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Vincent Mangematin

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Vincent Mangematin

INRA/SERD
Université Pierre Mendès France, BP 47X
38040 Grenoble Cedex 9
Ph : 33 4 76 82 56 86
Fax : 33 4 76 82 54 55
E-Mail : Vincent@grenoble.inra.fr

Abstract

Public authorities have recently supported development of the biotechnology sector by encouraging start-ups and creating favourable environments such as incubators, a specialised stock exchange or technopoles. The different programmes to encourage biotech development (subsidies for research performed jointly by firms and academic labs, subsidies for start-ups, creation of incubators) seem to be successful if the results are estimated in terms of the number of new firms (around 300 SMEs still in existence, since 1990). On 1 January 1999 France had just over 400 biotechnology SMEs employing a total of 15,000 people, with an estimated turnover of 2 billion euros. Average size in terms of number of employees per firm is about 40, compared to about 140 in the USA. All in all, biotechnology remains a small emergent sector compared to others such as agri-food (over 4,200 French firms with 372,300 employees and a turnover of 100 billion euros) or pharmaceuticals (94,500 employees in 271 firms and a turnover of 28,5 billion euros).

The creation of start-ups during the past ten years raises questions on the future of these new biotech firms (DBFs) in France and in Europe. Will consolidation occur in Europe and, if so, when? Will maturity of the biotech sector be accompanied by the progressive disappearance of many of these firms and the growth of a few of them? Will the sector be structured along the same lines as the automobile industry, with large firms with a high capacity for integration of research performed elsewhere and a large number of specialised

firms? What will the future be of the hundreds of small firms which focus on the local or regional market, especially service oriented firms?

To answer these questions, this paper presents three business models of biotech firms. By referring to the governance modes of each business model of biotech SMEs, it provides us with a better understanding of the logic of development of biotechnology SMEs in France. The first part presents the linkages between business models and governance modes. The second part, based on a survey on half of the 400 dedicated biotech firms (DBFs) in France, presents an overview of these firms and their development. The third part presents an attempt to map out the development trajectories of SMEs and the respective leading forces in each type of firm. Concluding remarks present three possible scenarios of the evolution of the sector.

1. Introduction

Public authorities have recently supported development of the biotechnology sector by encouraging start-ups and creating favourable environments such as incubators, a specialised stock exchange or technopoles. The different programmes to encourage biotech development (P. Monsan, 1999) (subsidies for research performed jointly by firms and academic labs, subsidies for start-ups, creation of incubators) seem to be successful if the results are estimated in terms of the number of new firms (around 300 SMEs still in existence, since 1990[1]). On 1 January 1999 France had just over 400 biotechnology SMEs employing a total of 15,000 people, with an estimated turnover of 2 billion euros[2]. Estimates based on the survey initiated by the MENRT[*] are consistent with information published by Ernst and Young, although they indicate a higher number of firms in France. Average size in terms of number of employees per firm is nevertheless similar: about 40 persons, compared to about 140 in USA. All in all, biotechnology remains a small emergent sector compared to others such as agri-food (over 4,200 French firms with 372,300 employees and a turnover of 100 billion euros) or pharmaceuticals (94,500 employees in 271 firms and a turnover of 28,5 billion euros[3]).

[1] As the mortality rate is high, our figure under-estimates the number of firms set up during the last 10 years. But it gives an idea of the number of firms set up and which survive.
[2] This figure does not take into account divisions in certain firms specialised in biotechnology, with over 500 employees.
[*] *Ministère de l'Education Nationale, de la Recherche et de la Technologie*. The French ministry in charge of research.
[3] Sessi, 1999: "La situation de l'industrie", *Annual Business Survey*, Sessi, Paris.

The creation of many start-ups during the past ten years raises questions on the future of biotech SMEs in France and in Europe. How will consolidation of the sector occur? Will maturity of the sector be accompanied by progressive disappearance of SMEs and the growth of firms? Will it be structured like the automobile industry, around collaboration between firms with a high capacity for integration of research performed elsewhere, and specialized firms such as parts manufacturers? What will the future be of the hundreds of small firms which focus on the local market or a specific technology, and which have grown at a moderate pace over the past ten years?

To answer these questions we have chosen to reason in terms of business models, that is, organisational models covering the targeted market (final or intermediate market), networks of partners, and shareholders. A business model corresponds to a set of key resources for the firm's development and to a mode of securing these resources within the organisation. It provides insight into the development logic of biotechnology SMEs in France.

The aim of this paper, based on the results of a 1999 survey on all biotech SMEs in France is to understand the development logics of these firms. The first part defines the concept of a business model. The second part is an overview of biotech firms in France and their development, based of the survey carried out in 1999. It presents three business models for biotech SMEs. The third part is an attempt to map out the development trajectories of SMEs and the respective leading forces in each type of firm. Concluding remarks present three possible scenarios for the evolution of the sector.

ORGANISATION OF FIRMS AND BUSINESS MODELS

Business model as an Archetype

The formal and informal structures of firms and their external linkages have an important bearing on the firm's growth rate. According to Teece (D. J. Teece, 1996), firms' distinctive modes of governance depend primarily on their boundaries, formal internal structure, informal structure and external relations. Rather than specifying all possible combinations, we have chosen to reason in terms of archetypes.

Greenwood and Hinings (R. Greenwood and C. R. Hinings, 1993) define an archetype by two general statements: “First, organizational structures and management are best understood by analysis of overall patterns rather than by analysis of narrowly drawn sets of organizational properties. [….] Second, patterns are a function of the ideas, beliefs, and values – the components of an interpretive scheme – that underpin and are embodied in organizational structures and systems”, (p 1052).

Research on archetypes generally focuses on large firms; only one of the archetypes identified by Teece (1996) describes a small organisation (the individual inventor and the stand-alone laboratory). Greeenwood and Hinings contrast bureaucratic organisations and professional organisations. These typologies are multidimensional. Generally, they are based on organisational structures (rule-making, formal structures of authority, etc.) or on decision-making processes. Yet a range of writings reflects this view of archetype as configured structures expressing underlying values. Ranson, Hinings and Greenwood (S. Ranson, C. R. Hinings and R. Greenwood, 1980) emphasise that it is necessary to investigate the social mechanisms which determine the structuring process and shape the ensuing structural forms if we are to fully understand the formation of organisational structures. One of the dimensions that has been identified to study architectural practices is motives for work, i.e. an intellectual ethos, a set of ideas about the architecture, that results in a particular set of organisational arrangements. A similar idea has been developed in Karpik’s conception of a 'logic of action' and in Callon and Vignolle’s notion of 'forms of coherence' (M. Callon and J. Vignolle, 1976).

High-tech SMEs are created around a sound project supported by the creators. This project strongly structures the resources and competencies that the firms will have to mobilise.

Mobilising resources to innovate

While research on strategy has traditionally focused on an analysis of competition (M. Porter, 1980), analysis in terms of resources and competencies has been developing since the mid-1980s. This change reflects the shift of interest from external towards internal analysis: organisations are studied from within rather than in relation to their environment. The increasing openness of organisations has gone hand in hand with a relative disappearance of boundaries. Thus, the theory of resources, for which the definition of boundaries is less fundamental than it is for approaches focused on competition, seems particularly rich. It proposes an analysis of the organisation and of its competitive advantages in terms of tangible and intangible resources and competencies (J. B. Barney, 1991; J. B. Barney, J. C. Spender and T. Reve, 1994; R. Grant, 1991; G. Hamel, 1991). Competitive advantage is based on a logic of comparative advantages derived from resources and competencies. It is by knowing and controlling them that strategic options can be defined and a competitive advantage created.

Resource-based theory (E. Penrose, 1959; M. Peteraf, 1993; J. L. Arrègle, 1996; J. Mahoney and J. Rajendran Pandrian, 1992; P. Shrivastava, A. S. Huff and J. E. Dutton, 1994; M. V. Russo and P. A. Fouts, 1997) like the theory of dependent resources (J. Pfeffer and G. R. Salancik, 1978; P. S. Tolbert, 1985; A. Valette, 1994; K. Weick, 1979) distinguishes resources which are inputs into the production process and can be of various kinds (capital, human resources, equipment, cooperative networks, or commercialisation networks, reputation or scientific visibility), on the one hand, and competencies which are related to the use and implementation of those resources, on the other. The sustainable nature of competitive advantage depends on the difficulty another organisation would have imitating the source of the reference organisation's success.

This approach seems particularly fertile for analysing an industry that relies primarily on a combination of resources because few of its products have as yet been marketed. Studies in organisation theory are based on a logic of supply. The identification of critical resources for each organisation helps to understand logics of cooperation and to contribute towards the analysis of modes of inter-organisation coordination in the context of resource-based theory.

In the biotechnology sector, several authors have analysed firms' strategies for acquiring and stabilising the resources needed for their business and growth. G and A Eliasson (G. Eliasson, Eliasson, A., 1996) point out the differences of the biotechnology sector compared to other industrial sectors:

(1) Biotechnology is a sector that stems from academic research. Technically, the differences between an academic and a private laboratory are small. However, competencies involved in implementation and industrialisation differ substantially.

(2) The main costs are those of research and commercialisation; production costs are relatively low.

(3) As Henderson *et al.* (R. Henderson, L. Orsenigo and G. Pisano, 1999) point out, discoveries result from the combination of different corpuses of knowledge and know-how. G. and A. Eliasson define all the competencies necessary for the discovery of new products or processes as a "competence bloc".

(4) Finally, when the competencies needed to innovate are scattered among several organisations, agreements between public and private organisations become essential.

G. and A. Eliasson show that the notion of a competence bloc exceeds purely scientific competencies: "to have a business potential, a competence bloc requires a minimum of more or less related competencies embodied in active, competent and resourceful consumers, innovators who select innovations that satisfy economic criteria, competent venture capitalists who recognize and finance commercially viable opportunities, and industrialists". These elements are added to the ability to form partnerships with laboratories or firms with complementary resources.

To understand the logics underpinning the creation and development of biotechnology firms in France, the firms in our sample can be positioned in relation to the different dimensions defined by G. and A. Eliasson :

- Following the article by A. Nilsson (A. Nilsson, 2000), two models of firms are identified. In the first, firms have integrated all functions, including commercialisation and marketing. These firms cater for final consumers, to whom they supply agri-food, cosmetic or pharmaceutical products. In the second model, biotech firms supply intermediary products which are integrated into the production processes of firms directly in contact with consumers. In our study, consumers' competencies were identified in this way.
- Industrialists and venture capitalists have a similar role. They help to finance firms by providing capital. They also link the firm, initially based on a scientific idea, to the business world. This connection has several forms: contact with potential industrial or commercial partners; opening of a market, particularly that of the parent company or other firms in the group, advice and support in strategic management (see *Nature Biotechnol* N°17, Supplement on Bioentrepreneurship, May 1999).
- Liebeskind *et al.* (J. P. Liebeskind *et al.*, 1996) describe the environment of biotechnology SMEs as hyper-competitive. In this context, the appropriability of research results in central. Innovation opportunities are grabbed particularly fast (D. Teece, 1986) when the appropriation regime is strong. International patent laws stipulate that only the first to discover a product or process can take advantage of the discovery (if it is patented). Thus, biotech SMEs compete with established firms which finance their own research – as Arora and Gambardella (A. Arora and A. Gambardella, 1990) show –, with other organisations engaged in biotech research (SMEs and universities) and with potential entrants.

Zucker *et al.* (L. Zucker, M. R. Darby and J. Armstrong, 1994) show that 97% of star scientists work in universities or non-profit research institutes. Only 3% work in enterprise.

- Even though star scientists do not work directly in biotech firms, these firms do have strong links with the academic world. Dedicated Biotech Firms (DBFs) are thus forced to develop organisational arrangements that give them access to external intellectual resources. The essential character of external resources is threefold:

  (1) Relations with the academic world enables firms to explore a wide variety of hypotheses while maintaining a large degree of flexibility. Thus, exploration of scientific hypotheses in other organisations enables them to reduce costs and to avoid sunk costs, but still to be the first to benefit from the discovery.

  (2) Powell (W. W. Powell, 1990) argues that social networks are the most efficient organisational arrangement for sourcing information because information is difficult to price (in a market) and to communicate through a hierarchical structure. Social networks serve as sources of reliable information, which is essential to efficient organisational learning. When knowledge is distributed among several organisations, not only access to information but also learning how to work in partnership become key variables in competition (W. W. Powell, Koput, K.W., Smith-Doerr, L., 1996; B. L. Simonin, 1997).

  (3) Relations with the academic world, via the social networks in which the creators of the firm are involved, enable the firm to have access to unique scientific expertise that is a critical resource for its survival and development.

To sum up, the hypothesis tested in this article is that French biotech SMEs can be described in terms of a limited number of business models structured by the way in which these DBFs mobilise competencies in order to innovate.

Data and Methods

Biotechnology: a small industrial sector

The French biotechnology sector is an emergent sector consisting of about 400 small businesses in widely diverse markets. 221 firms responded to our survey conducted in the first half of 1999. 186 complete answers were processed. (See box for the detailed methodology of the survey.)

Firms that do customised work for companies in direct contact with consumers

Like everywhere else, French DBFs have little contact with the end user. Only 12% of firms have such contact (mainly for agri-food products, cosmetics and, to a lesser degree, human health). 88% of biotech firms are active suppliers of intermediary goods and services for other firms in the fields of human or animal health, cosmetics, environment or agri-food.

As shown in Table 1, the majority of biotech SMEs specialise in the design, development and production of customised genetic or biological material. A small minority (20%) is engaged in product development (human health – 8% and other, apart from drugs – 12%). Most firms are service providers. They sell biological material to companies in all sectors, enabling them to produce either more quickly or better quality products (e.g. more standardised and better controlled quality), at a lower cost. 48% of firms produce goods, 18% supply products and services and 34% provide services only.

Insert table 1 here

The activity of biotechnology firms is described in relation to two dimensions: the business sector in which the firm sells its products or services, and the company's core competencies (or speciality). The sectors in which it sells its products or services are described in the following way:

- The firm caters for a sector: agriculture or the agri-food industries (26%), cosmetics (4%) or pharmaceuticals (37%).
- The firm commercialises its products and services in two sectors which do not require a marketing license: agriculture/agri-food and cosmetics (1%).
- The firm generates a cash flow from the sale of products and services in the cosmetic or agri-food sector and carries out research in the human health sector – a sector in which it takes longer to generate turnover (12%).
- The firm has generic know-how which it uses in all sectors (equipment, materials, etc.) (21%).

The core competencies of the firm describes the products and services that it designs, produces and markets. Four categories have been identified:

- Product development (20%). The firm's business is production and marketing of products. It does not produce customised products only; it also mass produces.
- Diagnosis and creation of tests and/or biological material (55%). These firms develop two complementary activities: a) as service providers to other companies they create tests, biological material with specific characteristics, and customised diagnoses; and b) they design, produce and commercialise diagnostic kits, either directly or through other companies.
- Design and production of equipment and material for laboratories. These firms cater for all sectors. They account for 9% of the total.
- Development aid methods or sequencing. These firms design methods enabling firms to improve their processes or to market their products more effectively (e.g. CRO[4]). These firms, which account for 17% of the total, cater primarily for the pharmaceutical and agri-food sectors.

To sum up, out of the firms active in the human health sector, few are directly engaged in the production of drugs. Firms in the agriculture, agri-food or environment fields produce mainly seeds or foods with specific characteristics (health or functional food). Service firms in these sectors mainly provide tests or diagnostic kits for agriculture or agri-food and the environment. SMEs focused on the cosmetic or animal health sectors have largely the same characteristics: close to firms in the human health field, they develop products or services which do not require specific marketing licenses. This market positioning often corresponds to a strategy for progressively conquering the human health market.

Firms active in all the sectors are mainly those which design and develop generic tools or methods (such as sequencing or instrumentation).

Mainly new DBFs

Close to 70% of firms which were still alive in 1999 had been founded after 1990. Firms that are 20 years old or more now account for 12% of the sample, while the most recent firms account for 69% of the total. Less than 20% of all firms were created between 1980 and 1990.

[4] Consultancy research organisation

Insert table 2 here

The average number of employees of an DBF is 37 persons, for an average turnover of 480 KE*. Whether in terms of turnover or number of employees, these firms remain small. 72% have a turnover under 1.5 ME**, compared to only 4% with over 15 ME. 24% have a turnover between 1.5 and 15 ME. Moreover, 55% employ fewer than 10 persons and only 14% employ over 50 persons. 31% employ between 10 and 50 persons. Although a slight difference is apparent between recruitment and generation of revenue, at the time of start up, the number of employees and the sale of products and services remain very closely linked. Firms established before 1980 and still alive in 1999 grew very fast, especially those active in the human health sector. Comparatively, the firms created between 1980 and 1990 grew more slowly.

Firms active in the agro-food or agronomic sectors and those which are active in the pharmaceutical sector are larger than the others in terms of number of employees. Business creation was spread out over time, and across all sectors equally.

BUSINESS MODELS

To understand the growth of firms and the dynamics in which they are engaged, we chose to reason in terms of business models. A business model describes a category of firm in relation to the market it targets, its expected growth and the organisation of its activity. The biotech firms which responded to our survey are spread out in the following way, in terms of criteria borrowed from Eliasson:

Insert table 3 here

The four dimensions proposed, following G. and A. Eliasson, enable us to define three business models structured around management of industrial property, networks of shareholders, and the firm's position in the market.

Table 4 presents a matrix of correlation between the different indicators (shareholders, final or intermediary market, customer sector, patent, age of firm, turnover and number of employees).

* thousand euros

Insert table 4 here

We can thus identify four groups of firm, the characteristics of which are given in Tables 5 and 6:

Insert tables 5 and 6 here

Group A : Firms with good development potential

These firms vary in size. Their main characteristics are that they patent and are financed by venture capital and shareholders who are natural persons. Considered as the flagship of the French biotech industry, the 30 firms in this group have experienced rapid growth. They specialise in customised production and service provision for pharmaceutical companies. They are rarely presented in sectors related to agriculture or agri-food. 28 out of 30 were created after 1980. Close to 50% of these firms employ over 10 people and a third have a turnover greater than 1.5 ME.

Development of these firms was based mainly on the presence of national and international capital investors. Present from the start, venture capital companies played an active part in their orientation and put them on a fast-growth trajectory. The widening of the circle of shareholders beyond the family circle enabled these companies to benefit from advice, contacts, human capital and an introduction into networks they hardly knew or that would have taken time to discover (under 30% of the 186 firms have a venture capital company as a shareholder). Quotation on the stock exchange enabled venture capitalists subsequently to sell their shares and to withdraw – a condition *sine qua non* for the perpetuation of financing of biotech firms by venture capital. The presence of venture capital firms in these companies paved the way for a transition from an essentially domestic environment (family capital, network of new entrepreneurs) to a truly entrepreneurial environment.

Fast growing firms rely on partnerships with French or foreign universities, as well as with public institutions such as the CNRS or INSERM, to maintain their scientific and technological competencies. For these firms, proximity to a pole of scientific excellence is essential if they are to benefit from spillovers from public research, through interpersonal

** million euros

relations and international interaction of academic laboratories. To attract the best researchers, PhDs and post-docs – all potential partners – these firms have an interest in taking advantage of centres of academic excellence both at start up and during their development. Several authors (D. Audretsch and P. Stephan, 1996; M. Feldman, 1999; J. P. Liebeskind *et al.*, 1996) have highlighted the role of proximity between high quality academic research and DBFs. Even if these firms are developing collaborative researches with academic labs wherever they are, these DBFs are located near the main pole of excellence, Paris and Strasbourg. Partnerships with other firms, especially pharmaceutical firms, enable them to transfer their technologies. Given the fact that these firms are essentially providers of goods or services to pharmaceutical companies, their turnover is dependent on formal collaboration, as shown by Sharp and Greis *et al.* (N. P. Greis, M. D. Dibner and A. S. Bean, 1994; W. W. Powell, 1998; M. Sharp, S. J. and I. Galimberti, 1994). These contracts are one of the ways of getting round barriers to entry, on both a scientific and a commercial level. They also enable these firms to benefit from faster learning and to acquire additional competencies.

Group B : Firms which develop in niches

These firms all started with the idea of an entrepreneur who mobilised family capital (60% of the firms have only natural persons as shareholders). Very few of them have venture capital firms or other firms among their shareholders. They have little capital and generate turnover from the outset, especially through customised production or service provision. Their turnover is substantially lower (under 1.5 ME) than that of other types of firm. They rarely develop an activity which caters specifically for pharmaceutical companies. On the other hand, they have a strong presence in the agriculture and agri-food fields. They rarely patent their technology although they sell their products to final consumers. These firms look in their immediate environment – family and geographic – for catching the resources to survive and grow. Often they have very few links to networks of actors active in biotechnology (consulting firms, venture capital firms, academics or recognised researchers, ANVAR, ministries, etc.). Relations with the market and users of their products and services are formed on the basis of geographic proximity. They grow as they expand their clientele beyond the local market, by broadening the range of their services or specialising their supply so that they become the leader in their market.

Group C : Firms attached to a group

The capital of firms in this group is mainly in the hands of natural persons and other firms. Venture capital is seldom present in firms in this group[5]. Either they were bought out when they were independent, or they were created directly by their parent company. In fact, one of the strategies of pharmaceutical or seed companies is to create biotech firms, either alone or in partnership with other firms. Biotechnologies are a high-risk business whose development relies on specific competencies that are sometimes difficult to maintain within a group. Small structures are more flexible and adjust better than large ones to changes induced by the production of new scientific knowledge. Finally, investing in a biotech subsidiary also enables firms to set up in countries where they can take advantage of externalities of its research and of new markets. Yet firms in this group form fewer ties with academic research than others, especially with INSERM and the CNRS. It seems that the parent company or shareholding company is a special partner, including for research.

Thus, major French companies (Limagrain, Aventis, etc.) and foreign corporations (Monsanto, etc.) have invested in subsidiaries created *ex nihilo* and specialised in biotechnology, in order to set up in France (e.g. BioSepra, Bachem Biochimie or Diagnostica Stago) or to isolate their biotechnology activity from their core business (e.g. Syral, Biosem or Limagrain Genetics). These firms, which benefit from the captive market of the parent company and the networks and markets to which it affords access, see their turnover increase faster than that of independent firms. Companies in this category are much bigger (in terms of number of employees) and have a significantly higher turnover than those in the other categories. This growth is based above all on the parent company's internal network. On the other hand, the fact that they patent less may not be significant, for some patents may be registered by the parent company.

Group R : New Biotech Firms (DBFs)

This group comprises firms that had been in existence for less than two years at the time of the survey. They are thus constantly evolving. Significantly smaller (Table 6) than firms in the other groups, in terms of number of employees and turnover (often two or three

[5] Since there is no significant difference in the set-up dates of the different groups, it seems likely that venture capital invests little in firms in this group, for its absence cannot be imputed to a withdrawal of venture capital companies after the sale of their shares.

persons, some of whom work part time), DBFs have registered few patents[6]. On the other hand, they have persuaded capital investors to become shareholders (Table 5). Capital investors are often firms in the seed business and are often regional and multi-sectoral. Their capital investments enable biotech firms to survive, for many of these DBFs generate no turnover. They are very seldom engaged in the production of goods for final consumers. By contrast, they have partnerships with research organisations, especially INSERM. The youngest firms are oriented essentially towards the pharmaceutical sector. They are less present in the agriculture, agri-food and cosmetic sectors.

COMPETING BUSINESS MODELS

Three logics for three business models

The statistic analysis reveals four types of firm which were designed differently from the outset. Firms in Group A base their development on their capacity to produce and transfer their scientific results. For them, a critical resource is access to scientific competencies and techniques developed by academic research. Their development logic can be summarised as follows:

> Scientific discovery that can be transferred--> registration of patent --> entry of venture capital into shareholding to finance an R&D activity--> strong ties with the academic world--> partnerships with pharmaceutical firms to gain access to the market and transfer research--> entry into the new market.

For these firms, often created by researchers from large groups or by academic researchers, insertion in the scientific network is a condition for growth. It is not sufficient, however, for firms must not only develop high-tech research but also transfer and commercialise their results. This often involves research or development contracts with a big company, in which the SME undertakes to provide its partner with specific materials, technologies, know-how or expertise. Relations are formed on the basis of a specific competency recognised by the big firm. The SME's technological lead depends on the quality of its

[6] In some cases it is difficult to identify patents since some were registered in the name of the inventor before being incorporated into the company's assets.

research, and the launching of the activity relies on capital input for the development of the product or process.

Firms in Group B are based on a different logic. Created by researchers or engineers who have identified a commercial opportunity, they focus on specific niches and generate turnover very soon after creation. These firms are part of a local economic fabric resulting from contracts developed by the entrepreneur during his or her previous activity.

The development logic can be outlined as follows:

> Identification of a niche or idea to transfer research --> creation of a firm based on family capital --> commercialisation of products or services to generate a cash flow --> development of business by expansion of the market.

In this logic, the firm's key resources are its first customers and its regional or sectoral position which enable it to be known.

Firms in Group C rely on the group to develop their business. They progressively expand their clientele.

Competition or complementarity

Competition between firms occurs when they are present in the same market. In that case, it is the firms' products or services that compete. Given the emergent character of the biotechnology sector and the innovative nature of the services or products offered, markets are constructed along with supply. Thus, it seems that, at this stage, firms are rivals in their market segment, within the same business model. The market, as usually described, represents a key resource in the development of firms only for those belonging to Group B.

On the other hand, all firms are rivals for the acquisition and integration of key resources for development.

Table 7 describes the different areas of competition. As they are based on research and most of them are financing their activities thanks to capital investments, firms on the different business models are not only competing on the markets. They are also competing to convince shareholders (and venture capitalists) to invest in their activities, to develop co-operation with established and promising academic teams (having a star scientist as a Nobel prize as a collaboration or in the scientific advisory board can boost your activity and your share) and to contract with large firms to finance the development and the commercialisation of product.

Insert table 7 here

Resources needed by firms to grow are specific to each type of business model. Thus, firms compete within a business model. But competition between business models remains marginal, both in markets and for the acquisition of resources which, even if they are similar, are owned by different actors.

CONCLUSION

Still to be done

ANNEXES

Box: Characteristic of the survey

At the initiative of the technology division (Biotechnology group) of the MENRT[7], a survey was conducted on firms engaged in biotechnology research or development. A questionnaire was sent to 450 private organisations, irrespective of their size or status (listed or not). 221 answers were received but they were largely incomplete. In order to obtain a representative sample, the data base thus obtained was matched with various other available data bases: the base created by the INRA/SERD team, The France Biotech base, the Genetic Engineering Directory, Infogreffe and Diane. Missing information was thus obtained and certain firms were added to the base when all necessary information was available.

In order to standardise the answers, only organisations listed in the trade and commercial register as companies (SA, SARL, SNC) were selected. To guarantee the relevance of comparisons with information published by Ernst and Young (1999 Report), our analysis took into account only those firms with under 500 employees. Lastly, we excluded the rare biotechnology firms founded before 1960. The analysis was finally based on 186 enterprises on which full information was available. The sample analysed can be considered representative, essentially because over 60% of the firms listed in the France Biotech 1998 directory and 90% of the firms in the Genetic Engineering Directory answered the questionnaire. By convention, we consider that the base analysed corresponds to roughly half of the biotechnology enterprises active in France.

[7] A steering committee composed of Pascale Auroy (ARD), Christine Bagnaro (ANVAR), Patrice Blanchet (DTA/2, MENRT), Marie José Dudézert (DTA/2, MENRT), Anne Sophie Godon (Arthur Andersen) and Vincent Mangematin (INRA/SERD) met in 1998-99 under the chairmanship of Jean Alexis Grimaud, to plan and carry out the survey.

The survey consisted of several steps:

1. Compilation of a list of enterprises engaged in biotechnology research, based on available sources;
2. Validation of this list compiled by regional technology representatives, and addition of complementary data;
3. Definition of a list of 450 target enterprises;
4. Administration of the questionnaire;
5. Processing of data and compilation of the directory.

The survey gathered information on several dimensions:

1. Identification of the firm;
2. Ownership and creators;
3. Targeted markets and technologies in use;
4. Patents and certification;
5. Financial information;
6. Partnerships.

List of variables

Creation 1980-90 : Creation of the firm between 1980 and 1990
A : Business model "Firms with high growth potential"
sh vent. K : Venture capital firm a shareholder in the SME
sh pers : Shareholder a natural person
sh firm : Firm a shareholder of the SME
Agri/envt : Targeted sector of the firm is agriculture, agro-food or environment
After 90 : Creation of the firm after 1990
Before 80 : Creation of the firm before 1980
B : Business model : Firms which develop in niches
Patent : hold patents
C : business model : Firms attached to a group
TO 1,5 and 15 Meuros : Turnover between 1.5 and 15 ME per year
TO less than 1,5 Meuros : Turnover less than 1.5 ME per year
TO up to 15 Meuros : Turnover up to 15 ME
CNRS : Partnership with an academic organisation
co-op labs : Academic partnerships
final cons. : Firm supplies goods and services to the final consumer
cosm ou veto : The targeted sector of the firm is veterinary products or cosmetic products
Number of employees between 10 and 50 : Number of employees between 10 and 50
Number of employees less than 10 : Number of employees less than 10
Number of employees up to 50: Number of employees up to 50
INRA : Partnership with an academic organisation dedicated to agronomic and agro-food research
INSERM : Partnership with an academic organisation dedicated to medical research
Pharma : The targeted sector is human health and pharmaceutical products
Product : The firm sells products rather than services

R : Business model Recently set up firms
Standard : The firm's products are mass-produced rather than customised
All sectors : The firm has no targeted sector. It produces generic research tools used by all sectors
UNI : Partnership with university

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Table 1: Activities of Biotechnology SMEs

			Speciality				Total
			Product development	Development aid or sequencing methods	Diagnosis and manufacturing of biological material	Equipment and material	
Sectors Customers	agri	N° empl.	17	1	27	3	48
		%	35.4%	2.1%	56.3%	6.3%	100.0%
	agri/cosmet.	N° empl.	1		1		2
		%	50,0%		50,0%		100,0%
	agri/cosmet./pharma.	N° empl.	2	3	15	2	22
		%	9.1%	13.6%	68.2%	9.1%	100.0%
	Cosmet.	N° empl.	4	1	2		7
		%	57.1%	14.3%	28.6%		100.0%
	Pharma.	N° empl.	13	20	32	3	68
		%	19.1%	29.4%	47.1%	4.4%	100.0%
	All	N° empl.		6	25	8	39
		%		15.4%	64.1%	20.5%	100.0%
Total		N° empl.	37	31	102	16	186
		%	19.9%	16.7%	54.8%	8.6%	100.0%

Khi-deux Tests

	Value	ddl	Asymptomatic signification (bilateral)
Pearson's Khi-deux	45.838	15	.000
Probability	53.148	15	.000
N° of valid observations	186		

a 13 cells (54.2%) have a theoretical number of employees of less than 5. The minimum theoretical number of employees is .17.

Table 2 : Size and age of biotechnology firms

			Age			Total
			Old	Med	Recent	
Customer sector	Agri	N° of empl.	9	10	29	48
		%	19%	21%	60%	100%
	Agri/cosmet	N° of empl.			2	2
		%			100%	100%
	Agri/cosmet/pharma	N° of empl.	1	5	16	22
		%	5%	23%	73%	100%
	Cosmet	N° of empl.	1	1	5	7
		%	14%	14%	71%	100%
	Pharma	N° of empl.	6	13	49	68
		%	9%	19%	72%	100%
	All	N° of empl.	3	8	28	39
		%	8%	21%	72%	100%
Total		N° of empl.	20	37	129	186
		%	11%	20%	69%	100%

Khi-deux : Value 6,131, ddl : 10, significance : 0,80

Average size of firms in number of employees

		AGE			
Customer sector	Customer sector	Old	Med	Recent	Total
	Agri	99	28	30	42
	Agri/cosmet			8	8
	Agri/cosmet/pharma	98	12	20	22
	Cosmet	110	36	4	39
	Pharma	150	64	29	53
	All	20	22	11	14
Total		108	37	23	37

Table 3 : Distribution of firms, according to the dimensions of G. and A. Eliasson

	Firms which target the final consumer	Firms which produce intermediary products or services
Intermediary firm or integrated firm	12.4%	87.6%

	Venture capital firms	Only natural persons	Other companies	Shareholders other than those listed	Total
Firms whose shareholders consist of	28.5%	32.8%	33.9%	4.8%	100.0%

	No patent	At least one patent	Total
Mode of management of industrial property	65.6%	34.4%	100.0%

	No partnerships	At least one partnership	*Of which with public labs*	*Of which with universities*	*Of which with foreign labs*
Firm's capacity to form academic partnerships	40.9%	59.1%	*40.3%*	*31.7%*	*6.5%*

Table 7 : Nature of competition for the different key resources

	Group A	Group B	Group C
Market and cash flow generated by the turnover	International competition within this group. Competition with other actors such as large firms or academic laboratories	Local competition at first, which spreads as the market expands.	These firms compete with certain firms in Group B.
Financial resources and shareholders.	Competition between firms in this group to persuade investors and ***set up a round table of venture capital.*** Competition may also continue when the firm is listed on the stock market.	When investors are in the family there is no competition. However, when the firms apply for local funding and investment from local venture capital firms, there may be competition.	Firms in this group are financed by sales of products and services. Shareholding companies also provide capital.
Relations with the academic community.	Competition between firms in this group to develop relations with academic teams and to sign exclusive licence agreements with them if the university team has patented a technology.	Relations with the academic community are formed on a basis of trust and partnership. Technologies are rarely patented. Niches are narrow and the number of competitors small.	Close relations with the group's research centre.
Relations with large companies.	Competition to sign cooperative agreements.	Few relations with large companies, except as suppliers.	Few relations with companies that are shareholders' rivals.

Table 4 : Matrix of correlations between the different indicators

		sh pers	sh vent. K	sh firm	final cons.	Product	Production standard	Agri ou env	Pharma	Cosm/veto	All sectors	Hold patent	Creation before 1980	Creation 1980-90	Creation after 90	co-op La publics
Sh pers	Corr	1,000														
	Sig.	,														
Sh vent. K	Corr	,226**	1,000													
	Sig.	,002	,													
Sh firm	Corr	-,46**	-,089	1,000												
	Sig.	,000	,229	,												
final cons.	Corr	-,130	,052	,086	1,000											
	Sig.	,077	,478	,241	,											
Product	Corr	,025	,099	,086	,269**	1,000										
	Sig.	,737	,177	,241	,000	,										
Production Standard	Corr	,002	,026	,087	,323**	,732**	1,000									
	Sig.	,978	,728	,239	,000	,000	,									
Agri/envt	Corr	-,147*	-,200**	,098	,145*	-,064	-,004	1,000								
	Sig.	,045	,006	,181	,048	,386	,952	,								
Pharma	Corr	,098	,111	,036	-,131	-,133	-,149*	-,413**	1,000							
	Sig.	,184	,133	,628	,075	,070	,043	,000	,							
Cosm ou veto	Corr	,115	,023	-,064	,197**	,091	,106	-,129	-,003	1,000						
	Sig.	,117	,755	,388	,007	,215	,149	,080	,965	,						
All sectors	Corr	,039	,055	-,052	-,193**	,062	,038	-,369**	-,493**	-,174*	1,000					
	Sig.	,598	,454	,481	,008	,403	,603	,000	,000	,018	,					
Hold Patent	Corr	,032	,295**	,112	,106	,207**	,142	-,040	,009	,129	-,039	1,000				
	Sig.	,668	,000	,129	,150	,004	,053	,587	,908	,078	,593	,				
Creation Before 80	Corr	-,174*	-,027	,065	,186*	,138	,155*	,082	-,089	-,002	-,051	,041	1,000			
	Sig.	,018	,716	,381	,011	,060	,035	,268	,226	,973	,490	,580	,			
Creation 1980-90	Corr	-,037	-,046	,079	-,064	,015	,068	-,015	,008	,010	,008	-,021	-,173*	1,000		
	Sig.	,620	,533	,284	,382	,837	,359	,837	,914	,894	,914	,779	,018	,		
Creation After 90	Corr	,148*	,058	-,112	-,069	-,106	-,163*	-,042	,053	-,007	,027	-,010	-,522**	-,750**	1,000	
	Sig.	,043	,432	,129	,348	,149	,026	,572	,472	,926	,712	,898	,000	,000	,	
co-op avec Labos publics	Corr	,115	,161	-,155*	-,086	,122	,045	-,075	-,036	-,009	,079	,096	,041	-,134	,088	1,000
	Sig.	,118	,028	,035	,241	,099	,544	,307	,628	,908	,285	,195	,575	,069	,232	,

** Significance of the correlation at the level 0.01 (bilatéral).
* Significance of the correlation at the level 0.05 (bilatéral).

Table 5 : Characteristics of each business model

		A	B	C	R	sh pers	Sh vent. K	sh firm	final	Product	standard	Agri envt	Pharma	cosm ou veto	All sectors	Hold patent	co-op labs	INRA	CNRS	INSERM	UNI
A	Corr	1,000																			
	Sig.	,																			
B	Corr	-,349**	1,000																		
	Sig.	,000	,																		
C	Corr	-,211**	-,383**	1,000																	
	Sig.	,004	,000	,																	
R	Corr	-,262**	-,475**	-,288**	1,000																
	Sig.	,000	,000	,000	,																
sh pers	Corr	,142	,162	-,499	,145	1,000															
	Sig.	,053	,027	,000	,048	,															
sh Krisk	Corr	,371**	-,282**	-,212**	,190**	,226**	1,000														
	Sig.	,000	,000	,004	,009	,002	,														
sh soc	Corr	-,127	-,234**	,467**	-,050	-,467**	-,089	1,000													
	Sig.	,085	,001	,000	,496	,000	,229	,													
final cons.	Corr	-,032	,137	,070	-,188*	-,130	,052	,086	1,000												
	Sig.	,669	,062	,343	,010	,077	,478	,241	,												
Product	Corr	,005	,009	,054	-,062	,025	,099	,086	,269**	1,000											
	Sig.	,946	,903	,465	,401	,737	,177	,241	,000	,											
Standard	Corr	,006	,068	,098	-,167*	,002	,026	,087	,323**	,732**	1,000										
	Sig.	,939	,358	,183	,023	,978	,728	,239	,000	,000	,										
Agri / envt	Corr	-,159*	,201**	,150*	-,222**	-,147*	-,200**	,098	,145*	-,064	-,004	1,000									
	Sig.	,030	,006	,042	,002	,045	,006	,181	,048	,386	,952	,									
Pharma	Corr	,136	-,231**	-,103	,233**	,098	,111	,036	-,131	-,133	-,149*	-,413**	1,000								
	Sig.	,064	,002	,161	,001	,184	,133	,628	,075	,070	,043	,000	,								
Cosm / Veto	Corr	,045	,169	-,072	-,161*	,115	,023	-,064	,197**	,091	,106	-,129	-,003	1,000							
	Sig.	,541	,021	,332	,028	,117	,755	,388	,007	,215	,149	,080	,965	,							
All sectors	Corr	,025	-,057	-,011	,052	,039	,055	-,052	-,193**	,062	,038	-,369**	-,493**	-,174*	1,000						
	Sig.	,730	,441	,877	,483	,598	,454	,481	,008	,403	,603	,000	,000	,018	,						
Patent Détenu	Corr	,267**	-,134	,086	-,151*	,032	,295**	,112	,106	,207**	,142	-,040	,009	,129	-,039	1,000					
	Sig.	,000	,068	,245	,040	,668	,000	,129	,150	,004	,053	,587	,908	,078	,593	,					
co-op labs	Corr	,067	,009	-,076	,001	,115	,161*	-,155*	-,086	,122	,045	-,075	-,036	-,009	,079	,096	1,000				
	Sig.	,363	,899	,306	,994	,118	,028	,035	,241	,099	,544	,307	,628	,908	,285	,195	,				
INRA	Corr	-,139	-,014	,075	,065	-,014	-,023	-,032	,077	,037	,024	,124	-,181*	-,089	,050	-,009	,343**	1,000			
	Sig.	,058	,848	,309	,375	,847	,751	,664	,296	,617	,748	,091	,014	,229	,496	,899	,000	,			
CNRS	Corr	,071	-,041	-,074	,051	,005	,186*	,027	-,085	,025	-,025	-,206**	,105	-,060	,115	,210**	,379**	,095	1,000		
	Sig.	,334	,582	,318	,491	,950	,011	,717	,250	,732	,739	,005	,153	,418	,118	,004	,000	,196	,		
INSERM	Corr	,134	-,129	-,131	,147*	,070	,254**	,005	-,071	,026	-,038	-,245**	,360**	,002	-,149*	,219**	,357**	,033	,197**	1,000	
	Sig.	,068	,080	,075	,046	,342	,000	,951	,333	,727	,607	,001	,000	,980	,043	,003	,000	,652	,007	,	
UNI	Corr	,109	,028	-,033	-,093	,092	,030	-,144	-,045	,024	-,048	,025	-,028	,037	,018	-,007	,567**	,014	,148*	-,038	1,000
	Sig.	,137	,709	,659	,207	,211	,680	,051	,538	,745	,513	,737	,700	,615	,809	,921	,000	,847	,043	,605	,

** Significance of the correlation at the level 0.01 (bilatéral).

* Significance of the correlation at the level 0.05 (bilatéral).

Table 6 : The development of each business model

		A	B	C	R
CA nul	Corr	-,143*	-,298**	-,177	,606**
	Sig.	,052	,000	,015	,000
TO less than 1,5 Meuros	Corr	,062	,237**	-,060	-,261**
	Sig.	,397	,001	,414	,000
TO between 1,5 and 15 Meuros	Corr	,055	,014	,250**	-,283**
	Sig.	,455	,851	,001	,000
TO up to 15 Meuros	Corr	,051	,049	,034	-,127
	Sig.	,488	,505	,650	,085
Number of employees Less than 10	Corr	-,072	-,048	-,267**	,350**
	Sig.	,331	,513	,000	,000
Number of employees Between 10 and 50	Corr	,031	,025	,185**	-,218**
	Sig.	,674	,733	,011	,003
Number of employees Up to 50	Corr	,061	,036	,144*	-,218**
	Sig.	,411	,627	,051	,003

** Significance of the correlation at the level 0.01 (bilatéral).
* Significance of the correlation at the level 0.05 (bilatéral).