Technological Competence and the Influence of Networks: A Comparative Analysis of New Biotechnology Firms in France and Britain

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ABSTRACT *The objective of this paper is to examine the role of external networks not only as a resource but also as a constraint for the evolution of the technological competence of twenty new biotechnology firms (NBFs) in France and Britain. The analysis is based on extensive interviews conducted with the Chief Executive Officers (CEOs) of twenty NBFs, ten in France and ten in Britain. The paper identifies the network structures of the twenty NBFs and the impact of networks on the evolution of their technological competence. The paper also attempts to identify the differences between NBFs in France and Britain in terms of the framework developed. It clearly illustrates that the capacity of NBFs to construct appropriate external linkages with other firms and financiers is crucial to their success.*

Introduction

Biotechnology refers to a set of techniques such as genetic engineering, cell and tissue cultures, protein synthesis and enzymology that involve manipulation or change of the genetic patrimony of living organisms. These techniques have recently emerged (since 1975) from developments in the biosciences such as biochemistry, biophysics, molecular biology, microbiology, cellular biology and genetics. They have been integrated in the production process of a number of industries including pharmaceuticals, chemicals, agriculture, agro-business, environment and cosmetics to create new products or lower the costs of production.

Between 1975 and 1993, more than a thousand new biotechnology firms or NBFs were created in the United States and about four hundred NBFs were created in Europe.[1] It has been well documented that the development of these NBFs were a function of their R&D efforts, their external networks and the national system of innovation of the country concerned.[2] Furthermore, among the European countries themselves, there are substantial differences in the national styles of technological innovation, i.e. the various processes by which firms and research institutions transform scientific knowledge into marketable technology. Like the 'national system of innovation', the notion 'style of technological innovation' is also a multidimensional variable that can be studied at various levels of aggregation and interpreted in various ways. In this context, the objective of this paper is to identify country-specific characteristics of national styles of technological innovation. This is done in terms of the mobilization of networks of some French and British NBFs in the creation of innovations.

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Our analysis is based on the information obtained from extensive interviews with the CEOs of 10 French and 10 British NBFs conducted in fulfilment of a project for the EEC.[3] The sample was constructed to include a variety of initial technological competencies in biotechnology. We chose to obtain information from interviews because information available through databases or postal questionnaires rarely reveals why a network is formed, how it evolves and what kind of an influence it has on the evolution of the firm, but because of the interview procedure we had to restrict ourselves to a small sample and given the concomitant problem of inadequate representation of the population, we did not attempt to apply standard statistical analysis on our data.

We then tried to answer four central questions:

(1) What are the network structures of the firms in our sample?
(2) What kind of networks influence the day to day functioning of the firms in our sample?
(3) What kinds of networks are decisive in the evolution of the technological competence of the firms?;
(4) What are the features that distinguish the French firms from the British firms in the answers to the above questions?

The paper is organized as follows: The next section presents the framework developed to analyze the evolution of technological competence and networks. The section following goes on to analyze the contents of the interviews with the twenty French and British firms according to our framework. The final section recapitulates the common and specific features of their national styles of innovation together with explanations and conclusions.

Networks and Production of Innovations

Starting from Adam Smith, it has been noted that the economic performance of firms depends not only on their financial resources, but also their endowment of firm specific assets and competencies. This view has gained further ground in recent years with the publication of seminal articles by Wernerfelt[4] and Hamel and Prahalad,[5] and has given rise to a literature, referred to as 'the resource based theories of the firm'. Competence seems to be a particularly relevant yardstick to apply to NBFs since their success crucially depends upon their ability to develop a competitive advantage with respect to a generic technology or a type of product.

Since competence is a multidimensional variable, without any single universally accepted definition,[6] in this paper, we focus on technological competence as embodied in the production process of the firm. Adapting from Hamel and Prahalad,[7] we take technological competence as the ability of a firm to exploit its resources to create the particular technologies relevant to its needs. We assume that it can be represented by the R & D and product portfolios of the firm and created either through internal R & D activities or through external networks.

The inclusion of networks as a resource is necessary to specify the institutional set up in which a firm is embedded. They help us to understand why two firms with the same financial and knowledge portfolio might acquire different levels of technological competence. It is not denied that the evolution of resources could themselves be interdependent; for instance a change in the knowledge base could involve a change in the network structure if the knowledge has been increased through external linkages. The important difference between networks and other resources is that networks may involve non-market exchanges and strategic alliances in addition to market transactions.

As De Bresson and Amesse[8] and also Freeman[9] state, network analysis does not refer to one theory, but a set of methodologies whose common element is their consideration of strategic interaction among a group of agents. In the extensive literature on networks, several studies have underlined their importance for the production of technological innovations.[10] They have shown that the processes underlying the production of technological innovations depend on the connection between three poles: science, technology and market. The actors in these three poles are laboratories, firms that develop technologies and users respectively. For these authors, the central question is to understand how networks form a means of co ordination between the actors of the three poles in the creation of innovations. Other authors such as Powell[11] also point out that networks constitute a form of coordination intermediate between markets and hierarchies. They enable firms to gain access to resources outside of the firm like information, but which at the same time are not available in markets. Liebeskind *et al.*[12] also indicate that networks serve to safeguard property rights when complete or contingent contracts are not possible. Powell, Koput and Smith-Doerr[13] illustrate that networks can serve to expand the boundaries of the firm without vertical integration and also induce collective learning within the firm. Thus the location of the production of innovations can shift from being at the centre of a firm to being at the centre of a network.

The objective of our analysis however is not to explore how networks can form a means of coordination between firms, or how networks constitute an organizational form for the creation of innovations. Our aim is to understand the strategic role played by networks in the determination of the trajectories of technological competence of firms. To tackle this question, we have chosen the structural approach proposed by Lazega[14] as a tool of analysis because it seems to us to provide the most comprehensive means of exploring the nature of the influence of networks. Adapting from Lazega, the network structure of a firm can be defined as a set of networks, one for every external agent with which the firm has a link. Furthermore, each network in the network structure refers to a set of relations that involves either a non-market exchange not involving monetary transfers (of information, instruments, genetic material, personnel, etc.); a market exchange (renting of locale, research contracts, production contracts, financing, licensing, consultancy, distribution contracts etc.); or a strategic alliance (which includes joint control of resources as well as monetary transfers). The relations could also involve collaboration, support, advice, control, etc. The *raison d'être* of the network structure is that it permits at least some of the actors to achieve their objectives that otherwise would not have been possible. Then the impact of a network structure on a NBF can be studied along three dimensions:

(1) *Morphological dimension:* identification of the actors composing the set of networks and the type of relations between the firm and the external actor concerned.
(2) *Functional dimension:* identification of the type of networks that influence the different functions of the firm (such as management, R & D, production and marketing).
(3) *Strategic dimension:* identification of the type of networks that play a decisive role in the evolution of the technological competence of the firm.

The structural analysis of networks as given above captures the influence of both formal and informal relations and integrates the temporal dimension. It also allows for an examination of the dual role played by networks, both as a resource and as a constraint on the evolution of the technological competence of the firm.[15] Thus it is used as a tool of analysis to identify the country specific characteristics of the style of technological innovation of the firms in our sample.

Table 1. Morphological analysis of networks

	France	UK
Scientific network	100%	100%
Location linked to a scientific laboratory	90%	80%
For recruitment	40%	70%
Supporting doctoral students	100%	50%
Strategic alliances	30%	60%
Pooling resources (access to instruments, renting laboratory space)	50%	20%
Political network	70%	50%
Participation in expert committees	40%	30%
Participation in national programmes	80%	N.A.[a]
Participation in EEC programmes	40%	20%
Won government grants	100%	70%
Professional network	50%	50%
Member or administrator of a professional association	50%	50%
Financial network	60%	60%
Venture capital for creation	60%	30%
Venture capital for refinancing	40%	50%
Advice for R & D or product development	0%	20%
Inter-firm network	100%	100%
Contracts	40%	60%
Strategic alliances	20%	80%
Financial participation by firms	60%	40%

[a]N.A. signifies not applicable.

The Morphological Analysis of the Network Structure of Firms

The network structure of a firm is particular to the sector in which it operates. Innovations in the biotechnology sectors have resulted from the integration of several scientific disciplines and technologies. To transform this knowledge into marketable technology it has been necessary to create networks with a variety of agents. The literature on the evolution of the biotechnology sectors indicates that five kinds of networks played an instrumental role in the evolution of technological competence of NBFs in France and Britain.[16] They were the scientific network, the political network, the professional network, the financial network, and the inter-firm network. The scientific network referred to relationships with universities and public laboratories. The financial network referred to links with venture capitalists. The political network referred to associations with government bodies and regulatory agencies; and the professional network referred to membership in professional associations relating to biotechnology.

During the interviews, the firms were asked if they had constructed any of the above five networks in the past, and if so, what was the nature of each network. In other words, a network or relation was associated with a firm, if the firm had at least one such relationship between the time of the creation of the firm and the time at which the interview was being conducted. We were then able to identify a set of characteristics of these networks as given in Table 1.

The figures indicate the percentage of firms in our sample of twenty firms with which a particular network or type of relation was associated.[17] The data was entered on a firm by firm basis. It did not contain any quantitative information on the density of each network. The following facts then became clear.

The scientific network is a crucial resource for the creation and evolution of firms in both France and Britain. In both countries, the scientific network fulfills five kinds of roles for the firm. It acts as a reservoir:

(1) For augmenting the knowledge base of a firm resulting in proximity of the firm to the research laboratory;
(2) For recruiting personnel for R & D activities (as researchers or engineers);
(3) Providing complementary competencies and resources for a firm which benefits from a sharing of locale, instruments and established infrastructure;
(4) Serving as a client of products or services of the firm;
(5) Being a partner for developing new products or processes through research contracts or work done by doctoral students.

The inter-firm network formed part of the network structure of all the firms in our sample. However strategic alliances and buyer–seller relationships were more common in the British sample, while in the French sample the relations arose through part ownership of the NBF by another firm. The British firms not only had more relations with other firms, but their networks were also more diversified, one for co-development, one for contract production, one for distribution, etc. The relations with non-European firms were also more pronounced in the British sample.

There were no major differences between the French and the British samples with respect to the financial network. As a resource, the venture capitalists principally performed three functions: aiding the creation of firms, opening the firms to the public (or refinancing), and providing counsel on strategy. The most commonly observed role was participation in refinancing, then came creation of firms. They rarely provided complementary competencies (10% of firms in our sample).

In France the political network was formed along a different dimension as compared to Britain. In France, most of the firms had a political network through participation in national or EEC programmes, while in Britain the firms had a political network through obtaining government grants. The professional network was observed in 50% of the firms in both the countries. These results are also captured graphically in Figure 1.

The Functional Analysis of the Network Structure of Firms

In discussing the nature of each network, the firms also revealed the impact of each network on the day to day functioning of the firms. It was clear that in both France and Britain, the political and professional networks had no influence on the short term functioning of the firm in terms of choice of R & D and product portfolios, marketing strategies or management routines. Similarly, in both countries the financial network had only an indirect impact on the functioning of the firms via its influence on the management staff. This prevailed when the financial institution had a major role to play in raising funds for the firm and used it as an opportunity to put persons of their choice in the management team of the firm. The rest of the findings are summarized in Table 2.

The scientific network intervened in the R & D or production functions of all the firms in our sample through transmission of new ideas and feedback of products and services of the firm. Furthermore in France, unlike in England, in some cases the scientific network played a role even in the 'marketing activities' of the firm. The main mechanisms through which it exerted an influence on marketing were through: helping in the promotion of the firm through publications in scientific journals; hosting executive educational programmes for firms; counselling firms on marketing strategies; acting as

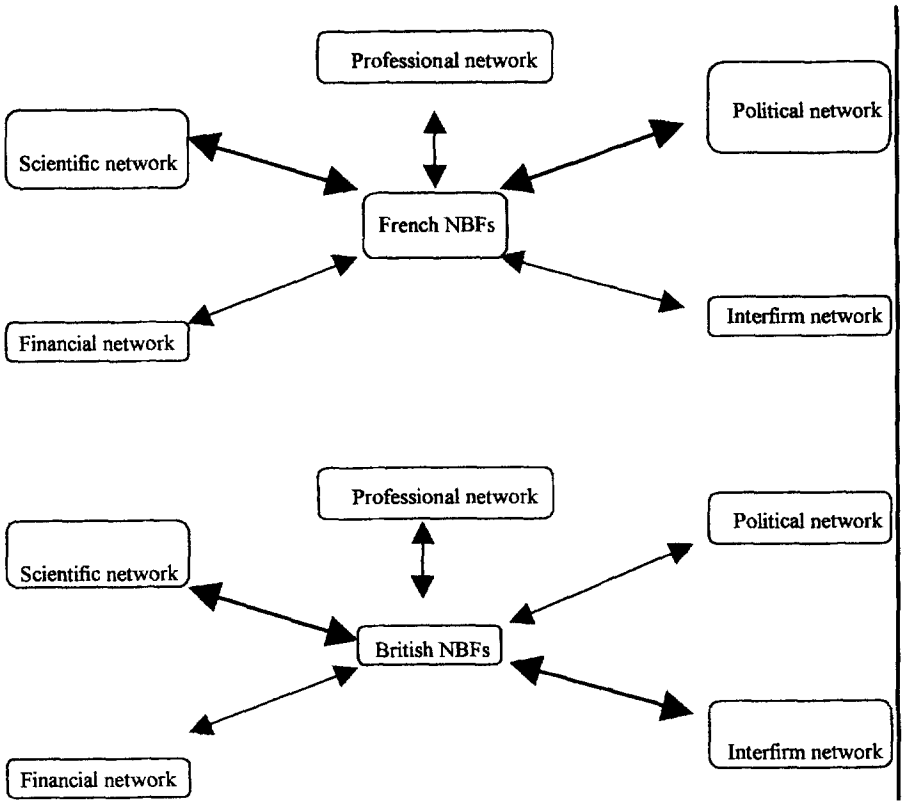

Figure 1.

clients of firms created by researchers; and working and interacting with firms in the context of EEC programmes.

On the other hand, the presence of inter-firm networks was more marked in all activities of the firm in the UK. The association of other firms in the activities of R & D, production or marketing or some combination of the three can be explained as follows. If a NBF restricts itself to research, it can survive by selling the product of its research outright; selling licenses or patents; conducting research for other firms through contracts; or co-developing a product with another firm which the other firm will eventually produce. In the above cases the NBF acts as a 'scientific gatekeeper' translating scientific knowledge into usable technology for other firms. It then becomes a source of 'complementary competence' for other firms to investigate the potential of science for the

Table 2. Functional analysis of networks

	R & D		Production		Marketing	
	France	**UK**	**France**	**UK**	**France**	**UK**
Percentage of firms with this function	100	100	80	60	80	60
Percentage of firms in which the following Network had a direct impact on the:						
Scientific network (%)	100	100	37.5	75	37.5	0
Inter-firm network (%)	50	70	50	83	60	100

commercialization of innovations. If a NBF integrates into production, its activities could again include producing for other firms through contracts; co-producing a product with another firm; or producing its own product for final consumption. The first two refer respectively to a market relation and a strategic alliance with another firm. It can be noted that if a NBF further integrates into marketing, it can again have one of the above three options.

The Strategic Analysis of the Network Structure of Firms

Taking technological competence as the R & D and product portfolios of the firm, our first task was to check if we could identify different types of evolutionary trajectories. The next step was to examine if any of these evolutionary trajectories had been induced or forced upon a firm by an external network. Again, the analysis was based on the information obtained through interviews, where the history of the firm had been discussed and the focus had been on the R&D and product portfolios of the firm, how they evolved and why they evolved the way they did. The period of reference was two points in time, at the creation of the firm and at the time when the firm was being interviewed.

The examination of the 20 firms led to identification of four kinds of trajectories of technological competence. The first kind was a 'passive learning trajectory' corresponding to firms that did not invest substantially in R & D and simply exploited a particular technology. In this case the knowledge base of the firm did not increase due to the R & D efforts of the firm. Any learning that occurred was through 'learning by doing', i.e. emerged as a side product of the activity of the firm.

On the other hand, when the firm invested in R & D, 'active' learning took place. An 'active learning trajectory' led to one of three types of trajectories that can be termed as the 'widening' or 'deepening' or 'narrowing' trajectories. A 'widening' trajectory of technological competence occurred whenever there was a diversification or improvement of technological competencies. Under a widening trajectory, new projects, processes or products were added to the R & D and product portfolio during the life cycle of the firm without any of the existing projects or products being abandoned. A 'deepening' trajectory referred to an improvement of existing competencies without the development of new competencies. In other words, the R & D expenditure of firms in this category was geared towards increasing the knowledge base pertinent to the existing R & D and product portfolio. A 'narrowing' trajectory referred to an abandoning of a set of existing projects, processes or products without the development of new competencies. We then define a 'decisive network' as one that that either induced or forced the firm into a particular evolutionary trajectory of technological competence.

On the basis of the above definitions it was evident that most of the firms in our sample pursued an 'active learning trajectory'. A widely held view is that start-ups in general, even those in the high tech sectors, do not invest in research with the specific objective of either improving their existing set of competencies or developing new ones. They are supposed to adopt a passive learning trajectory where the learning, within the firm comes by doing or simply functioning. This was far from being the case. In the French sample, all films pursued an active learning trajectory, while in the British sample 80% of the firms pursued an active learning trajectory.

The observations on the strategic analysis are captured in Table 3. While there is no evident correlation between firms in France or Britain and any particular evolutionary trajectory, it is clear that the kinds of networks that played a decisive role in the two countries were different.

Table 3. Strategic analysis of networks

	Creation		Widening		Deepening		Narrowing	
	France	UK	France	UK	France	UK	France	UK
Percentage of firms in each trajectory	100	100	23	12	31	50	46	38
Percentage of decisive networks								
Scientific network (%)	80	90	33	50	75	25	0	33
Inter-firm network (%)	30	30	0	50	25	75	50	33
Financial network (%)	10[a]	10[a]	66	0	25	25	50	33

[a]These figures are different from those in Table 1 because they only represent the cases where the financial network was decisive in the creation of the firm.

The table reveals that there were no perceptible differences between the two countries as far as the role of networks in the creation of firms is concerned. In both countries, the scientific network played a more important role in the creation of NBFs as compared to other types of networks. Three patterns could be observed whereby: a public laboratory supported one of its members to found a firm; a public laboratory took the initiative to found a firm; and, a public laboratory was prepared to share its resources with a start-up. The inter-firm network had a hand in the creation of firms whenever a NBF was founded by an industrial researcher, whenever a NBF was founded as a subsidiary of an established firm or whenever a NBF was created as a result of a contract with another firm.

As can be seen, the factor that discriminates between the two countries is not the frequency with which a particular trajectory was observed but the frequency with which a particular network was decisive. Thus the scientific network was more often decisive in initiating the widening trajectory in the UK as compared to France, while it was the reverse for the deepening trajectory. The inter-firm network, led more often to the deepening and widening trajectories in the UK, while it forced the narrowing trajectory more often in France. The financial network was more influential in France than in Britain for any trajectory.

The firms which pursued the 'deepening' trajectory were those that publicized their scientific competence through internal research made visible by patents, and survived through doing research for others, namely the large firms. In such instances the scientific network acted as a resource, generating new ideas and leading to transformation of R & D into production. In Britain, the scientific network also led to competence narrowing in some cases. For instance firms often got their new products tested by some public laboratory in their scientific network. When the feedback was negative the firms abandoned the concerned projects.

The inter-firm network led to competence widening and deepening in cooperative and constraining ways. It created synergy leading to widening of competence through the forging of strategic alliances between NBFs and other firms. The NBFs also got feedback from other firms that were its clients. Sometimes the NBFs were forced to improve or widen their competencies while creating 'made to order' products or services for other firms. The mechanisms by which outside firms forced NBFs to integrate into production were the same, except in one case, where a large firm bought out an NBF and forced it to commercialize some of its research projects through manufacturing.

Competence narrowing or abandoning of projects was forced on the NBF by the inter-firm network, through:

(1) A strategic alliance with another firm which felt that the NBF could evolve into being a strong competitor and therefore forced the NBF to abandon a particular project.

(2) A strategic alliance with another firm. where the latter had agreed to be the distributor and subsequently rejected a project because of small potential market size for the product.
(3) Another firm becoming a majority shareholder in the NBF.
(4) Another firm buying out the NBF.
(5) Regulations (especially in France) associated with clinical trials, which rendered the project too costly for commercialization.

The financial network influenced the transition points of competence through its place in the management hierarchy. This status was given to it on account of its financial participation in the firm. It also influenced the transition points through acting as brokers for NBFs to find large firms as partners, investors, and buyers.

In the French sample, the 'narrowing' trajectory was observed the most often. The firms in this category were associated with a high turnover of management and two kinds of decisive networks: the financial network and the inter-firm network. In the French case, the inter-firm network mainly influenced the NBFs through participation in capital holdings and buyouts, rarely through collaboration in the research or production process. The most common trajectory for the British firms was the competence-deepening trajectory. Though the academic network was a decisive external linkage for 80% of the British firms, their evolutionary trajectories were also determined by the needs of the market within which they functioned. 70% of the British NBFs had a strategic alliance, research collaboration or product co-development with large firms that was a valuable source of funds. In turn, the needs of the large firm influenced the evolution of competence of the NBF and the orientation of its knowledge base even when there were no knowledge transfers.

Common and Specific Features of Styles of Innovation

It is clear that in both countries NBFs can neither emerge nor grow without developing external alliances in the form of a network structure. The initial network structure of a firm depends on the existing networks of the founder of the firm and those of his partners involved in the creation of the firm. Then the network structure evolves as new suppliers, distributors, clients, or financiers are found. In turn, the external actors may either induce further evolution or crystallize the network structure through their influence along the functional and strategic dimensions. In France, the network structure of firms often crystallized around well-developed relations with public laboratories or fund-giving government bodies while in Britain it crystallized around public laboratories and large firms (see Figure 1). An 'active learning trajectory' characterized the technology strategy of most of the NBFs. There were no substantial differences between the two countries in terms of the frequency of the three types of trajectories of technological competence considered.

With respect to the creation of networks, in both countries NBFs had problems in getting contacts and forming networks with other films, especially large firms. They needed to develop routines to find out what larger companies were doing, the areas they were getting into and the individuals making key decisions. Similarly, in both countries, it was more difficult to find financial support a few years after the creation of the firm than at the period of creation itself. Lead times and development times for most of the products were long and required substantial amounts of patient capital. The firms had problems in negotiating milestone payments, i.e. getting reasonable amounts of working

capital on meeting deadlines. It was strongly felt that if financiers (private or public) in Europe did not take a long term investment view, the best ideas would be taken up and exploited in the US.

The main difference in the morphology of the network structure of the French and British firms was that the latter had a weaker political network, but a denser network with large firms. Along functional lines, the British firms seemed to have a network structure in which the use made of each partner in the network was more specific than for the French firms. Research institutes provided the essential backward linkage in both countries acting as a source of knowledge, while large firms formed the forward linkage, being the direct or indirect clients, whose needs determined the technology strategy of the NBFs. In France, the scientific network not only acted as a backward linkage but also served as a forward linkage often being a client of the NBF as well. However, the density of networks with large firms was greater in Britain as compared to France. The French firms seemed to be compensating for the weaknesses in their network structure with large firms through grants and participation in national and European programmes.

With respect to their strategic influence, the initial scientific network of the firm and the financial network played a decisive role often in France. In Britain, it was the network created with large firms at some point after the creation of the firm that frequently played a decisive role.

As a constraining factor, the financial and inter-firm networks seemed to be causing more tension for internal governance of the firms in France than in Britain. A majority of the French firms (60%), viewed financial networks as a danger to 'staying in control' and 'staying French'. It was based on two preoccupations: concerns about proprietorship and a desire to control strategic decision making relating to management and technological orientation. Venture capital firms were often viewed as lenders of last resort. Thus the founder usually started with a financial network of family members, friends and managers of firms known personally to the founder. When finally venture capitalists were brought in, they usually looked for partners for the French NBF on the international market. This practice was viewed very negatively. Similarly a buy-out of a French NBF by an American company, often at the initiative of the venture capital firm, was regarded as alien tapping of national research results. However this does not imply that the French firms did not enter into collaborative agreements with foreign companies; such agreements were preferably limited to commercial ones for the distribution of products. On the other hand, seven of the ten British firms in our sample had strategic alliances or collaborations with non-British firms or research institutes to develop innovations. Even for those which were partly or even totally held by foreign companies, the 'ownership' issue was not a problem. What the British firms saw as important was the emergence of firms in Britain and not of their being British. However the British firms did not explain their attitude or indicate whether such an attitude would be beneficial or detrimental to them in the long run.

Explanations

We propose three factors to explain the above configurations: (i) strategy of the state, (ii) attitudes of the large firms and (iii) the induced responses of the French and British NBFs.

In France, the national system of innovation has for centuries been influenced by the 'Colbertiste pattern' whereby the functioning of the public bodies is highly centralized.[18] Thus not surprisingly, the impetus for the creation of the biotechnology sectors came from the state itself in France, while in Britain it was spearheaded by the academics.[19]

The French government proved its strong commitment to the creation of industrial competence in the biotechnology sectors through direct intervention in the market and the launching of a series of national programmes. Such programmes provided subvention for research in the networks of national laboratories (INRA, CNRS, INSERM, Institut Pasteur, CEA, etc.) and initiated cooperation between the national laboratories and industrial groups. It was also committed to active participation in EEC programmes. However, over the 1990s, the focus of the French government's policy changed from being directed towards linking academic and industrial communities, to focusing on the large industrial groups. Gradually, the government ceased to be the leading actor in the integration of biotechnology, the post having been taken up by the large industrial groups.[20]

On the other hand, under the Thatcher government, the objective was to create a context similar to that of the US. Public research was supported but industries were expected to conduct applied research by themselves and also help the small and medium sized firms through outsourcing some of their research. The British government's strategy focused more on creating incentives rather than giving direct subventions. The logic of state intervention was quite different from that in France, as is evident from a popular quote of British politicians in the 1980s, 'the best industrial policy is no industrial policy'. Then during the 1990s the government continued to focus on developing the research base and stimulating the venture capital market.[21]

In France, both the large industrial groups and the financiers were and are still more interested in developing relations with American NBFs rather than investing in French NBFs. Such a strategy stems from the need to make inroads into the American market and also provides a means of keeping up with the latest scientific developments in the biotechnology sectors. Furthermore, French venture capitalists feel that French NBFs should think in terms of an international market rather than a domestic or even a European market. According to them, the three main rules that have to be followed by an NBF in order to be ensured success are: (i) 'to have the right person, at the right place and at the right time' which means that the managers of NBFs have to change according to the development stage of the firm; (ii) have contractual relationships or strategic alliances with large firms, (iii) after a few years of production, enter the American market through a strategic alliance with an American firm or be bought up by an American firm.[22]

The stronger government intervention in France has encouraged the creation of a larger number of NBFs by academic researchers as compared to Britain (though this is not reflected in our sample) and it has led to the French firms having closer and more diverse links with public research institutes, as well as a stronger political network. On the other hand, since the French researchers came from an environment where research was supported by the government, they found it more difficult to enter into the logic of the market. Again coming from an academic set up, the management style of French NBFs seemed to leave decision making on technology strategy as the prerogative of the founder. Therefore, networks with large firms or public laboratories or governmental bodies were developed in such a way as to be operational along the 'functional dimension' but not the 'strategic dimension'. In other words, the types of relationships which invoked an influence on the long term functioning of the firm, were avoided. Then when the founders of the French NBFs began to explore avenues to raise funds they often found (as in our case study) that large French groups and venture capitalists were not too keen on investing on French firms. At this point, the threat of being bought up by a foreign company caused tensions. Such problems were exacerbated by the fact that the links between research-based organisms and financial counselling companies or compa-

nies counselling in intellectual property rights, which could play a key role in the incubation of NBFs, were weak. In Britain, on the other hand, the policy did not change direction, it continued to fund fundamental research, with much less emphasis on industrial research. Such a harsher treatment seems to have created more enterprising NBFs that are less averse to the 'culture' of collaboration and integration of external networks. The British NBFs are more aggressive in seeking and exploiting external networks and at the same time more willing to accept the realities of adaptation, including change in the management staff, in order to serve the needs of the large firms.

It is clear then from the above analysis that there are distinct differences in the 'national styles of technological innovation' between French and British NBFs as given by the structural analysis of their networks. However, in both countries, the integration of biotechnology through the creation and mobilization of networks can be promoted through improving the links between researchers, industrialists and financiers. Finally, in both countries, NBFs aspiring to grow must initiate and exploit networks to develop their technological competence while adapting to serve the needs of their network partners. Then the dual roles of networks as a resource and a constraint need not be contradictory for the growth of such NBFs.

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15. This point has received some attention earlier. Callon, *op. cit.*, Ref. 10, and Mustar, *op. cit.*, Ref. 10, have underlined the importance for firms to manipulate networks in order arrive at an equilibrium between the 'stability' and the 'flexibility' offered by a network. The 'stability' of the network permits mobilization of the associated resources in the short run, but at the same time the 'stability' of the network might create rigidity and the irreversible constraints for the firm concerned in the long term. 'Flexibility' of the network, on the other hand, makes it possible to open the networks to other agents and allow for adaptation to changes in the environment.
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