Research Policy 31 (2002) 735–747

research policy

www.elsevier.com/locate/econbase

Innovation, collaboration and SMEs internal research capacities

Frédéric Bougrain [a,*], Bernard Haudeville [b]

[a] CSTB, 4 Avenue du Recteur Poincaré, 75782 Paris Cedex 16, France
[b] CEREFI, Université d'Aix-Marseille III, 13627 Aix-en-Provence Cedex 1, France

Accepted 3 July 2001

Abstract

The aim of this research paper is to assess how SMEs' internal research capacities help them to exploit external scientific and technical knowledge and to use networks of innovators. Our empirical analysis draws upon case studies made of projects which were partly financed by ANVAR, a French national agency responsible for the development of innovation projects in industry. The results of this study are three-fold.

- Technological co-operation does not seem to increase the chance of success of innovative projects.
- R&D intensity does not lead to discriminate between success and failure.
- Internal R&D capacities, such as a design office, enhance the firm's ability to co-operate and to carry its project to success.

© 2002 Elsevier Science B.V. All rights reserved.

JEL classification: O32

Keywords: Learning process; Industrial co-operation; Internal technological capabilities

1. Introduction

Stereo-types usually associate innovation with the work of 'a scientist of genius who can propose new combining, go against the tide, show stubborn determination to make his idea successful' (Callon, 1994, p. 6). Indeed, innovation and scientific discovery are attributed to individuals. The prizes awarded each year by the Nobel Foundation perfectly illustrate this situation. However, this emblematic picture is misleading. Every scientific and technological breakthrough results from numerous contributions rather than from individual creations. Successful innovations appear heavily dependant on trials and errors, uncertainty, compromises among several actors.

The growth of strategic alliances in new core technologies during the 1980s illustrates this situation (Hagedoorn, 1995). New interfaces have been created between disciplines (biotechnology plays a growing role in chemical, pharmaceutical, food-processing industries). The technological environment within which firms operate has been transformed. Technology has become so complex that it cannot be handled by individual corporations. Even the biggest companies have been touched by 'the declining technical self-sufficiency' (Fusfeld, 1986, p. 144). Scientific and technical knowledge is scattered among a large number of people. Its acquisition needs to rely on groups which interact through networks.

* Corresponding author. Tel.: +33-1-40-50-29-04.
E-mail address: f.bougrain@cstb.fr (F. Bougrain).

0048-7333/02/$ – see front matter © 2002 Elsevier Science B.V. All rights reserved.
PII: S0048-7333(01)00144-5

All firms have been affected by this technological challenge. Even small firms which performs R&D have been engaged in co-operation (Kleinknecht and Reijnen, 1992).

In most OECD's countries, this tendency has been reinforced by public authorities who prefer to favour inter-firm co-operation rather than to provide direct financial assistance.

Public sectors interventions are three-fold.

- Public authorities have laid increasing emphasis on inter-firm collaboration in advanced technology. Most of the time these programmes urge large firms located in the same geographical area to co-operate (e.g. the Esprit and Alvey programmes in the European Union). They also tend to focus on precompetitive research activities (Fusfeld, 1986). This policy has been influenced by similar successful alliances in the Japanese computer industry.
- The success of co-operation among small traditional firms in Italy has inspired regional initiatives (Rosenfeld, 1996). Public authorities have tried to recreate the Italian district atmosphere by providing new services and by fostering technology transfer.
- The success of networks in the Silicon Valley has led to the development of science parks/technopole which involve universities, public R&D laboratories and firms. The aim of this policy is to enhance the innovative capability of the host region by strengthening the ties among scientific, technical and institutional agents. Unlike policies inspired by Italian districts, universities and research institutions involvements are stronger. [1]

In spite of these initiatives, one must not forget that co-operative agreements are based on technology transfers which imply the respect of economic rules. The challenge is particularly delicate for SMEs. Those who establish weak ties with their environment may not favourably react to public policies which emphasis on inter-firm collaboration. Conversely, firms engaged in a virtuous process to acquire technological competencies should benefit from the policy orientations (Le Bas, 1993).

In the present paper, we report how firms' internal capacities generate this virtuous process. We will draw upon case studies made of projects which were carried out by about 300 SMEs, from 1980 to 1987. We will focus on firms which co-operate with other organisations. Before this empirical study, we will describe the notion of networks and discuss their role in innovation. Then, we will examine the role of the manager in the innovation process. Indeed, managers play a key role in the running of their business. Depending on their risk adversity, they will innovate and exploit networks information differently.

2. Industrial co-operation: from exchange to production

From a theoretical point of view, the notion of network is still very fuzzy. However, we can distinguish at least following two approaches.

- The transaction cost perspective identifies networks as an intermediate governance structure between markets and hierarchies. In this perspective, technology is dissociated from production which is secondary.
- The evolutionary theory considers that technology acquires its specific character through a learning process. In this perspective, we should place emphasis on the production activity.

2.1. Limits of the transaction cost theory

According to Williamson, asset specificity, uncertainty, the frequency with which transactions recur, bounded rationality and opportunism determine which governance structure is best adapted to manage transaction (Williamson, 1989).

Low asset specificity favours competitive bargains and leads to contractual solutions. To explain the emergence of networks (the hybrid form between markets and hierarchies), Williamson puts forward the existence of strong property rights combined with intermediary asset specificity. However markets and hybrid forms are not always adapted. When agents have to support durable investment, competition is transformed into a bilateral transaction. In such a situation, vertical integration is best adapted to avoid

[1] In France, different levels of public authorities are engaged in these policies. The European Community and the French central government lead the large projects. The institutional infrastructure built to promote regional co-operation was initiated by the central government. But its implementation is a matter for regional authorities. Finally, the technopolitan movement was launched by local authorities.

opportunistic behaviours. This decision is considered as a choice of last resort ('try markets, try long-term contracts and other hybrid modes, and revert to hierarchy only for compelling reasons' (Williamson, 1991, p. 83)).

Notwithstanding the interest of this approach to provide an analytical scheme for the study of networks, several limits remain.

- The primary goal of this theory is to know whether a firm should make or buy a good or a service. In this framework, firm and market are considered as perfect substitute. This situation derives from the assumption that information is costly for transaction purpose but not for production purpose (Demsetz, 1991). If one considers that the acquisition of information is costly, firms will not bear the same production costs. So it 'might be in the interest of a firm to produce its own inputs even if transaction costs were zero and management costs were positive' (Demsetz, 1991, p. 164).

  Considering that technology is costly to produce also reverses the transactional approach. According to this theory, arm's length agreements for technology transfer are costly. First, agents are engaged in negotiations to define the terms of the contract. Once the agreement is signed, they will undertake inspection to make sure that their partner is not shirking. Given these assumptions on opportunistic behaviours, transaction costs should reach prohibitive levels when innovation is involved. However, this is not the case. In fact, negotiations which lead up to a bargain should not be considered as a cost but as an investment (Everaere, 1993). Agents rely on this process to learn about their mutual needs and to make decision to avoid bottlenecks during the implementation of the project.
- The transactional approach puts too much emphasis on opportunism. However, 'an organisation should be understood at least much as a mechanism to enhance co-operation than as a device to reduce cheating and shirking' (Ménard, 1992). By and large recurrent transactions lead partners involved in a network to gradually trust one another. These collaborative relationships entail learning (Lundvall, 1993).
- As one of the 'four contemporary paradigms in the Theory of the Firm' described by Winter (1991, p. 187), transaction cost theory is first and foremost a matter of exchange and bounded rationality. Production is secondary. Consequently, it fails to 'examine how new resource uses are discovered, how resources are accumulated, how firms learn, which governance structures best promote learning, etc.' (Foss, 1996, p. 12).

2.2. Co-operation as a learning process

Knowledge for production purpose cannot be considered as free. The role of the firm is not to allocate costless technical competencies (Pelikan, 1988). [2] They have to set them up. These competencies change over time through a learning process and become tacit and specific to the firm (Foss, 1996). This change has crucial consequences for firms' performances and economic organisations.

- The tacitness of competencies make them difficult to imitate. Therefore, firms' endowments in technical capacities are not similar. Once they are built, they provide the firm with a competitive advantage. [3]
- The process of knowledge creation is costly to maintain. Therefore, firms need to achieve economies through specialisation (Demsetz, 1991). This may explains why firms usually prefer to concentrate their resources toward core activities. To obtain complementary assets, two solutions are possible: Market transaction or co-operation. However, tacitness and specificity impede the completion of technology transfer. [4] Thus, firms cannot rely on market to have access to new capabilities.

Co-operative agreements are adapted when firms are reluctant to develop additional capacities but need

[2] Pelikan considers that 'technical competence is the competence for designing products and production processes in terms of physical variables, and includes also the competence to learn such competence, or technical talents' (Pelikan, 1988, p. 383). Following this definition, we regard knowledge as a mean to enhance technical competence.

[3] '. . . The concept of the organisational capabilities that permit it (the firm) to remain competitive, and therefore profitable, in national and international markets (is) more pertinent than those of bounded rationality and opportunism' (Chandler, 1992, p. 490).

[4] 'Know-how has a strong learning-by-doing character, and it may be essential that human capital in an effective team configuration accompany the transfer' (Teece, 1980, p. 228).

to have access to closely complementary and dissimilar activities (Richardson, 1972). It is sought when ex ante co-ordination between different phases of production is necessary. Despite production and transaction costs, firms should not be reluctant to pursue a strategy of co-operative agreements for at least following two reasons.

- Considering that firms are not equally endowed with technical competence but need to construct them, increases the financial constraints which firms bear. In this scheme, investment costs are dissociated from receipts (Amendola and Gaffard, 1994). Thus, it takes time to recover the initial investment. Collaborative relationships will release the financial constraints by helping the firm to share the sunk costs associated with innovation.
- The second reason relates to learning. Collaborative relationships might take a hierarchical form. However, when trust replaces uncertainty and opportunism, informal obligations may constitute a more stable framework for interaction (Lundvall, 1988). This is possible if firms consider that the future is more significant than the present (Jacquemin, 1987). In the case of user–producer relations, the frequency of interactive relationships have proved to speed up the innovation process. Indeed, frequent communications help them to specify their mutual needs. In this case, unlike the transaction cost theory, recurrent transactions favour co-operative agreement. This interactive learning has following three dimensions (Lundvall, 1993).
  - Technical learning exists when interaction between users and producers induces an understanding of reciprocal needs.
  - Communicative learning involves the establishment of technical codes, tacit and specific to the partners.
  - Social learning limits opportunism by creating similar behavioural codes.

The access to external linkages is assumed to be crucial for SMEs competitiveness.

3. SMEs and external communication

SMEs tend to be less innovative than large companies and to dedicate less resources to the acquisition of external technologies. In France, from 1990 to 1992, 30.5% of firms with a number of employees ranging from 20 to 49, were considered as innovators and 93% of those with more than 2000 employees were engaged in this process (SESSI, 1996). These results do not mean that SMEs are less efficient than big firms.[5] The absence of hierarchical levels and horizontal communications favours quick reaction to keep abreast with environmental disturbances and fast changing market requirements.

In fact, what distinguishes SMEs in comparison with large companies is not in that they have a lower turnover or a smaller size. The crucial point is that they are usually managed by their owners.

3.1. The crucial role of the manager during the innovation process

In SMEs, the manager bears the responsibility of taking the decisions regarding all aspects of technical change. Thus, risk adversity may impede the innovation process. Following two types of behaviour are usually applicable to managers (OCDE, 1993).

- In the first category, one finds managers who look for the stability of their company and consider that innovation represents a large financial risk. So they only innovate under the pressure of their environment. They limit their contacts with the external environment to suppliers and clients. The management style is centralised.
- The second kind of entrepreneurial managers encourage rapid growth of their company. They accept risk and try to take advantages of every new opportunity. To enhance the performance and the growth of their company, they forge external technical and scientific linkages with educational establishments, research associations and other public agencies. They know that the success of their company is based on the quality of their employees and on their commitments to networks of innovators. In this prospect, the managers' educational level influences the scope of the network. Highly educated

[5] The survey carried out by the SPRU revealed that from 1945 to 1980, SMEs highly contributed to innovation. Their share in innovation was higher than their share in total formal R&D (Rothwell and Zegveld, 1982).

managers tend to rely more on research and advisory agencies and less on informal contacts.

3.2. The role of networks in SMEs competitiveness

Firms which benefit from interpersonal contacts through networks will gain following three kinds of competitive advantages.

- Information is the nerve of competition which sets up among firms. Nevertheless, the complexity of information makes it more difficult to master. Because of their lack of financial resources, SMEs are often disadvantaged in their ability to gather technical information of paramount importance (Julien, 1994). Vis-à-vis large firms, they suffer from an information gap. Networks allow SMEs to decode and appropriate flows of information. They reinforce SMEs' competitiveness by providing them with a window on technological change, sources of technical assistance, market requirements and strategic choices made by other firms.
- Tacit knowledge is very important in innovation (Senker, 1995). This knowledge cannot be transferred through written documents.[6] It is embodied in the personal knowledge of technical and scientific agents. Therefore, personal networks which favour acquaintances become the main channel for its transfer. To know who holds information is crucial when one faces complex technological issues. Members of networks 'provide the know-why, know-how, know-when, and know-what necessary for entrepreneurial success' (Malecki and Tootle, 1996, p. 45).
- Innovation is characterised by its uncertainty. Firms need to raise financial means as soon as they launch research projects. Conversely, results are uncertain and remote. Ten years can elapse between research and commercialisation. As time passes, resources become more specific. This augments the irreversibility of the firm's commitment. Moreover, in many fields, where technical changes are rapid and product life cycle very short, the acquisition of technology through traditional means (licence agreement) turns out to be risky and subject to obsolescence. By using either formal or informal networks, SMEs reduce their irreversibility costs[7] and have access to new knowledge.

To assess how co-operative R&D foster the success of innovative projects, we draw upon case studies made of projects which were launched by small business enterprises of the Centre region (around the Loire Valley).

4. Impact of co-operative relationships on successful innovation: analysis from a panel of French SMEs

4.1. Research methodology

The firms of our sample received public funds to partly finance their innovative activities. These funds were allocated by ANVAR, a French national agency responsible for the development of innovation projects in industry. The regional agencies, located everywhere in France, aid small firms not only through financial assistance,[8] but also through technological advice. Therefore, they play a key role in the existence of regional networks consisting of firms, academic institutions and government agencies.

We ground our study on 313 projects (247 enterprises) which were partly financed by the agency located in Orléans from 1980 to 1987. By selecting projects which were launched between 1980 and 1987, we wanted to be able to judge whether the firms had achieved their technological and commercial goals. In 1995, at the time of our inquiry, the results of each innovative projects were just known for the period 1980–1987.

Our analysis is a comparison of the ways in which success differ from failures. We estimated a logistic

[6] 'In each technology there are elements of tacit and specific knowledge that are not and cannot be written down in a 'blueprint' form, and cannot, therefore, be entirely diffused either in the form of public or proprietary information' (Dosi, 1988, p. 1131).

[7] According to Foray (1991), co-operative R&D can take various organisational forms. It goes from internal to contractual research. Along this axis, resources are less specific but reversibility is stronger.

[8] The financial assistance can cover up to 50% of the costs of the innovation project. The firms refund the agency only in case of success and without paying any interest. Large firm are usually excluded from this procedure. In France, about 5% of firms with more than 500 employees benefited from the financial aid.

regression model, with the dependant variable, the result of the innovative project, defined equal to 1 if the firm refunded ANVAR without notifying any technical problems to the agency, and equal to 0 if the project is a failure. The independent variables are the categories of firms, the sector of production of the innovation and the technical partners.

The categories of the firms: the enterprises were classified into eight categories depending on their size and their ownership status (Appendix A). These firms are not supposed to be representative of the population of French SMEs. If a firm asks for the assistance of the agency, it proves that it innovates and is open to its institutional environment.

4.1.1. The sector of production of the innovation

The innovative projects were classified according to the French Industrial Classification of Products and Activities (NAF 16) (SESSI, 1995). We added five categories to this nomenclature: food-processing industry, software industry, building industry and agriculture. The projects which did not fit into this classification belong to the 'other' category. The distribution of projects according to the size of the firm, the ownership status and the sectors of production of the innovations are presented in Table 1.

4.1.2. The technical partners

Some SMEs worked on their innovation project by relying exclusively on their internal competencies; Other collaborated both on formal and informal basis. Several technical partners were identified: clients, suppliers, other firms (than clients and suppliers), professional and technical centres, educational institutions (university, engineering school, technical college), research institutions (CNRS, INRA, INSERM and CEA). Individual inventors and designers are the 'other partners' (Table 2).

In Table 2, we report following three different models.

- The first tests the effect of co-operative relationships as a whole. One of the dependant variable is collaboration. It is equal to 1 if the firm relied on external competencies, and equal to 0 if the firm did not co-operate with external partners.
- The second tests the role of the partners which were approached by the firms for technical purposes.
- The last model only keeps the variables which were the most significant in models 1 and 2, in predicting the results of the innovative projects.

However, our approach is not exhaustive. It does not show how SMEs are linked to networks.

4.2. The role of linkages to external resources

The success rate of small and medium enterprises which obtained external knowledge from other companies or from public research institutions through technological co-operation, was higher (Table 3). However, from the results of our estimating procedure (Table 2, model 1), we cannot say that technological

Table 1
Distribution of projects according to firm size, ownership status and the sectors of production of the innovations (NAF 16)

Size and status of firms	Employees						Regional group	Subsidiary of group	Total[a]
Sectors	1–9	10–19	20–49	50–99	100–250	251–499			
Consumer goods	5	3	3	6	5	1	0	1	24 (7.7)
Automobile	2	0	0	1	3	2	1	2	11 (3.5)
Capital goods	29	17	37	20	19	4	10	12	148 (47.3)
Intermediate goods	10	4	13	9	9	6	1	22	74 (23.6)
Food processing	1	1	1	0	3	2	8	2	18 (5.7)
Agriculture	3	0	3	2	0	0	0	0	8 (2.6)
Construction	2	1	1	0	3	0	1	0	8 (2.6)
Computing activities	1	2	0	0	0	0	0	0	3 (1)
Other	2	2	7	1	2	2	1	2	19 (6.1)
Total	55	30	65	39	44	17	18	45	313
Percentages	17.6	9.6	20.8	12.5	14.0	5.4	5.7	14.4	100

[a] The values shown in the parenthesis are in percentages.

Table 2
Logistic regression of the likelihood of success of innovative projects

Dependant variable: success of innovative projects			
Name of the explanatory variables	Coefficient (*t* of Student): model 1	Coefficient (*t* of Student): model 2	Coefficient (*t* of Student): model 3
Constant	−0.3033 (−0.685)	0.3701 (0.877)	0.3554 (1.496)
Categories of firms			
Very small enterprises (1–9 employees)	−0.9152* (−1.938)	−1.2468** (−2.536)	−1.1226** (−2.936)
Very small enterprises (10–19 employees)	0.240 (0.487)	0.216 (0.415)	–
SME (20–49 employees)	0.1231 (0.296)	−0.2114 (−0.485)	–
SME (50–99 employees)	0.9406* (2.002)	0.7647 (1.551)	0.8808* (2.304)
SME (100–250 employees)	−0.1773 (−0.395)	−0.3186 (−0.667)	–
SME (251–499 employees)	−0.4788 (−0.763)	−0.9574 (−1.473)	−0.7976 (−1.388)
Regional group	0.9187 (1.457)	0.9871 (1.484)	1.1564* (2.090)
Subsidiaries	Reference	Reference	–
Sectors of production of the innovations			
Consumer goods industry	0.123 (0.244)	0.257 (0.479)	
Automobile industry	−1.2997 (−1.531)	−1.6095+ (−1.827)	−1.7413* (−2.050)
Capital goods industry	−0.4124 (−1.324)	−0.3416 (−1.049)	−0.4722+ (−1.829)
Food processing industry	−1.9053+ (−1.677)	−1.7642 (−1.489)	−1.83 (−1.591)
Agriculture	−0.1699 (−0.282)	0.3457 (0.526)	–
Other	−0.473 (−0.103)	0.4377 (0.009)	–
Intermediate goods industry	Reference	Reference	–
Co-operative relationships	0.196 (0.616)	–	–
Partners			
Supplier	–	−0.9202** (−2.826)	−0.8627** (−2.709)
Client	–	−0.1145 (−0.408)	–
Enterprise	–	−0.5025 (−1.629)	−0.4138 (−1.392)
Technical centre	–	0.3034 (0.936)	–
Engineering and technical school/university	–	0.213 (0.587)	–
National research centre	–	−1.9709** (−3.096)	−1.8226** (−2.997)
Other partners	–	−0.0886 (−0.180)	–
n	313	313	313
Log likelihood	−195.9618	−185.3175	−186.8962

Prediction with the logic	Prediction		Observations	Prediction (%)
	Failures	Success		
Model 1				
Failures	156	30	186	83.9
Success	80	47	127	37.0
Total	236	77	313	64.9
Model 2				
Failures	141	45	186	75.8
Success	60	67	127	52.8
Total	201	112	313	66.4

Table 2 (*Continued*)

Prediction with the logic	Prediction		Observations	Prediction (%)
	Failures	Success		
Model 3				
Failures	153	33	186	82.2
Success	73	54	127	42.5
Total	226	87	313	66.1

+ Significant at 10%.
* Significant at 5%.
** Significant at 1%.

Table 3
Links between co-operative relationships and innovation projects[a]

	Success	Success rate	Failures	Failure rate	Number of projects
Technological partnerships	109	42.2	149	57.8	258
Number of technological partnerships	18	32.7	37	67.3	55
Number of projects	127	40.6	186	59.4	313

[a] According to the χ^2-test, there is no direct link between the result of a project and technological partnerships.

co-operation increases the chance of success of innovative projects.

As can be seen the predictive performance of success is increased when the categories of collaborations are separated. Surprisingly, the two categories which appear significant affect negatively the results of the projects. Co-operative agreements with suppliers and research institutions decrease significantly the chances of success. [9]

However, we cannot cast doubt over policies which tend to establish partnerships between SMEs and other institutions. The failure of a project does not mean that SMEs would have done better by relying on their own capabilities. The weaknesses of our study are three-fold.

- Firstly, we lack qualitative information about the nature of the ties instituted between SMEs and their partners. Developing mutual trust implies the establishment of common codes of information. This process takes time before being effective (Lundvall, 1988).
- Secondly, this analysis comes up against the way to apprehend informal relationships. All co-operative projects between customers and suppliers do not always lead to payment in full. This is the case when a customer tests for free the new product of his supplier. In such a situation, informal exchange may not have appeared in the progress report of the project. Thus, we probably underestimated the customer–supplier relations. [10] This lack of information is problematic because of the importance of informal interactions to transfer tacit knowledge. [11]
- Finally, to analyse if co-operative relationships are effective, we cannot assume that SMEs adopt a passive behaviour vis-à-vis their partners. Indeed, an upsurge of co-operative R&D agreements has been noticed in recent years. However, this increase did

[9] The size affects negatively the results of the innovative projects only for very small enterprises (less than 10 employees). For extensive results on the relation between firm size and innovation and on co-operative relationships between SMEs and research institutions, see Bougrain (2000).

[10] In his study, Hagedoorn drew similar conclusions (1995).

[11] According to Von Hippel, informal know-how trading is very active when '(1) the needed know-how exists in the hands of some member of the trading network, and when (2) the know-how is proprietary only by virtue of its secrecy, and when (3) the value of a particular traded module is too small to justify an explicit negotiated agreement to sell, license or exchange' (Von Hippel, 1987, p. 300).

not indicate that collective research was a substitute for corporate research. Both were complementary (Mowery, 1983).

So we need to examine how firms' internal research capacities help them to exploit external scientific and technical knowledge.

5. Relationships between firms internal capabilities and successful innovations

5.1. Relation between absorptive capacity and external learning

Firms do not delegate their research activities to other industrial corporations. To keep initiative and technical leadership, they need to strengthen their in-house research facilities.

According to Cohen and Levinthal (1989), innovative capabilities depend on the ability to exploit external knowledge and on in-house R&D efforts. These arguments reverse Arrow's analytical framework who considered that firms underinvest in R&D because imitation costs are smaller than the cost of creating new knowledge. If 'these costs are relatively small, it is by virtue of the considerable R&D already conducted by the firms in the vicinity of the emission' (Cohen and Levinthal, 1989, p. 570).

Firms' ability to develop an absorptive capacity heavily depends on investment made during previous periods. These initial investments allow them to make better technological choices and to exploit new opportunities better. If a firm temporarily neglects to invest in a technical field, it will be less aware of technological opportunities (Cohen and Levinthal, 1990). So it will increase its initial weakness. To maintain their potential competitiveness, firms need to have at least a window on state-of-the-art technologies.

Communication systems also play a great role to increase organisational absorptive capacity. Firms must focus both on the interface between the departments and the external environment and on horizontal communication among departments. Overlapping knowledge across individuals is crucial to ameliorate internal transfer while diversity of knowledge elicit 'learning and problem solving that yields innovation' (Cohen and Levinthal, 1990, p. 133).

According to this theoretical scheme, firms' ability to exploit external knowledge depends on their absorptive capacity. Consequently, we cannot consider that an analysis of the link between collaborative relationships and innovation is adequate. We need to take into account internal factors which would improve the learning capacity and contribute to the success of co-operative projects. Following three factors which characterised in-house innovative capabilities will be analysed:

- R&D intensity;
- the number of executives employed by the firm;
- and the existence of a design office.

We did not take into account all the above-mentioned projects (313). We restrained our survey to SMEs which were involved in a co-operative agreement. Moreover we dismissed many projects because data were not fully available for each case. From 1980 to 1987, ANVAR changed its administrative forms. Thus, along the period, information concerning the firms were not homogeneous and rather limited.

Information related to the existence of a design office was available in 91 cases. We decided not to take into account the percentage of executives to employees for SMEs with less than 10 employees. We thought that these figures would not have been significant. Consequently, we just relied on 83 projects. R&D intensity was available for 79 files.

Due to the limited sample size, we only estimated basic logistic regression models and we performed a χ^2-test for the three factors which characterised in-house innovative capabilities.

5.2. Links between R&D intensity and successful innovation

According to our regression 1 (Table 4) and to the χ^2-test (Table 5), R&D intensity does not influence future prospects of a project. These results based on a small sample, confirm those of Rocha (1999, p. 268). He considered that greater R&D intensity is not necessary when firms need 'to absorb external knowledge produced through inter-firm alliances'.

However, our research methodology may explain these results. Production, diffusion and use of

Table 4
Logistic regression of the likelihood of success of innovative projects

Dependant variable: success of innovative projects			
Name of the explanatory variables	Coefficient (*t* of Student): model 1	Coefficient (*t* of Student): model 2	Coefficient (*t* of Student): model 3
Constant	0.0791 (−0.389)	0.1321 (0.347)	-0.469^{+} (−1.7997)
Research intensity	−0.0208 (−0.176)		
Size (number of employees)	−0.00018 (0.861)		
Executives (%)		−1.3198 (−0.431)	
Design office			0.045^{+} (0.088)
n	79	83	91
Log likelihood	−53.279	−185.3175	−186.8962

$^{+}$ Significant at 10%.

Table 5
Links between R&D intensity[a] and results of co-operative projects[b]

Projects results R&D intensity	Success	Success rate	Failures	Failure rate	Number of projects
Weak (less than 1% of sales)	10	43.5	13	56.5	23
Middle (between 1 and 4% of sales)	13	44.8	16	55.2	29
Strong (more than 4% of sales)	15	55.6	12	44.4	27
Number of projects	38	48.1	41	51.9	79

[a] These three classes of R&D intensity fit the recommendations advocated by the OCDE (1992). Firms which dedicate less than 1% of their turnover to R&D, belong to the class of weak research intensity.
[b] According to the χ^2-test, there is no direct link between the result of a project and R&D intensity.

innovation are different among sectors (Pavitt, 1984). However, to analyse the correlation between R&D intensity and projects results, we do not take into account the sectoral patterns of innovation. In high-tech sectors, a regime of fast technological change squeezes the firms to devote more resources to R&D. In the textile industry, technological constraints are not so strong.

Despite this drawback, our results tend to confirm that R&D intensity cannot be considered as a perfect indicator to measure the innovative activity which is performed in SMEs. Following two elements argue in this way.

- The main problem is to know which expenditures firms include in R&D. In France, firms may announce the figures which they declare to benefit from research tax deduction. But the appropriateness of the definition used by the fiscal administration to determine R&D expenditures, is criticised (Lhuillery and Templé, 1995).
- R&D is only one source of innovation.[12] This remark applies particularly to SMEs. Their research activities are not as formal and organised as in large firms.[13] SMEs may carry out their R&D activities 'without a formal R&D department or a formal budget and often even outside regular working hours' (Kleinknecht, 1989, p. 216). Consequently, it is difficult to identify R&D investments of small firms (Roper, 1998). This indicator cannot be satisfactory to analyse SMEs' ability to innovate.

[12] 'Whilst working on definitions and measurement of research and development in the 1960s one frequently encountered the view that what should be measured in industry was not R&D, but R, D&D—Research, Design and Development' (Freeman, 1992, p. 50).

[13] 'We have shown that when we treat technical change as synonymous with R&D activities in science-based industries, we are in danger of neglecting up to nearly 40% of what is going on in technical change, especially in non-electrical machinery and in small firms' (Patel and Pavitt, 1994, p. 543).

Table 6
Influence of executives presence on success rate of co-operative projects[a]

Project result (% of executives to employees)	Success	Success rate	Failures	Failure rate	Number of projects
From 0 to 5	9	42.9	12	57.1	21
From 5.01 to 9	15	55.6	12	44.4	27
≥9.01	19	54.3	16	45.7	35
Number of projects	43	51.8	40	48.2	83

[a] According to the χ^2-test, there is no direct link between the result of a project and the percentages of executives to employees.

5.3. The contribution of executives to successful collaborative relationships

The presence of executives indicates that the entrepreneurial manager delegates part of his power to its subordinates. So, he can spend more time to run effectively his business and to formulate strategic plans for technological development. Consequently, the presence of executives should increase the success rate of innovation. Our empirical results invalidate what we expected. According to regression 2 (Table 4) and to the χ^2-test (Table 6), there is not a direct link between the result of a co-operative project and the percentages of executives to employees. Following three elements may explain why collaborative relationships are not more successful when the percentage of executives to employees is larger.

- This category is heterogeneous. Research and production managers are often at the heart of the innovation process. Similarly, sales managers will enhance the firm's ability to respond to prospects of the market. Conversely, accountants and other administrative executives do not play a key role during the innovative activity. In other words, the percentage of executives is only quantitative. It does not give any information on the organisational efficiency of the firms (Perrin, 1991).
- We would also need information about executives' educational qualification. This lack of qualitative information is problematic. Indeed, the level of education influences the receptiveness of executives to external sources and their approach to innovation problems to a considerable extent (Gibbons and Johnston, 1974). When executives with a high level of education are confronted to a complex problem they recognise if the firm can rely on its own competencies to resolve this problem. If the firm's capabilities are not sufficient they know who to contact. Conversely, the staff with a lower level of education relies more on their own knowledge.
- In firms, innovative competencies do not depend exclusively on executive staff. Technicians are also crucial actors of product/process innovations in SMEs. They differently conceive the innovative activity but they contribute to incremental innovations as well as executives.

5.4. The contribution of design office to successful collaborative relationships

The activity of a design office is not as formal as in a R&D department. It is more orientated toward the development and improvement of existing products than radical innovation. The design office is composed of engineers and technicians. It gives a better picture of the innovative activities in SMEs. Sometimes in the smallest firms, engineers are not even present. Some entrepreneurial managers are reluctant to commit their projects to engineers because they fear their high level of education.

Firms who are endowed with this office have already structured their innovative capabilities. They rely less on informal knowledge. This explain why the success of collective innovation is correlated to the existence of the design office (Tables 4 and 7). Thanks to this office SMEs' partners know better who to inform in case of technical problems. We also assume that qualified employees working there are more able to understand information flowing through industrial networks. These results are in conformity with the assertion of Cohen and Levinthal (1989, p. 569) who suggested that 'while R&D obviously generates innovations, it also develops the firm's 'learning' or 'absorptive' capacity'.

Table 7
Links between design office and success rate of co-operative projects[a]

Project result (structure of SMEs)	Success	Success rate	Failures	Failure rate	Number of projects
Presence of a design office	36	50.7	35	49.3	71
No design office	5	25	15	75	20
Number of projects	41	45.1	50	54.9	91

[a] According to the χ^2-test, there is a direct link between the result of a project and the presence of a design office at 90% level.

Internal expertise facilitates the identification of external information, their absorption and the improvement of SMEs' performances. If a decoding does not happen, the assimilation of external knowledge to the firm's 'technological capital' (Le Bas and Zuscovitch, 1993, p. 185) will not be effective.

6. Conclusion

We know that SMEs are increasingly dependent on external sources of technical activity because the process which generates new technologies is becoming more complex. However, before having access to the knowledge held by competencies centres, SMEs need to develop and structure their own capacities. One way to achieve this goal is to hire technically qualified manpower.

Indeed, our results show that a design office facilitates the use of extensive information networks. Firms with no design office do not master the innovation process well. They experience difficulties not only to consult the appropriate source of information but also to get access to existing networks and to appropriate state-of-the-art technologies. Without this office collaborative relationships are riskier and not as effective.

Acknowledgements

A preliminary version of this paper was presented at the International Workshop on Innovation, SMEs and Local Development in Cremona, Italy. Some results were also discussed at the seminars at the Universities of Orléans (LEO) and Strasbourg (BETA). We are indebted to all participants. We are also grateful to the people who work at the ANVAR regional agency located in Orléans.

Appendix A

The enterprises were classified into eight categories depending on their size and their ownership status. Our classification is more detailed than the recommendations of the OECD (1992). The firms with between 1 and 9, 10 and 19, 20 and 49, 50 and 99, 100 and 250, 251 and 499 employees were all independent.

The other categories concern large enterprises and subsidiaries. We distinguish regional groups with more than 500 employees whose headquarters is located in the Centre region and subsidiaries of company whose group employment exceeds 500 employees and is located outside the Centre region.

By holding concurrently two criteria, the size of the firm and the ownership status, we avoid the classification discrepancies described by Tether et al. (1997).

References

Amendola, M., Gaffard, J.-L., 1994. Markets and organisations as coherent systems of innovation. Research Policy 23, 627–635.
Bougrain, F., 2000. Les P.M.E. et l'innovation: implications en matière de politique technologique régionale—Cas de la région Centre et comparaison avec le Bade-Wurtemberg. Ph.D. thesis (unpublished), Laboratoire d'Economie d'Orléans, Université d'Orléans.
Callon, M., 1994. L'innovation technologique et ses mythes. Annales des Mines Gérer et Comprendre 3, 5–17.
Chandler, A.D., 1992. What is a firm? A historical perspective. European Economic Review 36, 483–494.
Cohen, W.M., Levinthal, D.A., 1989. Innovation and learning: the two faces of R&D. The Economic Journal 99 (9), 569–596.
Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning innovation. Administrative Science Quaterly 35 (3), 128–152.
Demsetz, H., 1991. The theory of the firm revisited. In: Williamson, O.E., Winter, S.G. (Eds.), The Nature of the Firm. Oxford University Press, New York, pp. 159–178.
Dosi, G., 1988. Sources, procedures, and microeconomic effects of innovation. Journal of Economic Literature 26, 1120–1171.

Everaere, C., 1993. Des coûts aux investissements de transaction. Pour un renversement de la théorie de Williamson. Revue Française d'Economie 8 (Summer), 149–203.

Foray, D., 1991. Repères pour une économie des organisations de recherche-développement. Revue d'Economie Politique 101, 779–808.

Foss, N.J., 1996. Capabilities the theory of the firm. Revue d'Economie Industrielle 77 (3), 7–28.

Freeman C., 1992. The Economics of Hope. Pinter Publishers, London.

Fusfeld, H.I., 1986. The Technical Enterprise. Ballinger Publishing, Cambridge, MA.

Gibbons, M., Johnston, R., 1974. The roles of science in technological innovation. Research Policy 3, 221–242.

Hagedoorn, J., 1995. Strategic technology partnering during the 1980s: trends, networks and corporate patterns in non-core technologies. Research Policy 24, 207–231.

Jacquemin, A., 1987. Comportements collusifs et accords en recherche-développement. Revue d'Economie Politique 97, 1–23.

Julien, P.A., 1994. Les P.M.E.: Bilan et Perspectives. Economica, Paris.

Kleinknecht, A., 1989. Firm size and innovation. Small Business Economics 1, 215–222.

Kleinknecht, A., Reijnen, J.O.N., 1992. Why do firms co-operate on R&D? An empirical study. Research Policy 21, 347–360.

Le Bas, C., 1993. Le comportement d'investissement en ressources technologiques externes et l'absorption technologique dans les moyennes entreprises industrielles. Revue Internationale des P.M.E. 6, 35–64.

Le Bas, C., Zuscovitch, E., 1993. Apprentissage technologique et organisation: une analyse des configurations micro-économiques. Economies et Sociétés 27 (5), 153–195.

Lhuillery, S., Templé, P., 1995. L'impact du C.I.R. sur l'innovation dans les entreprises. In: Haudeville, B., Héraud, J.-A., Humbert, M. (Eds.), Technologie et Performances économiques. Economica, Paris, pp. 155–182.

Lundvall, B.-A., 1988. Innovation as an interactive process: from user–producer interaction to the national system of innovation. In: Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (Eds.), Technical Change and Economic Theory. Pinter Publishers, London, pp. 349–369.

Lundvall, B-A., 1993. Explaining inter-firm co-operation and innovation. In: Grabher, G.(Ed.), The Embedded Firm. Routledge, London, pp. 52–64.

Malecki, E.J., Tootle, D.M., 1996. The role of networks in small firm competitiveness. International Journal of Technology Management 11, 43–57.

Ménard, C., 1992. Why do agents co-operate? In: Proceedings of the Communication at CAESAR's Workshops. Paris.

Mowery, D.C., 1983. The relationship between intrafirm and contractual forms of industrial research in American manufacturing, 1900–1940. Explorations in Economic History 20, 351–374.

OCDE, 1992. Principes directeurs proposés par l'OCDE pour le recueil et l'interprétation des données sur l'innovation technologique—Manuel d'Oslo. OCDE, Paris.

OCDE, 1993. Les petites et moyennes Entreprises: Technologie et compétitivité. OCDE, Paris.

Patel, P., Pavitt, K., 1994. The continuing, widespread (and neglected) importance of improvements in mechanical technologies. Research Policy 23, 533–545.

Pavitt, K., 1984. Sectoral patterns of technical change: towards a taxonomy and a theory. Research Policy 13, 343–373.

Pelikan, P., 1988. Can the imperfect innovation systems of capitalism be outperformed? In: Dosi, G. (Ed.), Technical Change and Economic Theory. Pinter Publishers, London, pp. 370–398.

Perrin, J.-C., 1991. Analyse et évaluation des processus de production des techniques à partir des activités de conception. In: de Bandt, J., Foray, D. (Eds.), L'évaluation économique de la recherche et du changement Technique. Editions du CNRS, Paris, pp. 276–303.

Richardson, G.B., 1972. The organisation of industry. The Economic Journal 82 (9), 883–896.

Rocha, F., 1999. Inter-firm technological co-operation: effects of absorptive capacity, firm-size and specialisation. Economics of Innovation and New Technology 8, 79–103.

Roper, S., 1998. Under-reporting of R&D in small firms: the impact on international R&D comparisons. Small Business Economics 12, 131–135.

Rosenfeld, S.A., 1996. Does co-operation enhance competitiveness? Assessing the impacts of inter-firm collaboration. Research Policy 25, 247–263.

Rothwell, R., Zegveld, W., 1982. Innovation and the Small and Medium Sized Firm. Pinter Publishers, London.

Senker, J., 1995. Networks tacit knowledge in innovation. Economies et Sociétés 29 (9), 99–118.

SESSI, 1996. L'innovation technologique dans l'industrie. SESSI, Paris.

SESSI, 1995. L'industrie Française. SESSI, Paris.

Teece, D.J., 1980. Economies of scope and the scope of the enterprise. Journal of Economic Behaviour and Organisation 1, 223–247.

Tether, B.S., Smith, I.J., Thwaites, A.T., 1997. Smaller enterprises and innovation in the UK: the SPRU innovations database revisited. Research Policy 26 (3), 19–32.

Von Hippel, E., 1987. Co-operation between rivals: informal know-how trading. Research Policy 16, 291–302.

Williamson, O.E., 1989. Transaction cost economics. In: Schmalensee, R., Willig, R. (Eds.), Handbook of Industrial Organisation. North Holland, Amsterdam, pp. 135–182.

Williamson, O.E., 1991. Strategizing, economising, and economic organisation. Strategic Management Journal 12, 75–94.

Winter, S.G., 1991. On coase, competence, and the corporation. In: Williamson, O.E., Winter, S.G. (Eds.), The Nature of the Firm. Oxford University Press, New York, pp. 179–195.