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Patchworking Network Structures

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Abstract

In recent years, establishing successful collaborative arrangements and relationships between university, industry and public institutions has come to be seen as essential in transforming new scientific knowledge into new innovations and business ventures. The fit between these very different actor groups has been treated as a contingent factor. However, little attention has been given to the managerial efforts that entrepreneurs have make to establish the fit between small firms, university research, and public policies such as regulatory policies and R&D policies through network-type structures. New biotechnology organizations are perfect objects to study these relationships because new biotechnologies and techniques predominantly come from the university sector (Kenney, 1986; Yoxen; 1984; Zucker & Darby, 1997; Robbins-Roth, 2001). From the perspective of the small biotechnology firms (SBFs,) this paper analyzes four different managerial strategies of how to create network structures to deal with the interfaces between industry, university and public institutions. The research-oriented strategy, the incubator strategy, the industrial-partnering strategy, and the policy-oriented strategy. The research-oriented strategy focuses narrowly on how biotechnology firms transform scientific results into solid business plan or business models revealing the aim of the technologies, services or products. The incubator strategy is concerned with localization and how to overcome specific types of managerial problems in the initial stage of forming a business venture. The industrial-partnering strategy is concerned with how to overcome the problem of bringing the technologies from an experimental stage at a research lab to be able to handle industrial processes and full-scale production. Last, but not least, the policy-oriented strategy focuses on the problem of having products approved by the public authorities. The aim of the article is to demonstrate how SBFs over time develop network structures through patchwork-like activities, ongoing and overlapping activities, that serve as a blueprint for the management

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2. The patchwork metaphor

This paper draws upon ten years of investigation into how strategies are developed in small biotechnology firms (SBFs). It has become a popular notion, almost a dogma, when speaking of the biotechnology industry that the industry has been spun off in university labs (Kenney, 1986; Zucker & Darby, 1996), nurtured by the science park incubators (Luger & Goldstein, 1991), fuelled by venture capitalists (Norus, 2002), cooled down by public regulation, and marketed by the big pharmaceutical firms (Robbins-Roth, 2000). Hence linkages to these types of actors are regarded as crucial to become a successful company. This fits very well with the popular notion that modern innovation is developed in an interactive play between Science, Industry and Public Policies (such as implementation of R&D programmes, public regulation, tax credit policies etc), as opposed to older innovation models that tended to focus on innovation as a linear process driven by either scientific discoveries or by market demand (see for instance Rothwell & Zegveld, 1985).

Moreover, when reviewing the literature on the biotechnology industry and having conversations over time with biotechnology entrepreneurs, R&D-managers and business-insiders, two main characteristics of the biotechnology business have been persistent: The first characteristic is the network organization, not only within the single firm, but also at industry-level among its stakeholders, including venture capital firms, university labs, business organizations, public regulators, and big pharmaceutical firms. The second characteristic is the absence of long-term strategies owing to the fact that SBFs constantly renew and readjust their strategies according to changes in the context or environment of the firm. Together, these suggest a need for a more systematic way of interpreting how network structures are managed and developed in small SBFs.

I think it is fruitful to use an analogy of a patchwork picture to describe what a biotechnology firm is and how the constitutive forces of network structuring can be described. According to the Random House Unabridged Dictionary, a patchwork is:

1. *Something made up of an incongruous variety of pieces or parts; hodgepodge: a patchwork of verse forms.*
2. *Work made of pieces of cloth or leather of various colors or shapes sewed together, used esp. for covering quilts, cushions, etc.*

Both definitions of patchwork suggest analogies with an SBF:

1. A SBF is a type of firm that is embedded in number of networks and alliances of different form and character and with different types of actors. Their technologies and their mode of establishing networks make them very difficult to compare.
2. The ways that the biotechnology firms engage with their different partners varies, but aims to be consistent with the division of labor negotiated between the partners to bring about new innovations in the biotechnology industry.

Theoretically, this article draws upon social network theories and a dynamic view of network relations. (Gulati, 19xx). This is done in order to capture the nature of the relationships between different types of actors, but also to emphasize both the formal and informal nature of some of these relationships.

The paper starts out by stating its methodological foundations. Thereafter, the theoretical positioning of the network approach will argue that multiple network relationships are at play. It

shows that not only do these networks differ in structure and stability, but also rely heavily on the institutional and organizational origins so as to understand the complex and collaborative nature of the biotechnology environment. The positioning of the SBFs as the focal point of the analysis leads to a discussion of entrepreneurial business strategies in the biotechnology industry and of how these business strategies correlate with interorganizational relationships. The empirical evidence will be laid out in four cases representing each of the four suggested strategies. The conclusion discusses three implications: First, the theoretical contributions of the heterogeneity between the four partnering strategies; second, future directions in the research; third, the foreseen managerial challenges.

3. Data collection and research method

This paper emerges from a longitudinal case-study based on qualitative data on the co-evolution of strategies and networks in the Biotechnology Industry in the US and Denmark. From a total population of thirty-two small biotechnology firms, the study identified three different types of network-based strategies undertaken by the entrepreneurs in the industry: The project strategy, the incremental strategy and the vertical-integration strategy. After these first initial results, five of the thirty-two firms were investigated over a period of eight years to study how networks evolved over time and how they co-evolved with the development of the firms' business strategies. In total, the empirical data consists of sixty-seven interviews with people from the biotechnological community in the San Francisco Bay Area, San Diego, Boston, New York City, Chicago, Research Triangle Park, North Carolina and Copenhagen, Denmark.

Table 1: Geographic Distribution of Interviews

Table 2: Institutional Background of Informants

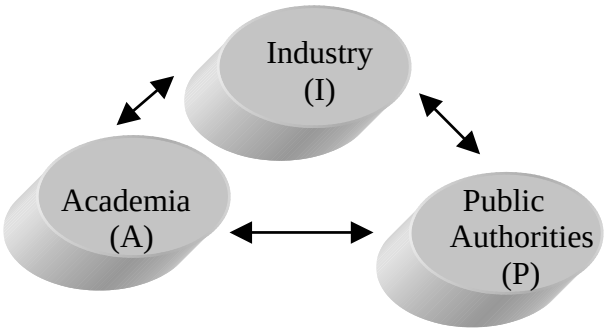
Boston	7
Chicago	10
New York City	3
Research Triangle Park, NC	9
San Diego	4
San Francisco Bay Area	17
Copenhagen, Denmark	17

Small Biotechnological Firms	52
Research Parks	3
Universities (Licensing Offices)	7
Public and regulatory bodies	6
Venture capital firms	6

The interviews were conducted in three different periods. The first series of interviews was held over a period of eight months in 1993-94. The second phase took place in late 1997 where only small biotechnological companies were visited. The third phase had taken place at the end of 2001 where updating of the companies strategies was done through phone interviews in five SBFs. Looking closely at table 1 and table 2, the number of interviews exceeds the actual total number of interviews since some of the informants belong to more than one category. Empirical data further consists of written material, such as company presentations, annual reports, and corporate prospectuses. Moreover, my data consists of Federal and State R&D Programs in biotechnology, and reviews of industry-related biotechnology journals.

The five SBFs were carefully selected because of their specific strategic approach and entrepreneurial strategies after first round of interviewing, therefore their strategies for interaction with their context were expected be very different from one another. However what became obvious in the second round of interview was that the company's entrepreneurial strategy (see later) changed all the time depending on its ability to get access to network partners through which they could mobilize scarce resources (money, knowledge, legitimacy) to further develop. Therefore, in my view, the four proposed strategies are mediating strategies that serve as blueprints for management of how SBFs, at specific points in time, overcome critical incidents. To illustrate this observation, I have chosen to investigate Calgene twice in this article

Figure 1: The nature of the roles of actors in the proposed strategies



Research Oriented strategy: I - A - p
Industrial partnering Strategy: (I - I – I …$_n$) - a - p
Incubator Strategy: I - A - I- P
Policy Oriented strategy: I - P – P - a

It is important to emphasize that the three types of actor-groups have a much more complicated institutional background than can be represented in figure 1. Therefore the most important actor-groups will be fleshed out in a later section. Also, the number of relationships with one actor group and the intensity of the relationships vary and shift over time. This is indicated by the use of small letters and capital letters in the figure. For instance, a firm that follows the incubator strategy is perceived to have defined its platform technology while still finding its relations to academia important. At the same time it is for them crucial to build networks with corporate partners to have their business model legitimised. In this strategy, too, the first initial step regarding regulatory policies is taken.

4. Network characteristics – network types and network dynamics

The literature on the Biotechnology Industry has primarily focused attention on the widespread formation of networks between the leading research institutions in the core biotechnology disciplines, such as molecular biology, and both small and large biotechnology firms (Kenney,

1986; Kreiner & Schultz, 1993; Darby & Zucker, 1995; Powell et al, 1998; Robbins-Roth, 2000). The argument for the strong ties between academia and industry is based on three empirical assumptions: First, the basic scientific knowledge in biotechnology stems from universities or related institutions; second, the vast majority of the new biotechnology ventures have strong antecedents in university settings; third, small biotechnology firms have to get access to the new knowledge in their area to develop new biotechnology products and services.

There are very good reasons why the formation of networks has either been assumed to be the way small biotechnology firms stay competitive with large and more resourceful firms, or as a way for small firms to enter into well-established markets when only possessing few internal resources. Thus networks have been seen as a means of accomplishing goals that otherwise would have been impossible. I will not argue against this, but point to the importance of investigating how particular networks are established and why the partners have engaged in these networks knowing that there are other partners out there. From my research in the biotechnology business, the SBFs have a less romantic view, one which raises questions about how the search process for new partners is organized. How do network partners meet and how has the collaboration developed over time? What characterizes a successful network relationship and what are the consequences of early termination of relationships?

Management theory has drawn on sociological and anthropological research-traditions in taking a social-network perspective of organizations' establishment of collaborative relations with different partners. In the same way that the socialization of human beings is a system of different types of personal networks of varying character and stability, it is taken for granted that firms also survive through different types of networks. The network-studies vary from being predominantly interested in interorganizational networks to focusing on how personal relations evolve in e.g. professional

groups in understanding the mechanism of how firms engage in external relations (Constant II, 1984; 1987; Kreiner & Schultz, 1993; Kristensen; 1995). These two approaches introduce the problem of formal versus informal networks. The network metaphor captures, therefore, some important characteristics concerning the relations between a firm and its stakeholders such as customers, suppliers, knowledge institutions, financial investors, policy-making institutions etc.

Constant conceives technologies as social arenas, so-called communities of practice. Communities are viewed as carriers of the body of knowledge that encompasses the technology in question (Constant II. 1984; 1987). Within communities of practice, conflicts emerge concerning the importance of different underlying techniques. The implication of this is that communities of practice consist of one or more technical representatives that promote different design configurations that appear around a certain technology. The concept of communities of practice makes it possible to capture a dynamic pattern in the way in which new technologies are developed and formed by gaining insight into the work, the methodologies, the patterns of communication and the career paths of the key researchers in the specific technologies in question. For the purposes of this article, the concept of communities of practice allows the observer to dissolve the organizational boundaries between industry and academia and look at the informal relationships in a professional arena or research area that foster the basic knowledge behind the technologies in question. This is important for studying biotechnology firms, because biotechnology as a concept consists of a number of subsystems that are represented by the different professional/technical approaches that the firms in question have chosen to follow. These approaches and methodologies are reflected in the networks the firms form and engage in, and in the relationships that the professional groups (communities of practice) participate in.

Another way of making the network perspective a dynamic one is to follow specific networks that the firms have developed over time rather than following the actors and stakeholders in the firm. It is my hypothesis that the majority of the networks start out as very loose contacts, where partners have the opportunity to try out the partnership before it is formalized, or terminated. Other networks are, by nature, informal and temporary, making them very difficult to depict and investigate without following the individual actors. An example that illustrates this point is when an employee seeks new knowledge in his personal network to sort out ideas that otherwise would have been dead-ends in the development work, saving the SBF time and money. From an analytical point of view, this informal networking knowledge that is transferred within a few minutes and may never be used again, but can be crucial to understand how problem-solving takes place in a SBF. To maintain the distinction between formal and informal, it is therefore important to separate informal networks from the formalized network-activities and seek to localize where in the organization the different networks appear and originate. At the same time it is important to find out how communication is organized internally, and how it flows, since the presented theories all point to the fact that communication patterns determine the rate and direction of the established networks and the establishment of future network relations.

Figure 2: Network typology

	Internal	External
Formal	***Communication/flows of information*** - Nature of hierarchy - Subsidiary – headquarter - Unit - Group	***Formalized contracts*** - Strategic alliances - Joint Ventures - Outsourcing arrangements - Licensing agreements

	- Superior – subordinate	
Informal	***Personal based*** - Sub-unit - division - Sub-unit – sub-group - Person to person	***Trust based*** - R&D collaboration - Internal jobmarkets - Person to person - Communities of practice

Figure 2 classifies networks and locates them according to their organizational and institutional origin. The bold italized headings in each of the columns indicate the overall trait or characteristics of the network relationships.

The typology is important for several reasons: First, it can be used to investigate how networks evolve over time. This is important in order to explain how the formalization of distinct types of networks happens over time and whether distinct types of networks can be categorized and/or identified as specific activities of strategic importance. Second, the typology can be used to analyse how networks are formed between different types of professions. For example, do networks that are established by management have a tendency to be more formal than networks that are established by the firm's researchers? In other words, the network activities have to be followed by a question about how these networks have evolved and why these networks have taken a specific form and character

Methodologically, and from the point of the typology, it is important to keep the distinctions in a relative pure form because it enables us to investigate the origin of these network relations and to research how these networks are created and how they develop over time. The strength of the figure is that it, on the one hand, seeks to classify different forms and types of networks and, at the same time, also reveals the differences. This makes it possible to illustrate that there might be a dynamic movement between the different types of networks. Looking at the left side of table, it is important to emphasize that the ability to form networks is limited by the internal organization and the way

that the internal communication is organized. The reason the internal networks have been included is due to the widespread idea in organizational sociology that the more hierarchical and formalized the procedures are structured in an organization, the more difficulty the members of the organization will have in developing intraorganizational networks on their own. Moreover, a strict hierarchical structure will make it difficult for individuals to mobilize resources through their personal network, for example in a community of practice, and there would also be limited possibilities to establish new personal networks. In both situations it will be impossible for the organization to utilize such types of network experiences or "free resources" in the development of the company; it will also restrict the firm's employees from developing a personal network because they do not have any knowledge to exchange in the networks. The figure lists four forms of formal and external network activities. Those networks are typically characterized as being contractual by nature. In a strategic alliance, the biotechnology firm receives revenues or payment to develop a specific product or project for a larger firm. With the establishment of a joint venture, two or more firms develop a subsidiary firm and this has been one of the major forms of network activities that have appeared in the biotechnology industry. Joint venturing has also been one of the collaborative arrangements where universities have been able to profit from their investments in basic research activities by engaging in setting up new businesses. Third, outsourcing has become another formalized network activity that is widespread among the SBFs. The firms outsource activities for which they either do not have the competencies or the interest in taking care of themselves, such as the production of cabinets for special devices or components, or activities such as production, marketing and distribution. Fourth, licensing agreements imply that the small biotechnology firm leaves the production rights and the distribution of a product in return for a royalty fee. However the most common licensing agreement is when a firm or an institution patents a technique that they license out to partnering companies.

Both the informal and external networks are predominantly connected with research and development activities. These networks are most often formed within communities of practice and are guided by trust-based relations. They are also characterized as personal, implying that these networks, from the perspective of the organization, are not directly accessible but are, for instance, formed between former classmates or key personnel from prior jobs (Norus, 1997). The personal relations or communities of practice also function as internal job markets. It is through these information channels that job opportunities are exchanged, which is of crucial importance for individuals that are employed in organizations that develop new technologies because of the insecurity concerning the viability of the technology in question. The insecurity of the technologies forces the employees to engage in communities of practice to form connections that can be used to get a new job if the firm goes down. The risk in being excluded from the network, combined with importance of belonging to such a network, diminishes the tendency to opportunism. If excluded, an employee is relegated from having access to useful knowledge in his/her present job and will not get any of the attractive job opportunities that are exchanged within a community of practice.

5. The nature of the environment

One way that SBFs signal attractiveness is by revealing both their formal and informal partnerships and networks with research institutions, universities, venture capital groups, pharmaceutical firms and other related businesses. The point here is that network formation is an essential activity for survival with much wider impact than just being a means of mobilizing knowledge and financial resources. For these firms, it is a never-ending story because it is crucial to have access to the most prestigious networks to legitimize the firm's present activities and thus to further mobilize resources for the future activities. Therefore, as emphasized when introducing the patchwork metaphor,

network activities are to be conceived as series of non-sequential decision- making processes that have to be made at different stages throughout the corporate life-cycle.

Although this article's aim is to have a closer look at the relations between entrepreneurs, academia and public and regulatory bodies, it is very hard not to acknowledge that other types of important actors intervene in this power triangle and play important roles as intermediate actors. Therefore these other types of actors are included in the overall description of the biotechnology community. However, apart from the technology parks, both the role of venture capital and the pharmaceutical firms will be almost absent from the analysis in the cases presented.
In the field of Biotechnology, six major actors and actor groups have been playing a dominating role in forming the new industry.

1. Small biotechnology firms that apply new biotechnological techniques to develop commercial products, projects, and services
2. Universities with strong research capabilities in new biotechnologies
3. Research or technology parks that function as incubators for small biotechnology firms
4. Public and regulatory bodies that have implemented biotechnology R&D programs in order to promote the biotechnology industry as well as institutions that regulate the biotechnology industry by initiating approval procedures and procedures for environmental protection
5. Venture capital firms that have financed the start up of many biotechnology firms
6. Pharmaceutical firms that overwhelmingly engage in the late-stage funding of the SBFs through buy-ups and strategic alliance making.

Figure 3. The interactive nature of the biotechnology community

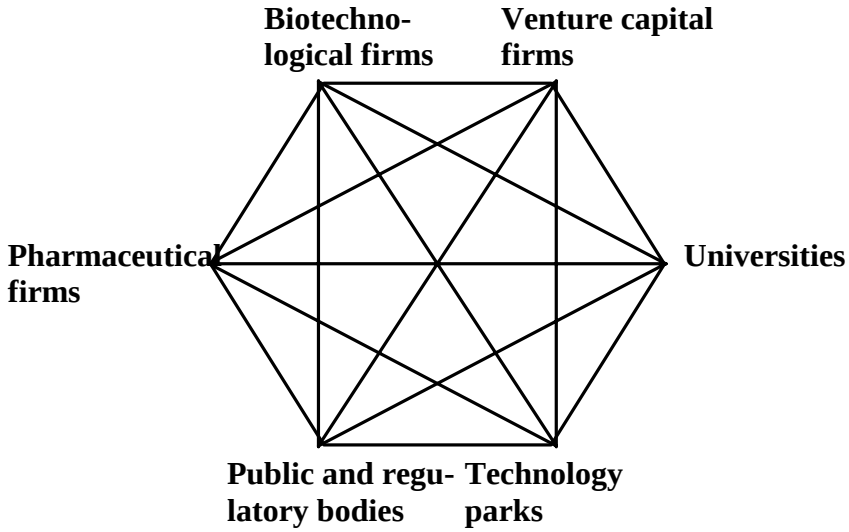


Figure 3 shows the interaction that takes place among small biotechnology firms in relation to the formation of networks with key actors. However, in the figure all actors appear to be equal at all times which is not the case. Instead I think it is fruitful to think of the six types of actors as necessary partners with whom future relationships are to be established.

6. Entrepreneurial strategies in biotechnology firms

The biotechnological industry has been formed and developed predominantly by small biotechnological firms with very strong roots and antecedents in scientific environments (Powell, 1994; 1996; 1998; Dodgson, 1993; McKelvey, 1996; Kenney, 1986, Robbins-Roth, 1999; Norus, 2002). Although they have been able to develop quite sophisticated technological projects and products, the small biotechnological firms (SBFs) only have a few employees. These technological projects are developed through a wide range of collaborative arrangements, such as informal networks (research collaboration, resource sharing etc.) and formalized networks (joint ventures, licensing agreements and strategic alliances) with a variety of partners (venture capital firms,

pharmaceutical and chemical firms, public and regulatory bodies, other small biotechnology firms, universities and research parks). This means that having a variety of different network arrangements is to be regarded as a means of survival in a new technological field where we would expect that only large multinational companies, with large financial and human resources, have the competencies and capabilities to direct and control the evolution of the technology in question.

It is beyond doubt that some of small biotechnology firms are established with the ambition of expanding activities into a company that can develop, produce and market new biotechnology-based products. Therefore it is not surprising that Peter Daly, in his 1985 book on the industry, *The Biotechnology Business*, is preoccupied with business strategies based on different aspects of how small biotechnology firms have aimed at being vertically-integrated companies. At that time, biotechnology had had its first boom on the stock market, and the firms in question therefore had sufficient financial resources to reach this goal. When investors and entrepreneurs realized the problems of scaling up the processes from an experimental stage to have cost effective, full-scale production plants, the vertical ambition came to an end. Small biotechnology firms were needed to develop mediating strategies with explicit exit strategies that were adaptable to the turbulent environment and flexible enough for the changes among the dominating actors in the biotechnology industry. The problem is that entrepreneurs often have neither the aspirations nor the resources to develop, manufacture, market and distribute new biotechnology products. Their major interest is in developing the science and the technology and they sell promising R&D projects in order to create space for the development of their biotechnological competencies. A population-ecology approach would tend to conclude that small biotechnology firms have had no impact on the development of the new biotechnology industry. Alternatively, such an approach would lead to the erroneous conclusion that new biotechnological techniques have no commercial interest since the developers,

the small firms, have failed to market any new products. Instead companies that aspire to becoming vertically integrated do not have the necessary resources and must therefore engage in strategic alliances and licensing agreements, or they will eventually be bought up.

For analytical reasons, it is important to distinguish between different types of biotechnology firms and different types of strategies that have developed over time for fulfilling the aspirations of the individual entrepreneurial firm. Therefore, it is fruitful to think of the biotechnology firm as a portfolio of related development projects in different chronological order. The project analogy is in accordance with the strategies pursued by the biotechnology firms in my population. Because of the different character and combination of the collaborative arrangements undertaken by the SBFs, it would be a flaw to search for an ideal strategy pursued by small biotechnological firms. A single best strategy in this area does not exist. Instead the search for best strategy has to be determined by the technological approach of the company, the aspirations of the entrepreneurs, and their modes of doing business through the organization and establishment of external networks. Three types of strategies undertaken by the SBFs will be outlined: the project strategy, the incremental strategy, and the vertical integration strategy.

In relation to the “project strategy” the SBF tries to develop a market for a portfolio of related R&D projects, which the SBFs have carried out. This strategy can best be described as characterizing the SBF as a “science boutique” where the distinct aim is to sell or license projects to large pharmaceutical or chemical companies in a continuous stream. Hence, the science in itself is a product.

The firms following the “incremental strategy” have a slightly different strategic approach where the SBF gradually learns about and gains experience of the nature of the different task. The aim is

to take command incrementally over more and more activities and, by doing so, fulfill the long-term goals of the company. The backbone of this strategy is to generate resources by selling projects, offering consulting services and by establishing joint ventures with larger firms. Through these partnerships, the SBF gradually builds up more and more competencies in-house while, at the same time, they protect what are considered the long-term assets of the company.

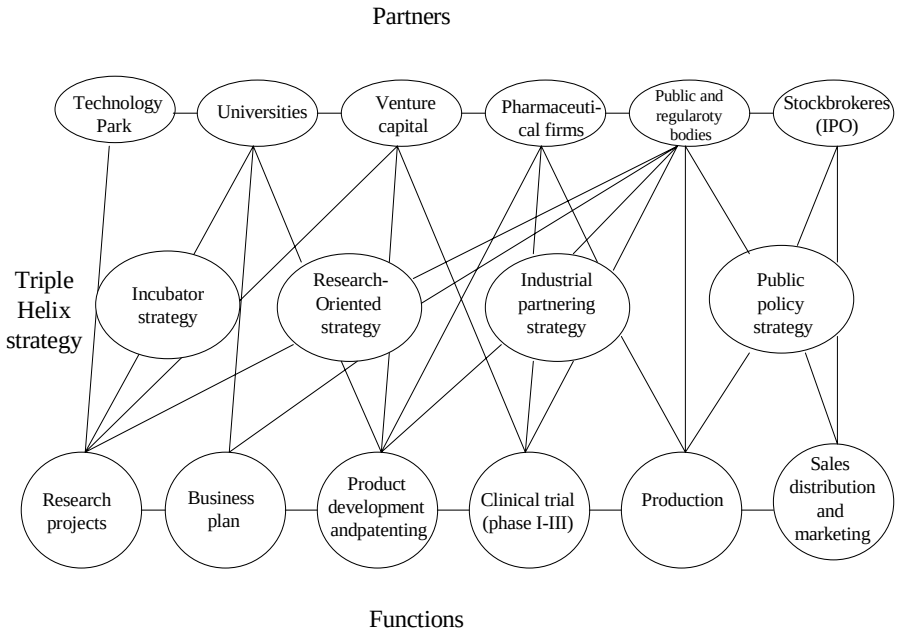
The SBFs that follow the “vertical integration strategy” have a much more comprehensible strategy in the sense that the idea is to become a vertically integrated company that takes care of all functions from the development of new products, to the production, sales, marketing and distribution. Only a few SBFs follow the vertical-integration strategy due to the complexity of the technology, the regulatory aspects of getting a product approved, and of course the lack of resources to achieve the long term goal. Another important reason is that small firms often face competence gaps and cannot build up fast enough an organization that can handle all aspects from research, production, marketing, regulatory aspects and distribution to capitalize on patents with a limited duration. This strategy means that the firm has to become a publicly traded company through an initial public offering (IPO) that challenges the routines for strategy formation, management and establishment of external networks.

7. Linking entrepreneurial strategies with the four mediating strategies

To investigate the dynamic aspects of network formation over time, the case analysis has to come to grips with the different types of decisions that are made at different points in time. An important analytical tool is the phase model that is outlined in figure 4. The phase model emphasizes the strategic options according to the different tasks and functions the small biotechnology firms carry

out with different types of network partners. The figure links the four different network strategies and puts them into chronological order. The steps from development to marketing express only some of the important steps on the ways to launch a product. The figure does not attempt to impose a functional logic concerning the importance nor the intensity in the network over time, since this must be an empirical question. Although the four strategies are put into a chronological order, it is important to stress that it is a non-linear process where feedback loops between the functions happens owing to the trial-and-error nature of the network relationships.

Figure 4: Linking actors to strategies



The research-oriented strategy narrowly focuses on how a biotechnology firm transforms its research result into promising technologies, services or products. The incubator strategy is concerned with the problem of location and how to approach specific types of managerial problems in the initial stage of forming a business venture. The industrial partnering strategy has to do with how to overcome the problem of bringing the technologies from an experimental stage at a research

lab to be able handle industrial processes and full scale production. Last, but by no means least, the policy-oriented strategy focuses attention on the problem of needing to have products approved by the public authorities.

The four strategies are not fixed, but mediating strategies, step-by-step processes that many biotechnology firms encounter when developing and commercializing their technologies. Hence the strategies depict and emphasize specific ways of dealing with strategic problems that are solved by building up interorganizational relations. The incubator strategy is concerned with the problem of location and how to approach specific types of managerial problem in the initial forming a business venture. The industrial partnering strategy has to do with how to overcome the problem of bringing the technologies from an experimental stage at a research lab to be able to handle industrial processes and full-scale production. Last, but by no means least, the policy-oriented strategy focuses attention on the problem of needing to have products approved by the public authorities.

8. The research-oriented strategy (Calgene, part one)

Calgene was founded in a garage in Davis, California as a company doing contract research. The fact that the firm started by doing contract research affected the way that Calgene sought to legitimize and organize its activities in later stages where it sought to control large market-segments of the tomato industry. It was doomed to fail and it failed. Until recently it was possible to download from Calgene's homepage the titles of all the scientific publications that the employees published in scientific journals in the period from 1981-1996, in total two hundred and forty-seven published articles. It is interesting to look at the distribution of the research papers over the years. In 1981 and 1982 only one paper was published each year. Then the number of published articles rose

to thirty articles per year in the period from 1985-1989. The number of articles that the Calgene researchers published then dropped to ten to fifteen articles in the period from 1989-96.[1]

The publication profile reflects that no professional community had been established in the area of genetic engineering in plant research when the firm started. There was an absence of available techniques that were used to identify and characterize the specific genes in the plants, and the area also lacked scientific models on genetically modified plants. Therefore, both a research community and the research field needed to be established and the only way to establish such communities was to establish the field through extensive contacts within the scientific environments in plant research. Thus, there was a hidden logic behind the corporate publication profile. First, the single researcher or a research firm has to demonstrate that they have developed research results that are of interest to the scientific communities in question. This ability is demonstrated through scientific publication. Secondly, publication is the ticket to be invited to meetings and conferences where the firm can present its research and the prospects of their business. It is in these meetings and conferences that new technological fields can be introduced and initiated.

Before a firm has relevant results to publish, it has to build up a common knowledge base of the firm. This period equals the first couple of years when Calgene only published a few scientific papers. Afterwards there is a phase where the new scientific field is established, a period where the results from the research begin to show up on a regular basis, which corresponds to the phase from 1985-1988. In the third phase there are as many results published as in the second phase, but now the field is established and the commercial perspectives becomes visible and the firm becomes more product-oriented. In this phase, the firm has to be careful not to make public too many articles that

[1] The homepage that was closed in the year 2000 and was originally found at: (http//:www.calgene-com.htm).

can reveal confidential development areas. This is seen in the period from 1989-1996 where the number of articles published by Calgene researchers decreased. Another interesting detail concerning the period from 1992-1996 is that the articles published are primarily concerned with the applications and the commercial perspectives of the new techniques. This shows that the small biotechnology firms do corporate research and present in both academic and business oriented settings as a means of attracting industrial partners. In Calgene, the research activities served a dual purpose: The firm developed the basic scientific knowledge in a specific area and the firm commercialized its research. The firm could only fulfill the last objective because the corporate researchers had the specific knowledge concerning the technological performance characteristics and hands-on knowledge in both the basic research and the commercialization of the technologies.

Calgene gained status both as a reliable business partner and as a serious partner in the establishment of research contracts by smoothing the lines between given presentations to a research community and given presentations of commercial nature. This routine was deeply rooted and meant that Calgene researchers had the main responsibility of attracting resources through research contracts and making partnerships with the industry to cover the expenses for their research projects. Thus the researchers were given the ability to succeed in two worlds: The research world, with the development of a research field or a community of practitioners of genetic engineering in plants, and the business world, where the Calgene researchers aimed to establish contacts with industry to convince them that they should engage in strategic alliances and pay Calgene to do the research.

Despite the divisionalization of the corporate activities, the firm continued to establish research contracts using the same channels as the firm did when it was a research boutique. Each individual

division, of course, made the contracts, but it was still the researchers that were in charge. This meant that Calgene continued its mode of engaging in strategic alliances with large firms. Therefore, Calgene established alliances with firms such as Campbell Soup regarding the Flavr Savr™ tomato, *Procter & Gamble* in developing oils for detergents, *Mobil Oil* regarding motor oil, and *Rhone Poulenc Agrochemie* regarding the development of cottonseeds. All these contracts were initiated through personal contacts with key personnel in the different divisions. As Calgene became more well-known in these firms, people from large firms came to visit the Calgene headquarter in Davis and shopped around in the different laboratories to search for interesting projects.

The interesting aspect of the research-oriented strategy in a network perspective is that the nature of the relationships that the company is developing is very much biased and guided by values that can be found in academia. It seems like all external relationships are to be developed from informal and trust-based relations, where the partnering model is based on a vision of going on a life-long journey with the partner. The way that the concept of trust is interpreted and taken for granted in these relationships means that the company, after establishing its technological platform, continues to develop its industrial partnering-strategy in the same way. When the company change its overall strategy from being a contract research-based company to become a vertically integrated tomato company, the firm probably will have great difficulties in establishing network relations that are not guided by scientific values. When we turn to the policy-oriented strategy we will see that Calgene established relations to the FDA (the Federal Food and Drug Administration) the exact same way.

9. The incubator strategy, ThermoGen

In 1988 David Demirjian Founded ThermoGen Inc. together with his former professor from the University of Chicago, Malcolm Casadaban. The firm is located in Chicago, Illinois and until 1998 it rented its facilities from the incubator in the Chicago Technology Park. During 1998, the firm moved out of the incubator and rented new buildings in the Chicago Technology Park only a few blocks from its prior location. This move from the incubator both qualitatively and quantitatively led to changes both from a strategic and an organizational point of view. The firm's technological platform was developed from a specific type of enzymes and proteins, thermophilic organisms that are used as biocatalysts. The biocatalysts, the enzymes, can be used in industrial processes, for example in the development of foodstuffs, chemical products and pharmaceutical products. Compared with traditional industrial enzymes, thermophilic enzymes are more stabile and can function in high temperatures. Hence fermentation processes can be carried through much faster than is the case with existing techniques.

The interviewees judged the role of the incubator in the Chicago Technology Park as not only economically crucial. The firm definitely would not have existed without the incubator. The access to up-to-date laboratory facilities in the initial phase would not have been possible to acquire for the USD 25,000 that was the company's seed money. Also the business knowledge and different types of consultancy services that the incubator provided in its initial stage could not have been bought outside the incubator.

For the members of the research team, the Chicago Technology Park was not an immediate find when they searched for facilities. They tried to locate in the incubator of the University of Evanston, but this incubator was not prepared for biotechnology firms. Afterwards the researchers tried to hire laboratory facilities at the University of Chicago. Thereafter they became aware of the Chicago

Technology Park and were surprised at the capacity of the incubator. First of all there, were experienced entrepreneurs present from whom the researchers got valuable information. Some of these firms had also bought quite sophisticated equipment that ThermoGen could borrow and that helped to lower the costs.

Surprisingly, the access to these networks influenced the way in which ThermoGen structured and organized its activities. For instance, the firms developed a flexible collaborative system, a sort of social security system that meant that the firms could internally hire and lend out human resources in periods with ups and downs. In that way, a sort of internal fence against bad times was established, this made it possible to keep jobs for the people that the companies had hired. At the same time, this collaborative system meant that all the firms did not necessarily need to acquire all laboratory facilities. For ThermoGen the collaborative system meant that the firm could stay independent of external financial investment for a longer period of time. In bad times, the internal security system was an advantage owing to the collaborative nature of the neighboring firms. In good times it was an advantage because of the possibility of hiring human resources from other firms, and borrowing laboratories and equipment from firms facing troubles.

Taking a network perspective on the initial phase of the history of ThermoGen, it is characteristic that a number of mediating actors (persons and institutions) are mobilized to find new partners and people that could further assist the business process. All these people have been very closely related to the company's location in the incubator. The mobilization of actors and institutions has been crucial in helping ThermoGen overcome the problem of bringing the firm from a basic research unit to an entrepreneurial business seeking to develop its own products and services. It is my interpretation that many small biotechnology firms die out in the process of defining the business

because they fail to get access to these mediating actors. Their search processes lead to dead-ends that do not allow the small firms to develop a precise business plan and a corporate vision. In the case of ThermoGen, all necessary contacts to lawyers, accountants etc. were initiated and organized through the Chicago Technology Park.

9. The industrial partnering strategy, incyte genomics

Incyte Genomics was founded in 1991 under the corporate name Incyte Pharmaceuticals. Incyte Genomics has specialized in design, development and marketing of database information products in the characterization and identification of genes and these genes' protein structure. This information is used by large pharmaceutical firms in the development of new types of drugs. The information products are also used in the development of genetically modified plants, where it is used to isolate specific genes. Incyte has stock copies of a huge number of gene sequences that they supply to their partners on demand, making it is possible for the customers to develop new products. Incyte sells their "products" by engaging in partnerships with pharmaceutical firms who access the database with non-exclusive rights. Incyte has also developed a range of applications for the database that allow customers to search for active substances to develop new drugs. For large industrial partners, there is a twenty-four-hour access to the database systems, whereas Incyte serves the smaller partner by providing in-house consultancy service.

The company's primary income comes from partnership fees and from consultancy services for small firms that do not have the interest in or the resources for an exclusive access to the database. These firms ask Incyte to take care of search processes. The partnership arrangement is created so that Incyte will have royalties from products that its partners have developed by subscribing to their

sequencing systems. The first two partnerships that Incyte established were the agreements with Pfizer and Pharmacia & Upjohn. These two firms got stock options as part of their agreements; thus these two firms in 1998 owned 6.7% and 7.5% respectively of the corporate stocks before the stock issue in 1997. In spite of the fact that these two firms have ownership in Incyte, all partnership agreements with other firms are established with non-exclusive rights so that Incyte has no special ties to any of its customers. None of the partners can say that they have special advantages or disadvantages compared to the other partners. Another reason that access to the databases is given on a non-exclusive basis is to avoid letting one of the major partners buy up the firm to keep the technology for itself. This aspect of the agreements may be the primary reason that the first two partners took an equity position, because they may have feared that they could have been used as a sales window to sell off the company afterwards, without having had an opportunity to make an offer on the firm themselves.

Incyte Genomics engages in two types of partnership agreements with firms: 1) Firms that buy access to the databases, and 2) firms that deliver or sell data to the databases. The latter type of agreement is Incyte's strategy to form partnerships with as many relevant firms as possible and have them to deliver the data that Incyte afterwards structures and packs into the databases. These partnerships concern the input to the database or bioinformations systems. These information systems are later indexed in interests groups such as animals, plants, bacteria etc.

Consistent with the experiences faced by the firms in my sample, Incyte did find that, as a firm legitimizes its technologies, there is no longer a question of how to attract new partners; rather, interested partners contact the firm to form partnerships or ask for their consultancy services. In this situation, the firm faces a need to make continuous evaluations and reviews of technologies and

techniques developed by small biotechnology firms that could be interesting to include into the databases. This very fact changes the way that the firm organizes its external relations. Previously, Incyte often attended research conferences to promote the firm and present the services that it could provide. Today the promotional work is much more focused around the development of new partnerships.

A third type of partnership that was developed in 1997 was a joint partnership with the pharmaceutical firm, SmithKline Beecham, in the formation of a joint venture firm, diaDexus, that develops molecular diagnostic products. The firm is located in Santa Clara, 10 miles south of Palo Alto. The agreement between SmithKline Beecham and Incyte is that the larger partner gives diaDexus an exclusive license to utilize a range of diagnostic tests, the rights to which SmithKline Beecham had bought from a third biotechnology firm, Human Genome Science, whereas Incyte provides access to the firm's bioinformation systems on a non-exclusive basis. The partnership should reduce the risk of failure because each of the firms adds some very scarce competencies. Incyte adds some very important support functions, whereas SmithKline Beecham has the competencies that make it possible to have the diagnostic products approved and marketed.

From a network perspective, it seems like the industrial-partnering strategy is an almost endless opportunity-seeking formula for developing a small biotechnology venture. That said, it is also fair to say that the strategy is not very easily copied or transferred into other types of biotechnology firms. Bioinformatics and genomics firms have a technological platform that allows them to act as a highly advanced service company and, at the same time, take out specific projects and develop them into new business ventures, for example, joint venturing in collaboration with their large industrial partners. This means fast growth both in terms of employees and in the numbers of partners. In turn,

this raises questions about a company's ability to manage this growth since there must be an upper limit to how many partnerships you can be committed to at same time.

10. The policy-oriented strategy, Calgene, part two

In the late 1980s, Calgene decided to develop its own products instead of continuing to be a research boutique; this decision meant that the firm started new activities to be well prepared for the happy day when the Federal Drug Administration (FDA) would approve the new products.
The FDA is seen as either the worst nightmare of a bureaucratic organization or as a relatively open organization. In principle, the FDA is performing an impossible task because it is unable to develop the competencies and skills necessary to keep up with the development of new products and technologies in the industry. In consequence, getting biotechnological products approved is considerably more time-consuming than getting traditional products approved. This causes difficulties for the companies because they are almost set on hold while waiting for the FDA approval. Therefore, small biotechnology firms in general must display a more proactive attitude toward the FDA while the clinical trials are going on instead of sitting back and waiting for the FDA decision. One example of the negative attitude toward the FDA appeared during the interview below with Dr. David Englemann, a Stanford professor who has formed four biotechnology ventures; in contrast, Carolyn Hayworth, in the excerpt which follows, speaks positively of the policy strategy followed by Calgene when having the genetically modified tomato approved.

> *I hate the FDA. The FDA is a barrier to entry. The FDA exists to prevent potentially toxic drugs or toxic or dangerous devices from getting to market. The FDA doesn't get any credit if a marvelous new drug is discovered and approved. But they get blamed if a marvelous new drug is*

approved and it turns out to have unanticipated toxicity. For that reason the FDA's sole purpose for existing is to prevent drugs and devices for getting approved because they only get blamed if something goes wrong. They don't get any credit if things go right. It takes ten years on average for a drug or device to be approved and it cost hundreds of millions of dollars. I see it as a negative incentive for the small company. It is one of the reasons why so few drugs are approved every year - because the FDA makes it so difficult. I think that the companies themselves should be responsible for assuring the safety of the drugs and the efficacy to the maximum of extent possible. But I believe in letting the market forces determine that. I think that there have to be some basic safety rules but the kind of testing that is required of the FDA, I don't agree with it. I think it is overkill.

Dr. David Englemann, Director of the Stanford Blood Center

We have an excellent relationship with the FDA right now. Not that they have given us anything as quickly as we wanted, but part of the development of this technology was that we wanted to be the first. We wanted to be the pioneer in this technology and get through the FDA and help the FDA to form the policies for these types of products, and that is what we have done. In 1992, the FDA, after we had presented our data, developed a policy for the development of new plant varieties and they included genetic engineering. Calgene has been instrumental and helped them to put together that policy. We had wanted to demonstrate the effectiveness to validate that the government has oversight in this area, and that their oversight is appropriate, and that is what we have done. They are validating our products as much as we are validating their agency in the area of biotechnology. So it is a kind of I help you, and you help me.

Carolyn Hayworth, Manager of The PR Department, Calgene

As indicated Calgene, at a very early point (by the end of 1988), formed its initial *productive* relationships with the FDA. The strategy was to get actively involved in the specifications of the rules and regulations that the FDA would demand of genetically modified food products. At that time the FDA had not developed a set of rules and regulations in this area because no companies had contacted the FDA to have such products approved. Therefore, Calgene was the first company that called for rules and regulations. This implied that Calgene, by its own account, established a very open dialogue with the FDA, and that Calgene assisted the FDA in the development of the policy that the FDA published in 1992. This policy was made public two years after Calgene had posted its first application for product approval of the Flavr Savr™ tomato to the FDA. This first application was renewed in 1991 and forced the FDA to carry out a policy and a set of rules and procedures aimed at the genetically modified food products that began to show up in 1991.

The approvals of the product took more time than expected. Eventually Calgene got the tomato approved in the beginning of May 1994 and Flavr Savr™ was the first genetically modified fresh fruit or vegetable product that was approved for human consumption by the FDA. The final approval was very positive from the perspective of Calgene because the FDA evaluation of the product concluded that the Flavr Savr™ tomato did not differ noticeably from traditional tomatoes on a number of characteristics. Therefore Calgene was not forced to put a special sticker on the tomatoes showing that the product was genetically modified. The selling of the tomatoes began three days after the approval in supermarkets in Illinois and Northern California. The sales figures were positive, but Calgene did not earn any money because it did not have access to enough square acres to grow the tomatoes, and therefore the firm could not supply the supermarket/customers with a stabile delivery and a sufficient quantity of the new tomatoes.

When the FDA had approved Flavr Savr™ in the beginning of May 1994, Calgene was prepared both internally and externally to take advantage of its rights to sell the product on the market. Despite the fact that the FDA did not find that the product differed from other tomatoes available on the market, Calgene changed the brandname of the tomato. Instead of the well-known name from the media, Flavr Savr™, the tomato was given a more neutral and *'agricultural'* name: "MacGregor®." According to Martineau, the name alluded to the children's song "Old MacDonald had a farm" (Martineau, 2001).

Part II of the Calgene case shows how the company still uses the same gameplan for building up relationships when approaching the FDA for the final product approval. In Belinda Martineau's book, "First Fruit", she describes how it was the senior researchers at Calgene that were given the task first of having their technological concept approved; it was the same group of researchers that eventually put together the final application and had the tomato approved, while the business-development people and the chief regulatory personal were given the task of promoting the first genetically modified fruit for human consumption in different forums, such as consumer rights groups, supermarkets etc. (Martineau, 2001)

11. Conclusion

This article shows that the initial networks that the companies form create paths for the future ability to form new partnerships. Therefore it could be interesting to investigate the path-dependent nature of strategies and try to link strategic analysis in a single firm with the ongoing research discussions on path-dependence and path-creation in the area of economics, economic sociology and technology sociology (Garud & Karnøe, 2001; Rosenberg, 1994). Such a discussion will point

to the very interesting dilemmas that managements face when creating new strategies. Another way to interpret the outcome of this paper is to view the entrepreneurial strategies as the top-management's vision aimed at the firm's stakeholders such as venture capital and other business partners, and look at the proposed strategies as operational strategies in order for the organization to have a strategic road map or milestones to see how progress is made.

This discussion points to several possible implications for business people, policymakers and academia. For business people, particularly those considering starting their own business, it seems to be of vital importance for entrepreneurs to face the challenges of how norms and values among the key personal are able to point the direction for how to engage in external partnerships. To the extent that we can argue that organizational routines are under construction in this stage of corporate life, the article demonstrates how valuable resources are mobilized in a variety of different external networks. However, how to establish network relations can be difficult in the later stages of corporate life if the new network is guided by a different set of values and norms. This is because networks often are of an exclusive nature, calling for strong relationship-building activities, management of reputation, etc.

For policymakers, the often rather blinkered focus on solitary entrepreneurs, and how to pick these winners and nurture them, may need to be replaced with a stronger focus on the importance of solidarity networks and the process of trust-building among entrepreneurs. Skills for business start-ups are available in network contexts and their importance for generating more business start-ups are presently underestimated in most industry policies we know of.

Finally, for academia it is necessary not only to acknowledge that networks are important in the processes of firm creation, but also to understand what they actually are able to take care of in business-creation processes. A stronger focus on the role of the systemic nature of business-creation processes is called for, in order to explore the division of labor actually taking place in the microcosm of business creation.

References

Constant II, E. 1984. Communities and Hierarchies: Structure in the Practice of Science and Technology. Laudan, R (ed:). ***The Nature of Technological Knowledge. Are Models of Scientific Change Relevant?*** Dordrecht: D. Reidel Publishers

Constant II, E. 1987. The Social Locus of Technological Practice: Community, System or Organization. in Bijker W., T. Hughes, & T. Pinch (eds.) ***The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology.*** Cambridge: MIT Press

Daly, P. 1985. ***The Biotechnology Business.*** London: Frances Pinter

Dodgson, M. 1993 ***The Management of Technological Learning: Lessons from Biotechnology Company.*** De Gruyter Studies in Organization: No 29. Berlin: De Gruyter

Garud, R. & P. Karnøe (eds.) 2001. ***Path Dependence and Creation.*** Mahwah: Lawrence Erlbaum Associates, Publishers

Kenney, M. 1986. ***Biotechnology: The University Industrial Complex.*** New Haven: Yale University Press

Kreiner, K. & M. Schultz 1993. Informal collaboration in R&D. The Formation of Networks Across Organizations. ***Organization Studies*** Vol 14. No 2, 189-209

McKelvey, M. 1996. ***Evolutionary Innovations –The Business of Biotechnology.*** Oxford: Oxford University Press

Mintzberg, Henry, Bruce Ahlstrand & Joseph Lampel (1998): ***Strategy Safari***. London: Prentice Hall

Norus, J. 1997. The Role of Personal and Professional Networks in the Process of Technological Transformation. American Behavioral Scientist Vol. 40, No 4 Sage Periodicals

Norus, J. 2002. ***Biotechnology Organizations in Action – Turning Knowledge into Business.*** Progress in Biotechnology Series, Volume 20. Amsterdam: Elsevier B.V.

Pfeffer, J. & Salanzik G. 1978. ***The External Control of Organizations. A Ressource Dependence Perspective.*** New York: Harper & Row Publishers.

Pfeffer, J. 1987. A Resource Dependence Perspective on intercorporate relations. In Mizruchi, M. S. & Schwartz, M. (eds.): ***Intercorporate Relations: The Structural Analysis of Business.*** Structural Analysis in the Social Sciences No 1. Cambridge: Cambridge University Press

Powell, W. W. et al. 1994. ***Technological Change and the Locus of Innovation: Networks of Learning in Biotechnology.*** Working Paper. Tucson: Department of Sociology, University of Arizona.

Powell, W. W. et al. 1996. Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. ***Administrative Science Quarterly***, 41: 116-145.

Powell, W.W. 1998. Learning from collaboration: Knowledge and networks in the biotechnology and pharmaceutical industries". ***California Management Review,*** 40: (3) 228-263.

Robbins- Roth, C. 2000***. From Alchemy to IPO – The Business of Biotechnology.*** Cambridge, Massachusetts: Perseus Publishing

Rosenberg, Nathan (ed.) (1994): ***Exploring the Black Box – Technology, economics, and History***. Cambridge: Cambridge University Press

Rothwell, Roy & Walter Zegveld (1985): ***Reindustrialization and Technology***. M.E. Sharpe

Seely Brown, J. & P. Duguid 2000. ***The Social Life of Information***. Boston, Mass.: Harvard Business School Press

Wenger, E., R. McDermott & W.Snyder 2002. ***Cultivating Communities of Practice.*** Boston, Mass.: Harvard Business School Press

Zucker, L. & M. Darby 1997. Individual Action and Demand for Institutions: Star Scientists and Institutional Transformation. ***American Behavioral Scientist*** Vol 40/No. 4 1997: 502-513