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A competing or co-operating cluster or seven decades of combinatory resources? What's behind a prospering biotech valley?☆

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Abstract

The Stockholm-Uppsala region is claimed to be one of the worlds' most expansive biomedical regions, both when it concerns scientific and business activities. Or, as it was formulated in a special section in Nature, October 2001: p. 6. "A world class scientific & business environment". A common explanation to the growing commercial activities in the Uppsala region has been a critical event within the cluster; the restructuring the pharmaceutical company Pharmacia. However, research focus on how resources are combined results in an almost opposite picture. It is in interaction with stable and healthy industrial and academic units that new projects/companies develop. Furthermore, this interacting seems not to be restricted to a biomedical cluster, but stretches over several different places and industrial areas.

Keywords: Interaction; Knowledge development; Value creation; Cluster borders; Networks

1. What is in sight of a cluster approach?

Since the early 1990s, politicians and policy makers have talked about being a host of a "cluster" (an agglomeration of related industries)[1] as something equal to hosting

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[1] Scholars in economic geography use the concept of agglomeration for two empirical phenomena: that economic activities tend to concentrate in certain places and that closely related industries tend to concentrate in certain places (see e.g. Malmberg & Maskell, 2002). The concept of clustering refers to the latter phenomenon.

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an engine that can create positive industrial and societal development. For example, when the Ministry of Science, UK (1999, p. 3) proposed a "fact-finding mission" to examine biotechnology clusters, the goal was to contribute to further cluster development in the UK. "There is a significant body of evidence and economic analysis that demonstrates the importance of clusters to economic growth". (Ministry of Science, UK, 1999, p. 9.) According to Malmberg and Maskell (2002, p. 431), this increasing trust in the positive effects of clustering is an international phenomenon: "Throughout (and beyond) the OECD world cluster-based policies have increasingly been seen as the main option in the field of industrial and regional policy".

Parallel to Manuel Castell's (1996, Vol. 1) proud declaration that during recent decades the forces of globalisation have replaced "space of place" with "space of flows" and made economic activities "deterritorialised", the 1990s witnessed how both academic scholars and politicians became increasingly convinced that the issue of "place and proximity" is closely related to the creation of "competitive advantages". In the words of one of the most prominent proponents of clustering dynamics, business strategist Michael Porter (1998, p. 80), "A cluster of independent and informally linked companies and institutions represents a robust organisational form that offers advantages in efficiency, effectiveness and flexibility".

Besides the traditional explanation of the advantages created by spatial proximity already stressed by Marshall (1890), Porter (1990) emphasises the necessity of strong competition within the cluster: "Vigorous local competition not only sharpens advantages at home but pressures domestic firms to sell abroad in order to grow". (Porter, 1990, p. 119) Thus, in Porter's perspective, which has influenced many scholars in business strategy and economic geography, (including the above-mentioned Ministry of Science, UK report) the agglomeration of several similar companies spurs each to develop unique competitive advantages: "Competitive advantage is created and sustained through a highly localised process". (1990, p. 19) A main advantage of spatial clustering is, according to Porter (1998, p. 181), that it boosts the development of rivalry: "the more intense, the better".

Inspired, in part, by Arthur (1989, 1994) and Krugman (1991), scholars engaged in studies of knowledge development also underline the strong relationship between spatial agglomeration and industrial dynamics. What this rather wide variety of studies have in common, as Boari, Odorici, and Zamarian (2003) point out, is the focus on co-operation among firms within clusters, "as a powerful determinant" of both the prosperity of the cluster and the individual firms within them. For example, Almeida and Kogut (1997) Saxenian (1994) Lorenzoni and Baden-Fuller (1995) Lorenzoni and Lipparini (1999) Boari and Lipparini (1999) Lundvall and Maskell (2000) all emphasise how location, proximity and learning processes affect both industrial structure and dynamics. In the interpretation of Powell, Koput, Bowie, and Smith-Doerr (2002), the strength of clusters is primarily due to the fact that geographic proximity facilitates the spread of innovative ideas among organisational units and companies within the cluster—i.e. clustering creates "knowledge

spillovers'' (Powell et al., 2001, p. 4).[2] Then, once a cluster, including an institutional infrastructure, is established, it will support the transformation of ''knowledge spillovers'' to new solutions preceded by new companies. Or, to use the wording of Powell et al. (2002), the infrastructure of a cluster ''fosters knowledge transfer and the formation of technology-based companies''. If we consider the explanations to one of the worlds' most famous clusters, Silicon Valley, (see e.g. Florida & Kenney, 1988; Schonhoven & Eisenhard, 1988; Saxenian, 1994; Cohen & Fields, 2000) these most often stress the internal social conditions of this region, underlined by concepts such as trust, norms, social capital, etc.

Thus, the dynamic forces of clusters are explained by the close interaction among its members—something that not only facilitates the development of new innovations, but also reduces the uncertainty of the solutions' economic sustainability.

At a first glance the differences between these two different explanations of spatial clustering dynamics is rather impressive. While the authors with a background in studies of knowledge development tend to explain spatial clustering dynamics with the facilitated development of trust, commitment and co-operation, which in turn facilitates knowledge spill-over, authors related to business strategy emphasise how the proximity of related industries boosts rivalry, which in turn boosts innovation. However, these schools also share some important common assumptions.

First, as stressed by Malmberg and Maskell (2002), although cluster approaches represent a wide variety of theoretical assumptions, there is a common focus on explaining the ''permanent advantages'' that accrue to the firms located within clusters. By disregarding the origin and historical development of localised clusters, the most obvious experiences made by scholars with a historical approach are neglected; that sooner or later they not only have to face emergence and prosperity—but also decline. ''This may mean that what was once a leading centre of dynamism within a given line of business ends up as an old industrial region'' (Malmberg & Maskell, 2002, p. 432).

Second, whether focusing upon co-operation or competition as the main driving force of knowledge development and innovativeness, the sources of dynamics are thought to exist within the spatial agglomeration or cluster (Håkansson, Waluszewski, & Tunisini, 2003). It is the conditions within the cluster—characterised by either co-operation, competition or a mix of both—that can explain the prosperity of both the clusters and the individual companies within them. Thus, when stressing the competitive or co-operative aspects of spatial clustering, the common underlying assumption is that the exchange conditions within a cluster differ from those outside it. Close interaction—whether in terms of intense competition or close co-operation—is treated as an exception, something dependent on spatial proximity.

Can it be that the ''power'' that is ascribed to competition or co-operation within clusters has rather vague connections to the empirical phenomenon of industrial

[2] Proximity is regarded as of utmost importance when the knowledge development is scientific, since this type of knowledge is regarded as more ''tacit'' than others, requiring ''face-to-face'' interaction.

development? Is the belief that the exchange pattern within a certain spatial agglomeration or cluster is radically different from the exchange pattern over the borders of different clusters simply a heritage from the model world of traditional economics? A model world where anonymous firms are exchanging homogeneous resources by relying on price signals, where autonomy constitutes normality and interdependency the exception. (Pelikan, 1988). Embedded into cluster approaches; within a cluster exchange is organised, outside a cluster is a market, i.e. a world of non-organised exchange activities. Can this overwhelming attention towards the different exchange conditions within clusters be regarded as a result of forgetfulness? Have we simply forgotten what many economists are aware of—that the assumption of economic behaviour is a strict stylised model world[3]—and embedded these into our research tools as if they were empirical experiences? Or, as McCloskey (1990, p. vii)[4] put it, most often we treat the "stories" told by economists as "stylised facts" or "approximation of the good". A current example of an area that has been interpreted as an utmost competitive cluster, flourishing after an event taking place within it, is the life science/biotech industry in the Uppsala region.[5]

2. From corporate ashes to a celebrated cluster

During the first years of the 21st century images of a new, dynamic and fast-growing life science/biotech cluster in Uppsala, Sweden, was circulating both in media and academic journals, with Nature (October, 2001), as the most prominent

[3] An interesting illustration this creation of place is the interaction between the industrial life science/biotech world and the academic world. In the development of a new technological and commercial solution, (i.e. in the development of an established supplier/customer interface) the academic world has an interesting double role. The academic world has an important role in the emergence of new technological and commercial solutions. It is a source of new knowledge and new ideas about how to create new solutions. However, the academic world's role in creating a use for these new solutions is equally important. Without the academic institutions' involvement in the testing of new prototypes, without them using these new solutions in their research, and without them producing research publications, there will never be a customer side for a life science/biotech product. It is the academic world that validates the benefit of combining a new resource constellation with the existing structure. The academic world has an important role as both "product developer and marketing channel." Thus, there is a very strong interdependency between the resources of these actors who, due to legal and ethical rules, are supposed to be independent.

[4] There are two issues that have been more long lived than others, and which divide economists and their critics. One concerns the rational behaviour of economic agents, an assumption that has been severely questioned during the last decades (see e.g. March & Simon, 1958; Cyert & March, 1963; Pasinetti, 1981; Mintzberg, 1987). Another dispute concerns the methods of economics, which according to Leontief (1982) can be characterised as mathematical models without any empirical data. Then we have the debate concerning the role of economics. Or as McCloskey (1990) argues, what originally were mathematical metaphors have been transferred to a language of power divorced from all types of experiences in the empirical world.

[5] Located only 70 km from Stockholm, and with several industrial and academic activities connecting these two cities, these regions are closely connected. However, since the aim of this study is to investigate the life science biotech industry in Uppsala and its connections to Uppsala University, this smaller region is used as focal point.

one: "The Uppsala biomedical cluster has continuously answered quality challenges and competed favourably with much larger global regions". Explanations for the Uppsala "life science/biotech" phenomenon exhibit a rather great conformity, regardless if presented in local media or in publications of a more analytical, investigative nature: the restructuring that Pharmacia underwent in the latter half of the 1990s as a direct result of its merger with Upjohn was the progenitor of the dynamic cluster. A cluster analysis made by the Centre for Market Analysis in Linköping and published by the Uppsala County Administrative Board in 2001 ascertains: "As a consequence of Pharmacia's globalisation, Uppsala University declined in importance, and in 1996, Pharmacia transferred its research operations to the USA. This marked the start of something new for Uppsala; suddenly there were new ideas, competence and venture capital, and a large number of new companies were formed". The same interpretation was repeated in the media: "Pharmacia's move is the start of something new" (Svenska Dagbladet, business section, November 7, 2000); "Pharmacia's move puts life into Uppsala" (*Dagens Industri*, January 24, 2001). This interpretation was eventually confirmed in Nature (October 2001): "By spinning off some of its local operations, Pharmacia has acted as a catalyst for the current biomedical boom. Former Pharmacia scientists and managers have been freed-up to channel their expertise and talents into start-up companies and projects". From the corporate ashes, in other words, a Phoenix of small enterprises was meant to have risen.

When it actually occurred, the transformation that Pharmacia underwent at the end of the 1990s was greeted with little warm applause, from either regional or national interests.

Company life in the life science/biotech field is, as Powell (1996), Powell and Owen-Smith (1998), and Powell, Koput, Smith-Doerr, and Owen-Smith (1999), underline, not only characterised by technologies that make these units multi-disciplinary, but also by interaction patterns that can be characterised as multi-institutional. In this case, Pharmacia is no exception. Pharmacia's development into a large international pharmaceutical company goes hand in hand with cooperative interaction with both national and international academic research universities and research hospitals, but Uppsala University appears as especially important.[6] In the mid-1950s when Pharmacia moved to Uppsala from Stockholm, where it was established in 1911, it was as a very small company with about 225 employees. The possibility of developing a research collaboration with researchers at Uppsala University was an important reason behind the move, and in the following decades several research projects with far-reaching effects for industrial activities where carried out.

When Pharmacia was merged with Upjohn at the end of 1996, it heralded a corporate reorganisation that was of a completely different nature from the domestic mergers that had been taking place since the latter part of the 1980s. Thus, the restructuring of Pharmacia in the late 1990s gave rise to the fear that the move of several marketing and R&D activities to the US—including academic

[6] Frankelius, 1999, Andersson, 1996.

cooperation—would cause a drain of experienced industrial and research people in the region. The Upjohn deal did not only give Pharmacia an American owner and a head office on the other side of the Atlantic; the strategic decision-making in R&D, clinical research, corporate development and international marketing also left the country, taking with it a business culture characterised by delegated decision-making, which is often said to typify Sweden or Scandinavia, sometimes Pharmacia itself. The reorganised company had to adapt to Upjohn's policy: competence originated at the top of the company and filtered down through the organisation.

The company also altered technological course. The new Pharmacia-Upjohn focus shifted to products based on synthetic chemistry, while Pharmacia's technology resided in the biological field. While many of the old Pharmacia's major products have been used in clinical therapies, Upjohn strove towards a different area of application: volume products that general practitioners could be expected to find a use for. From this perspective, it was completely logical for the Pharmacia-Upjohn management to kill some of the old Pharmacia's darlings, such as the development of products for application in ophthalmics and the treatment of incontinence.

True, Pharmacia had undergone changes before. The first half of the 1990s saw the upswing in Procordia's fortunes, the merger between Pharmacia and Kabi, and the acquisition of Italy's Pierrel and Farmitalia Carlo-Erba. However, the Upjohn deal was of a completely different nature. From a national perspective, it meant that ownership and management for yet another company was no longer on Swedish soil. And the transformation was no less tangible from a regional perspective either. Before the merger, the Swedish-controlled Pharmacia, with its 3000 odd researchers around the world, ranked as the world's 18th largest pharmaceutical company. Granted, the head office might have been relocated to Stockholm, but Uppsala retained both the strategic marketing and the research surrounding two of Pharmacia's big sellers: Healon and Detrusitol. After the merger, Pharmacia's business in Uppsala comprised a production unit with a staff of some 2000, incorporated into a US-controlled Group of 40,000. Not all research had emigrated, but what remained had been placed in Biovitrum, a spin-off company based in Stockholm with around 400 former Pharmacia researchers who were expected eventually to become self-supporting.

It goes without saying that the post-merger transformation that Pharmacia underwent was distressing, not only for people working at Pharmacia but also for all those who had the company as an important interactive partner: university researchers, politicians and a string of organisations and companies, all of which were directly or indirectly dependent on the pharmaceutical company. As for academia, Pharmacia's re-prioritisation of R&D projects was a particularly serious setback for departments at Uppsala University and Karolinska Institutet, not least in financial terms. Projects that had previously been in receipt of six-figure funding found themselves without support. In Uppsala, anxieties over the implications of the reorganisation—in the worst-case scenario, a brain drain of researchers working in the life science/biotech field—mobilised a number of public bodies and lobby groups. Investigations were launched into the nature of life science/biotech activities in Uppsala after reorganisation, including the infrastructure action required to improve

them. There was also a drive to project as attractive an image as possible of the life science/biotech region in Uppsala. It was at Biotech Forum, a life science/biotech expo held in October 2000 that the city was first presented to a wider public as a ''Region of Biotechnology''. One of the arrangers of this venture (the Uppsvenska Chamber of Commerce, 2000) described developments in a press release headed ''Pharmacia's research migration paved the way for an expansive biotech industry in Uppsala'' thus: ''Uppsala, a city lying a little to the north of Stockholm, has quickly become one of the world's major centres of biotechnology. …When the pharmaceutical company Pharmacia merged with America's Upjohn, it moved elements of its research out of Sweden and Uppsala. Concerns about what this would mean for regional growth were deep. Instead, however, the move has freed up resources and untapped ideas from within Pharmacia, which have been converted into successful new companies. …Pharmacia has proved critical to Uppsala's transformation into a stalwart new biotech centre, which today comprises around 140 companies''.

Working alongside the Uppsvenska chamber of commerce was another closely related and energetically run lobby organisation called the STUNS foundation, whose mission was to stimulate commercial and community growth by initiating and running a range of projects. Behind STUNS, which runs the ''Campus Uppsala'' project, are Uppsala University, the Swedish University of Agricultural Sciences (SLU), Uppsala's local and regional authorities and county administrative board, and the Uppsvenska chamber of commerce. In its efforts to seek out attractive investors/companies, the STUNS management launched a proactive media drive, and partly by commissioning freelance journalists managed, or so the management claims, to ''place'' more than 200 articles on the theme of Uppsala and its dynamic biotech industry in the early 2000s. In an article entitled ''What's new: A highly competitive Life Science cluster'' the Uppsala phenomenon was presented on the STUNS/Campus Uppsala website (www.campusuppsala.com, January 2003) thus: ''In 1996, Pharmacia's research endeavours moved to the USA. This created a new situation in Uppsala where suddenly ideas and venture capital were available and a large number of new companies started up''. The effectively unchallenged ''Phoenix tale'' can be taken as confirmation that these organisations achieved the task of refocusing the media image of Uppsala with resounding success. This in similarity with the famous Silicon Valley, where the interpretations of the regions genesis are, according to Sturgeon (2000), strongly coloured by a short-term perspective. As Kenney (2000, p. 3) puts it: ''Industrial developments in the Sant Clara Valley became known to the general public only when the region was named''. Sturgeon (2000, p. 2424) argues that although the history of science has generated a few alternative accounts of Silicon Valley's history, (e.g. Norberg, 1976; Williams, 1987, 1990; Morgan, 1967) these have all escaped wide attention and ''none of these works have altered the widespread misperceptions about the timing and nature of Silicon Valley's genesis''.

Nonetheless, in media one or other dissident voice concerning the Uppsala Biotech Valley has been heard. When Pharmacia-Upjohn was taken over by Pfizer in December 2002, the finance magazine *Veckans Affärer* asked why the out flagging of

Pharmacia was shrouded in so much silence: "Come December 9 it'll all be over. The American Pfizer will be taking over, erasing Pharmacia's Swedish identity for ever. Naïve directors and avaricious owners have sacrificed national interests in the battle for a Swedish flagship. …The company, which was to be the world number 5, never became the profit and growth success it was meant to be. Despite yet another merger, it only reached 10th place, and earnings per share are little higher than in 1994. …Yet not a peep has been heard from the normally vociferous critics".

Doubts were also cast on the positive effects that the restructuring was said to have had for the region. "What the loss of Pharmacia's head office and research has meant for Sweden remains a matter of speculation, as no one can know what effect the alternative would have had. But many former employees are enraged at all the fairy tales about how the biotech sector has blossomed thanks to all those who were subsequently freed up to take on new ventures". The same article included an interview with Bo Ahlstrand, former manager of Pharmacia's Peptide Hormones business area, who said: "This so-called "cluster" can never replace the lost infrastructure. Biophausia turns over like a hot-dog stand, and most of them have never generated a profit. The next generation of leaders will be completely lacking in experience of global corporations".

The Uppsalian life science/biotech world can thus be depicted as a Norse saga, with Pharmacia's reorganisation as some life-giving force, or as a whodunit ending in destitution; either way, these two seemingly diametrically opposed views nevertheless embody some common assumptions. First and foremost, they both express a firm belief that an isolated event within a cluster can explain the dynamics of this. Second, they reflect (at least the Norse saga view does) an attitude that the success and growth of clusters or regions result from competition with other regions, i.e. they imply that economic resources, in the form of both people and technology, are commodities used and controlled by individual companies. Thus, these assumptions fits like the hand in the glove with the underlying assumptions of cluster approaches sketched above.

3. What's behind an amazing success story?

Why care whether an approach, consciously or not, is resting on the assumption that the kind of exchange sketched in traditional economic theory constitutes normality, and close interaction is an exception, occurring due to spatial proximity? Simply because any work carries the stamp of the tools. Or, as several authors engaged in disciplines ranging from history to physicists argue; the outcome of any investigation is the result of the interaction between certain empirical phenomena and the tools used to investigate them. As Burke (1992) stresses, even the most strictly narrative account of certain empirical phenomena rests on some models—although occasionally the performers are not aware of the underlying assumptions and simplifications. A similar understanding is expressed by Galison (1997), who shows that even within the role model for research as being truly positivistic

phenomena, physics, there is a close interdependence between how the research tools are constructed and the results.

Is it that the awareness of the influence of research tools is higher within science as compared to social science? The suspicion is entertained when confronted with a typical publication of a scientific journal. Perhaps the layout does not split so much from the tradition within social science. In general, such a paper starts with a presentation of the research problem and what method was used to carry out the investigation—for example, a protein analysis carried out with 2D electrophoresis and mass-spectrometry. However, most often such a study is permeated with an enviable consciousness about what the researcher is able to articulate—simply only what the research tools allow. Translated to social science; the only aspects we can see are those that our research tools allow us to capture.

Despite the obvious risk of destroying an amazing success story, let us consider whether there are any other explanations for the rise of a new, prospering life science/biotech region than changes within this. Certainly all the investigations of company life and prosperity carried out with research tools focusing upon conditions within spatial clusters have contributed to a rich and elaborate view of the qualities of such agglomerations. However, are there other important aspects out of sight of the logic of cluster approaches coloured by the assumptions that the exchange pattern within the cluster is radically different as compared to the exchange pattern over the borders of clusters? What patterns are put in the shade of the understanding that intensified competition or increased co-operation within a spatial agglomeration or a cluster, (and in the Uppsala case, spiced with the death of an established company structure), can breed industrial development?

If we want to capture new aspects of a certain empirical phenomenon, in this case how companies located to a certain region co-evolve with counterparts over time, regardless if these are located to the same ''cluster'', to another ''cluster'' or outside anything that can be depicted as such, we are in the same boat as our colleagues within physics, biochemistry or any other scientific research fields. The only way to catch these new facets is with the help of new research tools. In order to investigate how companies co-evolve over time, including how local and non-local interaction contributes in this process, we have to use a tool that allow us to investigate the interactive features of industrial development, i.e. that reflects the mutual dependency aspects of companies' lives.

However, before we take a closer look at such a tool-kit we should consider some traps that it is easy to fall into when looking for an alternative approach. Seldom is an alternative in itself a guarantee for viewing certain phenomena in a new way. Consciously or not, the new tool is often developed using the old as the point of departure. (See e.g. Galison, 1997; Nowotny, 1987.) In our case, this means that there is an obvious risk that we are developing an approach with the underlying assumption that the traditional economy's view of market exchange constitutes normality and interaction or co-evolution is the exception. Thus, in the same way as a physicist who wants to investigate waves instead of particles must switch to completely different research instruments, we have to investigate interactive features with tools specially adapted for such endeavours.

3.1. An alternative tool kit

If, as Edith Penrose (1959) suggest, it is the way a resource is activated that creates its "services", then its value is due to how it is combined with other resources—within organisations, within relationships between organisations or even due to indirect interaction over the borders of visible relationships. Thus, in order to grasp such processes, we need a research tool that allows us to capture interaction between heterogeneous resources, regardless what actors these are represented by. The setting of this tool, developed in Håkansson and Waluszewski (2002) is the so-called industrial network or IMP network approach, and its underlying assumption that a company's technological, social and economic features are the result of its interaction with other companies (See e.g. Axelsson & Easton, 1992; Håkansson & Snehota, 1995; Håkansson & Waluszewski, 2002).[7] The interplay between companies/organisations is treated as a phenomenon that can have a wide variety of expressions—ranging from more distant relationships to close interactions—where the social and technological resources are confronted and adapted. It is an approach coloured by the understanding that developments occur when companies and organisations encounter one another (Håkansson & Waluszewski, 2002).

With these underlying assumptions embedded into a research tool focusing upon direct and indirect resource interaction, we can investigate how a company's technological and commercial solutions are developed and utilised in interaction with its direct and indirect counterparts—regardless where these are localised. Thus, we are able to map how resources are related, confronted and remodelled in relation to each other over time. The used investigation tool is based on four types of resources developed in different interaction processes. Two types of resources are mainly social; organisational units, developed in co-operation process, and organisational relationships, developed in networking processes. Two mainly physical; products, developed in buying–selling processes and production facilities developed in producing–using processes. What this tool allows, is the investigation of how resources are related, confronted and remodelled in relation to each other, within and over the borders of companies and organisations. (Håkansson & Waluszewski, 2002) (Fig. 1).

This project, which was started in January 2001 through an initiative by Uppsala University, aims to investigate the development pattern behind the emergence of the industrial activities within the life science/biotech sector in the Uppsala region.[8] The

[7] More recent works are available at the website www.impgroup.org.

[8] The project, which formally is located at the Department of Business Studies, Uppsala, is carried out in co-operation with researchers engaged in different disciplines, both in Uppsala and at other universities. Besides the main study, a special study on the role of the venture capital in the biotech industry is carried out in co-operation with researchers at Stockholm School of Economics. (Waluszewski & Wedin, 2003). A detailed investigation of the development journey of one biotech equipment supplier and how it has used resources available at different places is carried out in co-operation with BI, Oslo and University of Urbino, Italy. (Håkansson, Tunisini, & Waluszewski, 2002). In co-operation with BI, Oslo, a detailed study on the interface between an industrial supplier of a biotech tool and the academic user network emerging around some of its installations in UK is carried out. (Harrison & Waluszewski, 2003). The

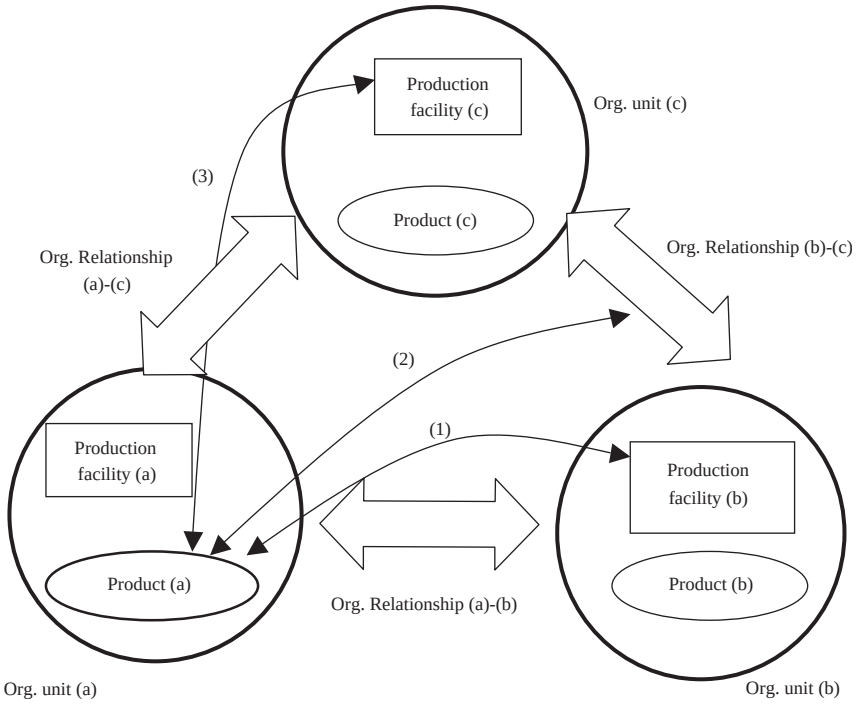

Fig. 1. A tool kit to investigate resource interaction among three organisational units and their interfaces with three other types of resources: products, production facilities and business relationships. (Håkansson & Waluszewski, 2002; Wedin, 2001).

main study includes the mapping of the main historical and contemporary resource interfaces of about 25 ''industrialised'' life science/biotech companies in the Uppsala region. (Covering the 25 largest companies in the Uppsala region meant that the study includes all units with more than 4–5 employees, with at least one product or prototype developed, and with some established supplier/customer interfaces.) The collection of data concerning these resource interfaces, including which places these are connecting, comprise more than hundred personal interviews. The research tool allowed the investigation of direct and indirect resource interfaces of the four different types of resources, on both the supply and user side. (Waluszewski, Wedin, & Sjödin, 2003).

Before we take a closer look at the picture outlined, we must consider the dilemma discussed in the introduction. If the only aspects we can see are those that our

(*footnote continued*)
historical part of the study is carried out in co-operation with Department of History of Science, Uppsala University and a project on the development of Biotechnology as a research field in the 2000th century. In co-operation with Department of History of Science a study of contemporary interaction between academic life science/biotech research at Uppsala University and academic and industrial counterparts is carried out.

research tools allow us to capture, then the only thing this investigation can reflect is industrial development in light of:

1. How companies/organisations' resources develop in interaction with other resources to which they are related both directly and indirectly.
2. How these resources are preceded by directly or indirectly involved actors.

4. From the ashes of pharmacia no phoenix rose

With the help of the previously described research tool, we see a rather different picture of the life science/biotech companies within the Uppsala region. The first and most overwhelming impression is that there is no simple mechanism behind the emergence of a prospering life science/biotech area. The majority of the life science/biotech companies within this region have some kind of kinship with established units in the region through their combining and recombining of resources. However, not direct to Pharmacia, and the restructuring of its pharmaceutical area. Instead, there are four other units that appear as important for the emerging companies. One is the prospering biotech instrument producer Amersham Biosciences, (former Amersham Pharmacia Biotech, former Pharmacia Biotech). Another company with a similar role is Pharmacia Diagnostics, world-leader in vitro allergy tests. Furthermore, there are two units outside the Pharmacia sphere that appear as important resource combining nodes for several Uppsala life science/biotech companies: Uppsala University and its research hospital, and the University of Agriculture, SLU.

Second, a closer look at the "new" life science/biotech companies' population in the Uppsala region reveals that most of them have a long history. The majority have their resource roots in projects initiated long before the restructuring of Pharmacia. Many of them have existed for decades, sometimes as visible companies, sometimes hidden as projects within different parts of the universities or companies. The small company Medical Products Octagon is an illustrative example. The company was established in 1971 but existed as a project in the early 1960s. As one of the initiators, Professor Uno Erikson,[9] explains: "We were many researchers with our daily work at the University hospital, within such disciplines as anaesthesia, physiology, radiology, cardiology, etc., and continually experienced technological problems connected to available equipment and material. It was this displeasure, and particularly all the negative effects we saw on the patients, that triggered us to use our medical knowledge for the development of new technological solutions. However, for decades we were forced to handle this work—development of new solutions, patents and licenses—in secrecy. For a professor at Uppsala University running a business was regarded as very suspect".

Third, a closer contact with the companies in the area reveals the difficulty of both defining and drawing borders around a "life science/biotech cluster". According to

[9] Interview (2002.02.05).

the Chamber of Commerce there are about 140 life science companies and projects in the region, about 70 of which are established companies. However, when we exclude suppliers of general software, electronics and other equipment, and concentrate on companies using or producing life science/biotech products or equipment there are, except the above mentioned four "big" established ones, we can find about 20–25 companies of varying age. If we consider these companies local interaction pattern, we can identify a cluster where almost all of the emerging companies in one way or another have some kind of kinship with the above mentioned established units: Amersham Biosciences, Pharmacia Diagnostics, Uppsala University and the University of Agriculture. One the other hand, if we consider the emerging companies total interaction pattern, the local interaction appears as just the top of the ice mountain. It is only a very few companies that have important supplier–customer interfaces within the region (for example, some companies who are sub-suppliers of allergens to Pharmacia Diagnostics). Instead, the value of the solutions these new companies are representing seems to be the result of an intricate interaction pattern where the above mentioned established units have important roles in terms of attracting new immaterial and material solutions to the region. However, the tricky process of transforming these "embryos" to new products and/or productions processes appears much more as a process of bringing these out of the region again, into new contexts, where new kind of users engage in the difficult task of embedding these into structures where they can contribute both in terms of technology and economy.

Thus, with the outline of an alternative picture of the life science/biotech industry in Uppsala, it is easy to agree with Sturgeon (2000, p. 16) and his argument that a too narrow historical and geographical perspective breeds the "myth of instant industrialisation". Sturgeon (2000. p. 15) argues that by divorcing the almost 100 years old Silicon Valley from the economic geography of the San Francisco Bay area, and from an electronic industry that began close to the turn of the twentieth century, an image outlined "that a region with no prior industrial history could make a direct leap to a leading-edge industry".

What can a wider historical and geographical perspective, with focus upon how resources are related and embedded, reveal about the "Uppsala Biotech Valley"? Let us take a brief look at the emergence of life science/biotech region that in this perspective appears as the result of many intriguing, long-time interaction processes confronting resources available at many different places with each other. Some of these processes resulted in new projects, some became companies and only a few new, but mostly the old, slowly emerging ones, became profitable—while many new ones face a risky situation living on venture capital.[10]

4.1. Life science/biotech Uppsala: resource interaction and combinatory efforts

How nice it should have been to find a close connection between a tough restructuring of a pharmaceutical company and the birth of a prospering life

[10] This issue will not be further considered here, but is discussed in Waluszewski and Wedin (2003).

science/biotech cluster—what an encouraging picture to bring forward to other regions faced with similar events. However, the patterns outlined with the above research tools are almost the opposite. Development of new solutions is facilitated by the patronage of stable and healthy industrial companies and academic research units—and their ability to attract and redirect new material and immaterial resources. Often the efforts to recombine these resources and embed them into new supplier–customer interfaces are carried out in the form of formal and informal projects where the involved resources are represented by different business or organisational units. Thus, these efforts stretch both over the borders of organisational units and most often also over both regional and national borders. And, sometimes these projects take the form of new companies.

Thus, it is a picture that is partly in line with the view sketched by Lorenzoni and Baden-Fuller (1995), who emphasise how large, established companies act like "hubs" in their interactions with smaller ones. It is also partly in line with the interpretation of prospering life science/biotech areas in the US made Powell et al. (2001) and in US versus Europe made by Owen-Smith, Riccaboni, Pammolli and Powell (2002). These studies emphasise the necessity of centrality to create strength and depth in the interaction between research universities, large pharmaceutical companies and small firms. However, these authors' focus upon the actor level highlights a role of the "hubs" or "centralities" as being "strategic centres"—directing development endeavours in certain ways. This idea partly contradicts the resource interaction focus of the Uppsala study. In the latter study, the role of the "hubs" does not appear as "strategic centres", but rather as "switchboards" that certainly attract new immaterial and material solutions. However, when these solutions are embedded into new supplier–customer interfaces, i.e. when brought into new interaction processes where the original solutions are shattered, remodelled and redirected, the influence of the "switchboard" can be rather restricted.[11]

In terms of its resource interaction pattern, the company that appears as perhaps the most important "switchboard" for attracting solutions and bringing these into new interaction processes in the Uppsala life science/biotech region is Amersham Biosciences. Another important unit is Pharmacia Diagnostics. Together these prominent biotech equipment and in vitro allergy diagnostic companies have acted as "switchboards" for about 2/3 of the embryos that later emerged into their own companies. The new companies with obvious technological, social or commercial kinship to Amersham Biosciences and Pharmacia Diagnostics are also some of the most industrialised.

[11] As an illustration of the different pictures outlined by these perspectives, we can consider the interpretation made by Powell, Koput, and Smith-Doerr (1996) and Powell, Koput, Smith-Doerr, and Owen-Smith (1999). In these studies the biotech industry is a phenomenon emerging from the 1980s forward, a period when many companies dedicated to life science/biotech activities were established. As we will see in the following discussion, with a focus upon how resources are combined and utilised, at least the Uppsala life science/biotech field appears as the result of interaction processes stretching over a much longer time period. However, often these combinatory efforts where hidden under the surface of actors officially dedicated to other activities.

If we start with a closer look at some of the newcomers related to Amersham Biosciences/Pharmacia Biotech we find Biacore, a company that is a well-reputed instrument company (both in the life science research world and on the stock market). Biacore's history starts with a project to combine a speciality developed within physics, surface plasmone resonance, with Pharmacia Biotech's (now Amersham Biosciences) engagement in tools for investigations of bio-molecules. The project was born in 1983, became a spin-off in 1986 and launched its first product in 1990. Despite the fact that during its first decade Biacore could utilise several of Pharmacia Biotech's resources, especially its marketing organisation, it took 11 years and the spending of about 70 million Euros before it started to show a profit. In other words, for many years this profitable company was an economy problem child, lacking customer application and sales income.

Along with Biacore there are four other examples of similar, new biotech instrument companies, all with between 50 and 250 employees, with established products and supplier/customer relationships, and with close kinship to the resource base of Amersham Biosciences: Pyrosequencing (established 1997), Personal Chemistry (established 1996), Gyros (established 2000)[12] and Eurona (established 1993, now part of Gemeni Genomics). Eurona never reached a break-even point before it was bought by Gemeni Genomics. None of the three others is showing a profit yet, but are in the state where their new solutions are starting to be embedded in their users' activities. To the above mentioned group of companies a smaller one can be added, which supplies both Amersham and Gyros with micro technology solutions.

Even if Amersham Biosciences appears as an important "switchboard" in the redirecting and remodelling of resources, this does not mean that all the ideas of how to create new solutions stem from this unit. The role of Amersham Biosciences appears to be attracting technological, social and commercial resources, while the issue of how they are redirected and remodelled is due to other forces. For example, the surface plasmone resonance (SPR) technology Biacore rests on is strongly influenced by the work carried out at the Linköping University, Laboratory of Applied Physics, and the group around Professor Ingemar Lundström. The technology on which Pyrosequencing is built is derived from research carried out under the leadership of professor Mattias Uhlén at KTH, and in its early stage was related to a group of researchers within Amersham Biosciences. Personal Chemistry has roots in the work carried out in cooperation between research groups managed by Professor Sharon Stone-Elander at Karolinska, Stockholm and Professor Nils Elander, molecular physics, Stockholm University. While Biacore, Eurona and Gyros all became formal projects within Amersham Biosciences/Pharmacia Biotech, the Pyrosequencing and Personal Chemistry projects where developed in interaction with some of this units researchers and never came to the awareness of the management. However, what all these units have in common is that the applications of these technologies were developed in interaction with different kinds of users in

[12] Whether Gyros is still in a platform stage or if their prototypes are on their way to be established is a controversial question.

the academic and industrial world—i.e. with units other than Amersham Biosciences, of which only a few are located to the Uppsala region.

Previously we only mentioned one aspect of the newcomers' interaction with Amersham Biosciences: its role in the emergence of new projects and companies. Certainly there are other, both direct and indirect, important aspects of being related to Amersham and its established relationships on both the supplier and customer side. Some brief examples from the supply side: Amersham's production facility in Umeå carries out development, design and production work for several of the newcomers. Some of Amersham's most skilled prototype engineers act as critical consultants for several new companies. One of Amersham's first suppliers of software, Prevas, which stems from a unit of ABB, used their experiences of working with the leading biotech equipment company to develop a new area of application, Prevas Bioinformatics. And from the customer side: While Pyrosequencing, Personal Chemistry and Gyros are establishing their own sales organisations, Biacore could until their introduction on the stock market in 1996 benefit from using the sales organisation of Pharmaica Biotech—their reputation of being a world leading biotech supplier included. What Biacore, Pyrosequencing, Personal Chemistry, Gyros and Eurona (and several other smaller start-ups) also have in common is that their products to a large extent are developed and sold by people with a background in Amersham. Thus, all these units could benefit from Amersham's long established relationships with "opinion–leaders" and other users within the academic world, and with the large-scale customers: the research labs of the pharmaceutical industry.

Although Amersham Biosciences and its resource network, including their relationships to national and international research areas as well as to supplier and customer structures, appears as an important "switchboard" for several of Uppsala life science/biotech companies, this is not the only such environment in the region. Another industrial unit with a similar role, but for companies with other application areas, is Pharmacia Diagnostics, 50% owned by Pharmacia and mainly engaged in vitro allergy diagnostics. MIAB is a smaller company that has co-existed with Pharmacia Diagnostics since the 1960s. From the beginning, MIAB has supplied Pharmacia Diagnostics with specially adapted insert substances for its test kits. Other companies in close interaction with Pharmacia Diagnostics are Ana Mar (established 1998, but existing as project since 1978), with technological roots at Lund University, and Mercodia (established 1991), both engaged in different aspects of allergy diagnostics. Another company related to Pharmacia Diagnostic is Carmetec (established 1988), which also is one of a very few examples of units that actually were started by people who lost their jobs at the pharmaceutical part of Pharmacia.[13] However, the closing down of a process technology unit where Hanno

[13] Q-med, together with Biacore and Radi Medical Systems one of the largest and most profitable units among Uppsala life science/biotech units usually is referred to as a typical example of companies emerging from the restructuring of Pharmacia. However, Q-med, which produces products for aesthetics, urology, etc. based in healon acid, is just another example of newcomers with an earlier history, started in 1987. Certainly application of healon was one of the major areas of Pharmacia. However, the knowledge of how to use this resource came through Pharmacia Biotech and its cooperation with a Hungarian–American researcher engaged in purification and use of this substance (Waluszewski, Wedin, & Sjödin, 2002).

Lindroth and Owe Sandberg were working, occurred already in 1988, when Pharmacia merged with Kabi, i.e. long before the merger with Upjohn. When Lindroth and Sandberg continued on their own, Pharmacia Diagnostics became an important source of both personnel and equipment knowledge. The other big Swedish based pharmaceutical company, Astra, became an early and important first customer.

4.2. Some historical connections to the pharmacia resource interaction pattern

Although the development pattern behind the main part of Uppsala's life science/biotech companies does not reveal any simple, linear link to the restructuring of Pharmacia, there are several historical and contemporary connections to the pharmaceutical company and its resource interaction pattern. When discussing the connections to Pharmacia, one must not overlook the university's role in both the pharmaceutical company's move from Stockholm to Uppsala in 1950 and in the birth of Uppsala's first two biotech supply companies.

What Amersham Biosciences and Pharmacia Diagnostics, Uppsala's most important contemporary resource switchboard, have in common is that they both emerged as a result of the interaction between the pharmaceutical company, Pharmacia, and Uppsala University's Department of Biochemistry.

Pharmacia Diagnostics has its roots in the discovery of IgE and the development of the so-called RAST allergy diagnostic test. RAST was developed by Hans Bennich, Gunnar Johansson and Leif Wide while they were engaged as researchers at the Department of Biochemistry. At that time, the second half of the 1960s, Pharmacia was the natural discussion partner when it came to industrial applications of Uppsala-based research within the life science/biotech field. When Pharmacia bought this test it became the technological foundation of something that later became a new spin-off company, Pharmacia Diagnostics. (This occurred while all the economically rewarded researchers behind the solution used their money to develop new companies including Johanssons' MIAB and Bennich's Biojon. The latter was one of the first suppliers of mass-spectrometry equipment for investigation of biomolecules, bought in the early 1990s by Applied Biosystems.) Today Pharmacia Diagnostics, with about 500 employees in Uppsala, is one of the dominating suppliers of in vitro tests of allergy diagnostics.

Amersham Bioscience's Uppsala unit, formerly Pharmacia Biotech, also has important roots in research activities carried out by the Department of Biochemistry and its academic and industrial counterparts.[14] When the Department of Biochemistry was established in the early 1900s, it was with inspiration gained from the US. With professor The Svedberg (later a Nobel Prize recipient) in the forefront, followed by professor Arne Thiselius, also a Nobel Prize recipient, the research activities for decades carried the stamp of these research leaders' interaction with

[14] The following section looks at a related project in the development of biotechnological and biomedical sciences during the early 1900s, carried out by Sven Widmalm, Department of History of Sciences, Uppsala University (See Widmalm, 2003, forthcoming).

both academic and industrial units in Europe and the US. During the era of Svedberg, a research tradition emerged that included cooperation with other academic fields, such as physics and biology, as well as with industrial units, including the pulp and food industries. The purpose was to develop both theory and tools for investigation of proteins. One of the main research issues at that time was whether proteins were monodisperse, and consequently purification of proteins became a key technology. The need for equivalent purification or separation tools forced Svedberg to collaborate with different industrial units. For example, Svedberg's engagement in the ultra centrifuge was carried out in close cooperation with engineers at Ljungströms Ångturbin, Stockholm (a steam turbine producer), Separator (producing separation equipment for dairies), and ASEA (now ABB). Svedberg also carried out research in cooperation with other industries including Kärnbolaget Stockholmsbryggerier (a brewery, which in the 1950s became the pharmaceutical company KABI, now part of Pharmacia), Mo Domsjö AB, (a pulp producer), Kema bolagen (chemicals), Liljeholmens (a candle producer) and Bofors (military products). Until the mid 1940s the ultracentrifuge and the electrophoresis equipment, developed under the leadership of Arne Thiselius, only existed at the department. Consequently it attracted many academic and industrial researchers eager to study their samples. To facilitate both its own and its research colleagues' activities, Uppsala's first biotech tool company, LKB, was started in 1946 with Svedberg as one of the initiators. (In 1985 LKB was bought by Pharmacia Biotech, later Amersham Biosciences. A modern version of the electrophoresis equipment is currently one of Amersham Bioscience's most profitable products).

Due to the ability to use both the ultracentrifuge and electrophoresis in investigating the characteristics of large proteins, in the early 1940s Svenska Sockerbolaget (the Swedish Sugar Company) approached the department with a request that turned out to be very beneficial to Pharmacia in several ways. The project that was initiated and financed by the Sugar Company aimed to investigate macro molecules in beet sugar juice. One of the responsible researchers, Björn Ingelman, found that the beet sugar juice was contaminated by a bacterium that produced a certain kind of glucose called dextran (known since the mid 19th century). Further investigation of dextran revealed that this type of glucose did not interfere with human antibodies. This finding certainly made sense in a research department that, like many other biomedical and military research environments worldwide, was struggling with the issue of how to handle the lack of blood plasma in wartime. When it was discovered that dextran, aside from its beneficial physiological composition, was neutral to the human antibody system, trials were initiated to develop an application as a plasma substitute. In 1943, Pharmacia was approached and in 1947 the product Dextran (later called Macrodex) was launched.

The many studies[15] of dextran during the 1940s increased understanding of the possibilities of utilising its molecule composition. In the early 1950s, when department researchers were struggling to improve the separation medium used in columns, trials were begun to replace the cellulose composition with dextran. The

[15] See Friman (2002) for an overview of some recent studies on this issue.

work, lead by Jerker Porath, (who became Professor and Manager of the Department of Biochemistry) and a researcher, Per Flodin, who had moved to Pharmacia, resulted in the development of a new gel that could separate bio-material after molecule size. The general manager of Pharmacia was approached, and after some hesitation a new project within the company, Pharmacia Fine Chemicals, was started. (At this time Pharmacia, which had recently moved from Stockholm to Uppsala, was a small pharmaceutical company, with about 225 employees.) The separation medium, named Sephadex (an abbreviation for *se*paration, *Ph*armacia and *dex*tran), was developed. This gel, presented in *Nature* 1959 as a totally new method of separating proteins and other bio-material after molecule size, became Pharmacia's first step in the development of a new area of industrial activities. From the small group of researchers working with Sephadex, a new business slowly emerged: development of chemicals, instruments and methods for separation of bio-material (See Johansson, 1986 for a description of the early work with Sephadex and Andersson, 1996, for a detailed study of how the biotech supply unit was developed and has been related to its customers since the start to the mid-1990s).

In 1967, when the group working with Sephadex became its own division named Pharmacia Fine Chemicals, it consisted of about 20 people. The new business gradually developed in close cooperation with its customers, academic and industrial research units, with Uppsala University's Department of Biochemistry as one of the most important (also as a base for recruiting researchers). While the first mission was to develop refined separation methods and tools, in the early 1980s this was combined with another important mission: to contribute to the automation of a handicraft-laboratory work. In 1982, the first product was launched that consisted not only of gels and columns, but worked as a system solution: FPLC, "fast protein liquid chromatography. Despite initial problem it became accepted by the customers, according to Peter Erenheim, vice president, Amersham Biosciences: "It consisted of a pump, a new separation medium and standard Macintosh computer. No parts were developed in relation to the other, and in the beginning there were many reclaims. However, it fit into the laboratories, it was easy to use and it forced us to focus on systems and not on single solutions".[16]

It was not until the mid 1980s that anything in the company name indicated that this unit was related to biotechnology. During some mergers in the 1980s and 1990s, both the name and the size of the company were radically changed. After buying LKB in 1986, the new company became Pharmacia LKB Biotechnology. In 1992 it changed its name to Pharmacia Biotech, and after the merger with British Amersham in 1997 it became Amersham Pharmacia Biotech. Late 2001 the company ownership was no longer connected to Pharmacia, and the company's new name were Amersham Biosciences. Along with the traditional activities of separation technology for research and industrial applications, Amersham, in the late 1990s, engaged in a new activity called proteomics. In summary: from a 20-person project in the early 1960s to a business unit with about 150 employees in the mid-1970s, today

[16] Interview Peter Erenheim, vice president, Amersham Biosciences, 2001.02.09.

Amersham Biosciences Uppsala has nearly 1000 employees (about 5000 worldwide), with about 100 new researchers employed in 2001.

At the same time, it developed a network of suppliers engaged in activities from bending sheet metal to the development of specially adapted lab robots, optical devices, software, etc. Furthermore, with about 2000 products on its production programme an extensive network of customers has emerged—ranging from advanced research labs to industrial units using large-scale separation equipment. The turnover of Amersham's Uppsala site, which in year 2001 reached about 400 million euro,[17] is about four times as much as compared to the then largest shall be the ten largest "new" life science/biotech companies in Uppsala reach together. Thus, even if neither the development journey, nor the present activities of Amersham Biosciences have been taken into any serious consideration in the discussions of what's behind a growing "biotech valley", its interaction pattern appears important for the attraction resources available both nationally and internationally. And, not least, for redirecting these resources by bringing them into new interaction processes where they are embedded into new resource combinations, activated in new contexts.

To sum up, if the interaction pattern around the pharmaceutical company Pharmacia appears as the important resource switchboard from the late 1950s, today this role seems to be overtaken by its spin-offs, Amersham Biosciences and Pharmacia Diagnostics.

4.3. Some contemporary connections to the pharmacia resource interaction pattern

Although most of the new life science/biotech companies in the Uppsala region do not reveal any simple and direct links to the late 1990s restructuring of Pharmacia, there are several indirect connections to this unit including a dramatic change. First, if the merger with Upjohn and the move of many strategic functions was not the source from which many new companies started to grow, indirectly this event had an impact on the handling of new projects/start-ups within the life science/biotech area. Due to the merger, the decision making that had previously been concentrated in one management group was transferred to several business units. For example, Amersham Biosciences, then Pharmacia Biotech, became an independent unit. This meant that it could act in terms of its own economic and technological logic—an approach different from a pharmaceutical company. Consequently it was able to singularly make decisions about which projects to engage in and which to spin off. Thus, the restructuring meant that the established structure managed by Pharmacia was broken and re-arranged, allowing different constellations to decide about existing and new ways to combine resources.

Second, the new image of Uppsala's life science/biotech as a dynamic region intervened in several contemporary processes. It had an effect on the governmental actors' engagement in regional development, for example in the planning of the infra structure of Uppsala. It also had an effect on how suppliers viewed companies in the

[17] World-wide Amershams's turnover reached about 950 million euro in 2001.

region, particularly by suppliers of venture capital, customers and especially by potential employees and potential new localities. Fair or not, the image of Uppsala as being a rapidly prospering life science/biotech cluster has affected the way companies and organisations relate to units located here.

A third contemporary event with a severe impact not only on the Uppsala based but all Swedish life science/biotech companies, is the increased supply of venture capital, which changed dramatically in mid-1995 due to new legal arrangements for investors managing governmental funds.[18]

4.4. Life science/biotech Uppsala: some academic units and their resource interaction

So far the discussion has been concentrated on Uppsala's life science/biotech companies with direct or indirect connections to the heritage from the Department of Biochemistry and the Pharmacia sphere. However, there are other life science companies in the region with only vague connections to these hubs.[19] Companies like Radi Medical Systems (established in the 1960s), Neopharma (established 1994) and Hemapure (established 1998) all have a background that is very similar to the one sketched by one of the initiators behind previously mentioned Medical Products Octagon. Researchers and medical doctors at the University hospital, who were faced with different types of equipment and products and their suppliers daily, began developing new solutions. The university hospital and its relationship with both the academic world and medical equipment industries were essential to all of these companies.

Another type of Uppsala University related company is represented by Melacure, (established 1997 through a transition of the small company Wafarm, and established 1987). Engaged in drug development, Melacure has its roots in pharmaceutical research at both Uppsala University and Umeå University. Even if the development of this company is not directly related to the Pharmacia sphere, it could benefit from restructuring through recruiting both Pharmacia's scientific and commercially experienced personnel. Another way of relating to drug discovery is practised by Diabact (established 1995) with roots in the University of Gothenburg, which benefits from developing new combinations of established substances. Resistentia (established 1998) has its roots in research in molecular biology at Uppsala University and develops an allergy vaccine which is not yet launched. Among these companies a considerable amount of people with a background in the pharmaceutical part of Pharmacia can be found—not seldom skilled researchers that in the turbulence of the Pharmacia-Upjohn merger where searching for new places to work.

There is also another important academic resource network in the Uppsala region—the University for Agriculture. Through the interaction between researchers

[18] A special study of the increased inflow of venture capital and its *disturbing effects* in a long since established life science/biotech region is presented in Waluszewski and Wedin (2003).

[19] However, there are several indirect connections to the Pharmacia, Pharmacia Diagnostics and Amersham sphere, for example in terms of common suppliers or subsuppliers.

engaged in veterinary medicine or plant breeding, several companies were developed, some of which existed for decades. Those companies include Bio-Agri (established 1996) och Isconova (established 1999 but with its roots in a research project started in the early 1980s) and Pegasus Lab (established 1984). Of these it is only the latter one, with about 15 employees, that is self-supporting.

5. Interaction as a force that encounters, redirects and remodels resources—connecting places and creating economic effects

Considering the emergence and development of Uppsala's life science/biotech companies from the perspective of interaction between heterogeneous resources, the picture outlined is rather different from the view that—consciously or not—is painted with colours borrowed traditional economics, cluster perspectives included. The picture painted with colours reflecting resources as heterogeneous and interacting provides an alternative view of the emergence and development of Uppsala's life science/biotech industry. Instead of being the result of an overnight success and events taking place within a spatial cluster, technological and economic effects appears as due to combinatory efforts that stretch over at least seven decades and over the borders of many regions and nations. Taking place within and between companies and organisations of different size and age, with different technologic and economic logic, and not least, located at different places, these processes show the power of interaction and the encountering of resources. Although these processes, which sometimes result in the development of new companies, occurred at different times and at different places, and are sometimes only vaguely related, they seem to have at least three different characteristics in common.

1. *Interaction creates possibilities for new solutions. It is in the meeting between those representing different resources, the ''interactors'', that resources are encountered. This encountering can create shattering, remodelling and redirection of resources, allowing new technological and economic effects to occur.*

A first prerequisite for interaction processes where new technological and economic effects are created through the recombination of resources to occur seems to be to allow *variety*. The need for variety becomes evident when considering how resources are encountered and recombined. Sometimes new technological and economic effects stem from processes where established resource combinations were confronted with new theoretical knowledge. Sometimes they stem from processes where established resource combinations where confronted with new technological experiences. And sometimes they stems from trials due to problems with existing theoretical, technological or commercial solutions. Additionally, these processes can take place in the interaction between established companies or academic institutions, sometimes in interplay between small projects inside or outside such units. Most often such endeavours stretch over the borders of several companies or organisations, and over the borders of both regions and nations. Occasionally the new solutions emerge in an environment characterised by restricted financial means and sometimes they are supported by larger capital. However, all these different

processes where new technological and economic effects are created through recombination of resources have one thing in common: *the resources exposed to remodelling and redirecting are preceded by ''interactors''—who through their interaction processes, encounter them with other resources in a wide variety of ways.*

2. *Interaction demands that the ''interactors'' relate to the existing structure. The more the new solution can be embedded into the existing structure, the larger the economic advantage for both the supply and user sides.*

A second prerequisite for interaction processes where new technological and economic effects are created through encountering and recombining resources to occur seems to be to relate to heaviness, i.e. to existing structures. The remodelling of resources—packaged as for example a new product or a new production facility—has different content for direct and indirect related supply or user units. For example, a new analytical tool can be related to in rather different ways by its supplier of electronic components, its suppliers of customised components, its application developers—and, not least, its user in a academic or industrial research units. Thus, the creation of an economic value of such a new solution or package includes some tricky complications. In order to gain an economic value, any new solution must not only be able to blend with related units different technological logic, but also their different economic logic.

3. *Interaction demands that the ''interactors'' creates place for the new—i.e. that they break with parts of the existing structure. New solutions have to be compatible with some existing solutions—but cannot be compatible with all. Thus, in order to create technological and economic effects through the recombining of resources, the interactors have to address these conflicts.*

A third prerequisite for interaction processes where new technological and economic effects are created through encountering and recombining of resources to occur seems to be to create place for the new. Both on its supplier and user side any new solution is dependent of the creation of both technological/theoretical and economic place. All efforts to create such place include confrontations of both human and physical resources. This implies that organised activities are combined with more anarchistic ones. Moreover, they include the reconstruction and rebuilding of established structures, although they seem to favour the main part of the established economic structure and its vast amount of combinatory resources.

With these three characteristics outlined the resources available at a certain place or within a cluster certainly appears as a source of dynamics—but also, as an outcome of interaction between companies/organisations occurring at different places, in different time. Instead of solely searching for explanations to industrial dynamics at the place where companies/organisation are situated, we have to consider how each organisation represents unique combinations of resources related to some specific places, and furthermore, a unique channel to these resources. (Håkansson, Tunisini, & Waluszewski, 2003), Thus, instead of focusing of contemporary features of places or clusters, we have to consider historical patterns of how resources available at different places have been combined. Or, as Sturgeon (2000, p. 17) argues, with a wider historical and geographical perspective the ''Holy Grain of economic development'', Silicon Valley, appears much closer to the

traditional portraits in economic and historical geography, where industrial development is "profoundly structured by place and historical context, and acquires path-dependent characteristics that continue to influence outcomes far into the future".

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