechnology firms thus feature strong universities or research centres in biology, medicine and the like.

¹² Even if there are some overlaps regarding for example Munich and Berlin in Germany or California in the USA.

Moreover, not only in Germany, in most of the agglomerations of biotechnology companies powerful public support programmes are available (Niosi/Bas 2003). Inside the concentrations, biotechnology firms are located mainly in peripheral areas of the cities, mostly in new innovation and technology centres.

Biotechnology is usually considered to be a strong science-based technology and as such in large part dominated by the use and further development of abstract and codified knowledge. Under these circumstances, knowledge should be theoretically available to everybody. The economic exploitation of biotechnology, however, requires a lot of complementary, predominantly tacit knowledge (Audretsch 2001). To the extent that the transmission of tacit knowledge is facilitated by geographic proximity, clustering may thus be a likely outcome (Sorenson 2003, Tappi 2000).

3.2 Multimedia

Indisputably, the development of new information and communication technologies has not only strengthened the importance of the sector as such but also had wide ranging effects on the economy as a whole. The multimedia sector owes its emergence last but not least to the rapid development of new transmission and data storage technologies. Another very important factor for the rapid development of the multimedia sector can be seen on the demand side. During the last ten years, nearly every firm began to require features linked to multimedia (web-pages, e-commerce etc.).

The technical artefact 'multimedia' is usually described as a combination of several digital media, which are partly time-sensitive (e.g. sound or moving pictures) and partly time-insensitive (e.g. graphics or text) and which can be used in an interactively and in an integrative manner (Braczyk et al. 1999). In its core the multimedia sector is composed of highly specialised multimedia producers and service providers (as, for

example, multimedia agencies, internet designers), and, in its periphery¹³, by a much bigger number of companies of related classes of businesses (like print media, advertisement, software, telecommunication etc.) in whose portfolio multimedia is only one component besides others. Our research deals only with the core group of multimedia producers.

Indeed, not only technical characteristics, but also new and extended possibilities arising by the changing information and communication *behaviour* of the users of multimedia as well as combinations of already available technical and social patterns and features are constituting elements of this new sector (Braczyk 1995).¹⁴ The boom of the multimedia sector in the second half of the 1990s has caused a rapid development of new techniques and services, becoming constantly more integrated with the users of the technologies (user-producer interaction). The combination of relatively low barriers of market entry and minor financial requirements, low technological risks and a high public acceptance has led to high firm foundation rates. Between 1990 and 1996 the number of new firm foundations in Multimedia grew by 500% in Baden-Württemberg, while the rate stayed stable for the economy in general. Firms are mainly SMEs, in their initial phase strongly oriented to regional markets¹⁵. The median firm in Baden-Württemberg employed 4 persons in 1998 and 71% of their turn over was done with customers in the region.

¹³ For the core-periphery model of the multimedia sector cf. Fuchs/Wolf 1999.

¹⁴ A more detailed analysis of the multimedia sector can be found in Fuchs/Wolf (1999, 2000).

¹⁵ Or even to single buyers who have played significant roles in the formation of the new multimedia company (externalisation and/or spin-off-processes).

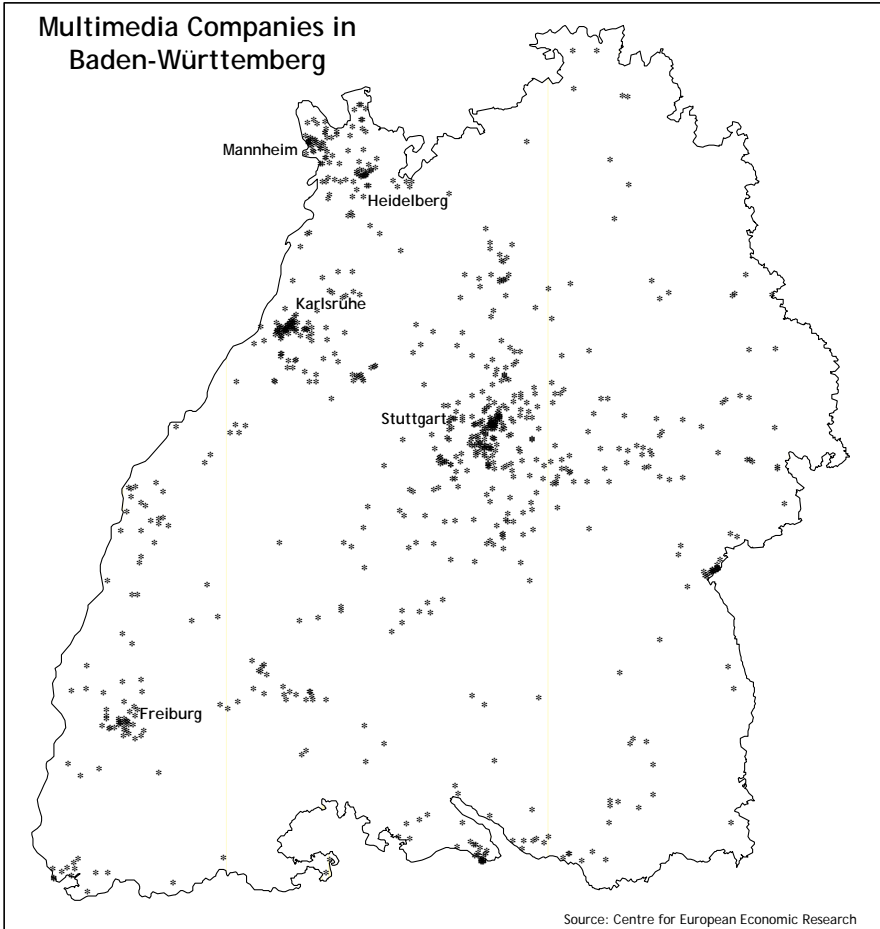


Fig. 3: Spatial distribution of multimedia companies in the German state of Baden-Württemberg (1997)

Those who claimed that the new information and communication technologies and especially the Internet might lead to a “death of distance” seem to be contradicted when observing the spatial patterns of economic activities in the multimedia sector (and by the distribution of economic activities in other sectors as well). Statistical analysis shows that the

firms in the multimedia sector are concentrated mainly in urban agglomerations with dense population, low unemployment rates and a high number of employees in the service sector (see Fig. 3 for Baden-Württemberg, Eckert/Egelin 1997)¹⁶. Looking inside the agglomerations, one can observe that multimedia firms seem to prefer representative locations (e.g. inner city neighbourhoods) featuring interesting architecture (old industrial buildings, army barracks, 'in'-neighbourhoods etc). In the German federal state of Baden-Württemberg, multimedia companies are concentrated mainly in the urban agglomerations of Stuttgart, Mannheim/Heidelberg and Karlsruhe (see Fig. 3).

Just like research institutes and public support in biotechnology, there are bridging elements between innovation and market in multimedia: For the multimedia industry, especially the broad spectrum of the traditional media industry is of significance. The media industry traditionally showed strong regional poles of concentration. These poles are mirrored by the multimedia companies. Multimedia centres in Germany like Hamburg benefit from the presence of publishing houses there, the multimedia cluster in Cologne is mainly dependent on the resident public and private television industry, Munich benefits both from a publishing and movie industry concentration as well as from its closeness to the electronics giant Siemens. The specialisation of the traditional media industry has direct effects on the new multimedia sector, which also gets specialised. In consequence, inside spatial concentrations, it is not the cooperative networks between firms, but rather the connections to clients, which finally are responsible for the differences in the organisation of production, the qualification of the employees and the product specific expertise.

The structures and processes of the agglomeration of economic activities in the two sectors in question can now be summarised as follows (see Fig. 4):

¹⁶ Many of the contributions in Braczyk et al. (1999) reach similar conclusions.

- Firms in both sectors are spatially concentrated; recent empirical evidence is furthermore showing that spatial agglomeration is intensifying.
- While multimedia firms locate principally in metropolitan agglomerations and show strong linkages to (potential) clients, biotechnology firms are mainly located in regions with strong research potentials (not necessarily urban regions). This hints to the different knowledge base of the two sectors: creative vs. scientific.
- For biotechnology firms, the availability of capital, technology centres and political support in spatial proximity is of major importance (Niosi/Bas 2003); for multimedia firms, on the other hand, it is more the representativeness of the location and the linkages to the market that make locations interesting. Insofar there are also clearly different real estate requirements for firms in the two sectors.

Relevance of	Biotechnology	Multimedia
<i>urban agglomerations</i>	+	+++
<i>technology centres and incubators</i>	+++	+
<i>explicit knowledge/basic research</i>	+++	+
<i>financing/venture capital</i>	+++	+
<i>connections to local industry</i>	+	+++
<i>market entry barriers</i>	+++	+
<i>standard employment relationship</i>	+++	+
<i>politics/support and promotion policies</i>	+++	+

Fig. 4: Location factors in Biotechnology and Multimedia (cp. Fuchs 2001)

3.3 Knowledge, Innovation and Market Entry

As has been shown, the patterns of localisation are different in the innovative sectors of biotechnology and multimedia. To analyse the underlying reasons, we will try to elaborate some of the location-relevant specific differences between the sectors. Fundamental differences can be found for example in the innovation processes and the resulting demands for a supportive environment. Behind innovation, it is knowledge evolution (creation) and knowledge diffusion (transfer) determining the emergence and commercialisation of new products, services and firms.

Most firms in the two sectors can be characterised as knowledge intensive companies. Knowledge creation and its transfer between persons, firms and intermediate institutions is playing a crucial role in the process of firm formation, market entry and on the market itself. Nevertheless, one may observe significant differences between the two sectors regarding the role of knowledge and the ways how to integrate it into processes of innovation.

The main reason for the young biotechnology firms' close linkages to (basic) scientific research is to be seen in the importance of explicit knowledge in codified form for the development of their products. A majority of the founders of new biotechnology firms have been (or still are) employees of universities or specialised research institutions, predominantly in biology, chemistry or medicine or are at least strongly linked to these institutions. The result in the spatial dimension is that most biotechnology companies locate close to research institutions. The reverse indeed is not the fact: not every location with an excellent research infrastructure will guarantee the emergence of an economically powerful industry (Audretsch/Stephan 1996). As knowledge is bound to individuals, the existence of powerful intermediate institutions linking excellent research and access to the market is crucial. These intermediates have to function as brokers for acquiring venture capital, purchase orders etc. They serve as bridges between science and market. Scientists

must be able to gain knowledge about the economic utilisation of their ideas. On the other hand, they must be willing to make use of their knowledge by founding a firm. 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).

In the multimedia sector, scientific knowledge is of minor relevance. Research has actually shown that there is a negative relationship between the existence of relevant universities and new firm foundations in this sector (Eckert/Egeln 1997). Emerging enterprises are mainly based on implicit knowledge embodied in the founder of the company. Founders have a very diverse background (coming from sciences as well art or social sciences) but have mostly passed a university type education (cp. Fuchs/Wolf 2000: 30/31). Innovation processes (invention – product development – market entry) in multimedia are less risky, require less knowledge and capital and are thus easier to conduct and more rapid than in biotechnology (see Fig. 5).

Innovation Processes in Biotechnology and Multimedia

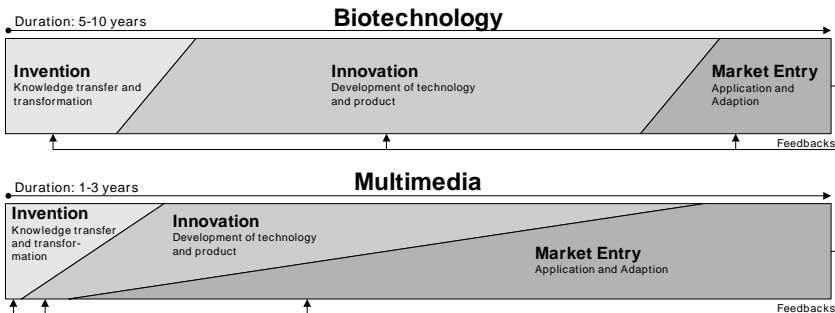


Fig. 5: Characteristics of innovation processes in the biotechnology and multimedia sector

In fact, many of the studied multimedia enterprises were doing invention, innovation and market entry simultaneously. Frequently, products or services were further developed while providing them to customers (user-producer interaction). As a matter of fact, many multimedia enterprises already have customers when starting their company. Another reason for this is that the founders frequently have been working as employees or freelancers in the media or in the ICT-sector beforehand and were able to base their company on the specific knowledge and networks acquired in their former employment (corporate spin-off foundations).¹⁷ Additional innovations are mainly based on these initial fundaments, which provide a certain level of security.

Most of the newly founded firms in red biotechnology trying to develop new products show far more delimited phases within their innovation processes. The companies normally need years to bring their products to the market. The development of biotechnological products is dependent on high financial investments and there exist high degrees of uncertainty regarding the success of products. Consequently, the innovation process and the product development is highly risky in biotechnology, because even in the later stages of the product development, a product and, as a consequence, the whole company may fail.¹⁸

Market entry is the most critical stage of development of a new enterprise. When accessing (or trying to access) the market, the viability of the applied innovation strategies will be revealed. As has been shown, market entry in the multimedia sector is more rapid and a rather continuous process in comparison to biotechnology, where market entry is likewise an abrupt end of a long-term innovation process. For young biotechnology firms, it is especially important to be first-movers and pioneers to realise economic benefits. On the other hand, biotechnological products

¹⁷ Recent research by Koch (2003) revealed, for example, that more than 30 % of the firms in the IT-sector in the Stuttgart region in Germany emerged as such spin-offs.

¹⁸ A strategy to avoid failure applied by many biotechnology firms is diversification (e.g. the provision of services).

are less flexible and may even fail during the final stages of the research and development process. Therefore, once adopted strategic decisions are hard to revise later. The more rapid product development supported by the frequently intense user-producer interactions and learning-by-doing processes requires substantial flexibility for the new multimedia enterprises. Furthermore, multimedia companies are frequently confronted with discontinuous growth caused mainly by a highly dynamic (technological) environment.

The importance of regional linkages also differs with the state of development of a new firm and subsequently a new industry. As Lemarié et al (2001, p.67) state, during the initial phases of a new firm, "the survival and development of the firm depends on the founder's close network of relations" (geographical proximity), whilst later on, when the firm is established, it "builds sound relations in the same scientific, productive and commercial network" (organisational proximity). Due to the extended development stage (time to market) of biotechnology firms, it is probable that geographical proximity is of more importance.

To summarise, the following can be stated: Young biotechnology enterprises mainly depend on *input factors* such as knowledge, capital and innovation. On the regional level, this results in the observable spatial proximity to (public) science and research infrastructures. Moreover, as codified knowledge is a fundamental factor for the emergence and development of a new biotechnology company, many of the founders have been formerly employed by these research institutions and found their firm in spatial proximity to their former employer. Newly founded multimedia companies, on the other hand, are much more dependent on the market (*output side*) in the early stages of their development. Venture capital or even bank credits do not play a decisive role. Among the companies surveyed in 1998 venture capital was available only to 0,4% of the sample and bank credits were used by 27,9% in the foundation phase. In addition, the innovation processes in multimedia are characterised *ceteris paribus* by intense user-producer interaction where new products and services emerge very dynamically. Not only the strong linkages to the market, but also many personal linkages of the founders to their

customers (who frequently were former employers) lead to the decision to locate the new firms close to their (potential) customers.

3.4 Interaction and Networks

By the integration in networks and by active participation in network creation, new companies try to minimise, control and overcome the risks that occur particularly in the early stages of firm development. This can happen by the rather accidental integration into (personal) social networks (Sorenson 2003) or by the deliberate involvement into more or less organised innovation and production networks. Network relationships offer numerous advantages to young firms: Through direct and personalised relationships, information and new knowledge can be acquired, transferred and exchanged efficiently. Networks enable the firms to react quicker and in a more flexible way to technological and economic change. Moreover, networks in a certain way work also over long spatial distances (Audretsch/Stephan 1996). A network of external experts offers the firms the possibility to evaluate their own knowledge base critically and to adapt its strategies accordingly.

As many network relationships are based on close and personal interaction spatial agglomeration of economic activities can be an outcome. Moreover, especially in the early stages of the firm development, as firm founders heavily rely on their personal contacts, mainly local and regional relations are important, while later on the relations could extend to other spatial levels.

Regarding different types of networks in the context of the foundation of new companies, we may differentiate between two general types of networks (see Fig. 6).

	Innovation and Support Networks	Interfirm and Production Networks
<i>Creation</i>	Exogenous or endogenous	Endogenous
<i>Relevance in stage of foundation</i>	Pre-entry and early foundation stage	Early development and growth stage
<i>Cooperation partners in the network</i>	Public and private research and support institutions, companies	Vertically and/or horizontally co-operating firms
<i>Major goals</i>	Information and knowledge exchange. Support, consultancy and financing for company foundations	Resource and risk sharing, flexibility reservoirs, provision of integrated solutions
<i>Relevance for biotechnology companies</i>	+++	+
<i>Relevance for multimedia companies</i>	+	+++

Fig. 6: Types of networks and their relevance in biotechnology and multimedia (based on Buhmann et al. 2002)

- **Innovation and support networks:** These types of networks serve to support innovation processes. They can be characterised by the co-existence (and partial co-operation) of different, mostly public institutions (intermediates) supporting the foundation of new enterprises. These networks are generally open to all participants and have the primordial function to reduce information deficits and to make finances accessible for new companies in early stages of their development. Moreover, they serve to conduct the more and more interactive innovation processes and to establish links between different actors.
- **Interfirm and production networks:** In contrast to the innovation networks described above, interfirm networks are composed of enterprises co-operating on horizontal and vertical levels. Thus, by (formal and informal) market-oriented co-operation, foundation related and sector specific risks can be reduced. These networks are directed towards the production of goods and services.

The significance of different interaction and network structures differs between the two sectors. Whilst biotechnology enterprises tend to be

integrated into existing support and innovation networks, multimedia companies are mainly engaged in self-constructed interfirm networks (Buhmann et al. 2002).

The reason for this can be found in the above described characteristics of the innovation processes which are more time-intensive in biotechnology. Furthermore, young biotechnology firms integrate themselves in a more passive way into existing, mostly public network structures. In biotechnology a co-existence of different network connections of young firms can be observed. Besides virulent competitive arrangements on an international level there are mainly co-operative relations with public science and research institutes on a horizontal level. Relations to other companies are mainly restricted to a vertical level with user-producer interaction, service-oriented arrangements and product-oriented cooperation with selected other companies. These co-operations are mainly restricted to single projects, have rigid time limits and are mostly bilateral (Dolata 1999:136ff). Biotechnology firms are more reluctant to cooperate with other companies due to the sensitivity of their knowledge. Nevertheless, some biotechnology companies try to establish long-term alliances with potential customers like big pharma firms in order to achieve a greater planning reliability. The only real network relations in biotechnology are those between public science and research and the companies. Following Liebeskind et al. (1996: 432) it can be said that networking with a broad spectrum of external scientists firstly raises the probability for the company to be the first to have access to new knowledge and findings. Secondly, a young biotech company may be able to reduce its own costs, because it thus gets an immediate access to publicly financed top research, whereas mere market relationships would imply much higher costs. Thirdly, social networks often offer a better protection of intellectual property, since not all knowledge always is easily patentable (appropriability problem). And finally networks possibly may represent the only way for a young biotech start-up to access top scientific knowledge, since academic scientists otherwise would hardly transfer their knowledge to the private economy.

Multimedia enterprises, on the other hand, are more active in their networks and also contribute to the creation of new networks. For multimedia enterprises, the network integration serves mainly the purpose to access complementary competencies, to balance capacity oscillations and to achieve market power by co-operation with other firms. Our survey showed, that 21% of the companies interviewed routinely co-operated with companies possessing other core competencies and only 12 % co-operated never. The rest co-operated sometimes. In multimedia, furthermore informal networks have a strong influence. Many of the founders of multimedia enterprises are some kind of “yuppies” who frequently meet their peers in order to talk about work, projects and trends. The existence of a “scene” was rated as a location characteristic by questioned firms very high on the agenda. Formal qualification is of minor importance in multimedia – many of the people entered the sector by lateral hire. The project-oriented, mostly short-term character of work in the multimedia sector is supporting local ties.

4 Conclusion: Determinants of Location and Clustering

The aim of this contribution was to analyse the different patterns of agglomeration of economic activity in the new and innovative sectors of biotechnology and multimedia. Both sectors are – due to their early stage of development – mostly dominated by recently founded firms. We have shown that in high tech sectors there continues to be a strong tendency towards clustering – contrary to many expectations. Clustering in the two sectors show commonalties as well as significant differences.

Three interactive factors have been analysed: The foundation of new enterprises, the different innovation processes, and the existing interaction processes and network structures. It has been argued that the foundation of new firms gives the initial impact to the development of the spatial patterns of a new industry. The characteristics of firm foundations on their part are influenced by characteristics of the innovation process and of interaction and network patterns of the new firms in their region. Consequently, the characteristics of innovation processes and interaction schemes influence the spatial agglomeration of economic activities in the two sectors.

The recent processes of intensification of spatial agglomeration in biotechnology and multimedia indicate that two stages in the development of the new industries can already be distinguished: During the very beginnings of the sectors, some kind of location factors seem to be relevant. In biotechnology, the linkages to scientific research and development (and not to existing industry) are of special importance, whilst the multimedia sector demonstrates rather a market orientation and is mainly oriented to the locations of the already existing (media) industry. Later on, during the evolution of the sectors, the initially established structures are self-reinforcing and begin to show persistence. These processes show

elements of what Storper and Walker described in their model of “Geographical Industrialization” (Storper/Walker 1989). In both cases it can also be detected that elements of path dependency are at work. For the case of multimedia the media and information industries are a powerful pole of attraction and for biotechnology the often mentioned research facilities. Insofar the windows of opportunity seem to be open only in some locations – even for the case of new industries.

Both the characteristics of innovation processes and the specific network structures are interdependently linked. The nature of the innovation processes requires the existence or the formation of adequate network structures. In biotechnology, innovation processes are time-intensive, costly and risky; furthermore, they are mainly based on codified knowledge. During the innovation stage, biotechnology firms usually do not have established links to the market. For those enterprises, innovation and support networks formed by research institutions, intermediate agencies and a powerful public support infrastructure are of relevance. As the specialised knowledge of the founders is a basic ingredient for the innovation process (and as founders rarely relocate), the initial spatial cores of the biotechnology sector are located close to research institutions or in places, where public support was provided. In the multimedia sector, innovation processes are mostly short-term, they are frequently integrated into production processes or into service provision. Formalised knowledge and the qualification of the founders is not of major importance.

For multimedia enterprises, contacts to the market are of crucial relevance. As a matter of fact, the multimedia sector is most prospering in places where the demand for multimedia products and services is high, i.e. in urban agglomerations with a strong industry or service sector, even more so in places where the traditional media industry is strong. Moreover, locational opportunities seem to be bigger in the multimedia sector. Consequently, some “soft factors” like representative locations and personal preferences have been playing a major role in the initial stage. Later on, similar to biotechnology, factors of reinforcement and persistence increase spatial concentration.

In more general terms, it can be stated that in the case of the evolution and development of the two examined sectors it was finally the nature of the innovation processes that had the decisive influence on the development of the patterns of the localization of economic activities.

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