Hitotsubashi University
Institute of Innovation Research

Organizational Competencies and Innovation Performances
The Case of Large Firms in Belgium

Carine Peeters
Bruno van Pottelsberghe de la Potterie

IIR Working Paper WP#03-19

September 2003

Institute of Innovation Research
Hitotsubashi University
Tokyo, Japan
http://www.iir.hit-u.ac.jp

Organizational Competencies and Innovation Performances

The Case of Large Firms in Belgium

Carine Peeters
Bruno van Pottelsberghe de la Potterie

September 2003

WP#03-19

Organizational Competencies and Innovation Performances

The Case of Large Firms in Belgium

Carine Peeters[∇] *and Bruno van Pottelsberghe de la Potterie*[α]

September 2003

Abstract

The objective of this paper is to assess whether large firms' organizational competencies affect their innovation performances. About 40 organizational sub-competencies are defined and measured through an original survey questionnaire answered by 148 large firms in Belgium. The sub-competencies are grouped into seven broad organizational competencies associated with the innovation process. For each broad competence a principal component analysis is run to illustrate whether the sub-competencies are related to three innovation performance indicators, including R&D intensity, the number of patents and the share of sales accounted for by innovative products and processes. The empirical results show that the output related innovation performance indicators (innovative output and the number of patents) are closely related with most organizational competencies, whereas R&D intensity is only correlated with two competencies (developing an innovation culture and using internal funding for innovation). Innovation performance is not only a function of the investment devoted to the creation of new products, processes or services, but also a function of the organizational process underlying innovative activities.

Keywords: Organizational competencies, innovation performance, R&D, principal component analysis

JEL: L20, L25, O31, O32, O34

[∇] FNRS/Bernheim Fellow Researcher, Centre E. Bernheim, Solvay Business School, Université Libre de Bruxelles, av F.D. Roosevelt 50 CP 145/1, 1050 Brussels, BELGIUM. Tel: +32-2-650.42.47, Fax: +32-2-650.48.99, E-mail: carine.peeters@ulb.ac.be

[α] Solvay SA Chair of Innovation, Solvay Business School, Université Libre de Bruxelles (ULB), Centre E. Bernheim, av F.D. Roosevelt 50 CP 145/1, B-1050 Brussels, BELGIUM. Tel: +32-2-650.48.99, E-mail: bruno.vanpottelsberghe@ulb.ac.be.

Introduction

Innovation has long been recognized[1] as a crucial factor underlying firms' sustainable performance. Numerous empirical analyzes have indeed demonstrated the relationship between research and development (R&D) and long term growth. The picture is however less clear when looking at the organizational competencies coming into play in the innovation process. Organizational competencies are of central concern for managers since they are recognized as the main source of competitive advantage for firms (Prahalad and Hamel, 1990). Actually, a firm's competence comes from its capability to combine resources in order to efficiently achieve a particular activity (Grant, 1991). The resources are the basic components of competencies, but the competitiveness of firms comes from their specific competencies (Bounfour, 1999). This would mean that innovation performance is not only a function of the investment devoted to the creation of new products, processes or services, but also a function of the organizational processes underlying innovative activities.

This paper is the logical pursuit of our desire to better understand how firms' organizational competencies associated with the innovation process and innovation performances are related. The objective is to use a principal component analytical tool to investigate the relationship between firms' organizational competencies related to the innovation process and their innovation performances. It is based on Peeters and van Pottelsberghe (2003) who present in details seven broad organizational competencies associated with the innovation process. These broad competencies are composed of about 40 sub-competencies. Three main indicators are used to approximate innovation performances. The first one is related to innovation efforts as proxied by the R&D intensity of the firms (R&D to sales ratio). The two other indicators are more related to the output of the innovation process. They measure the number of patent applications and the share of turnover due to new products and processes. The sample is composed of 148 large firms based in Belgium who replied to a survey on innovation competencies and performances.

[1] See for example Geroski *et al.* (1993), Baldwin *et al.* (1995), Baldwin and Johnson (1996), Crépon *et al.* (1998), Lööf and Heshmati (2002).

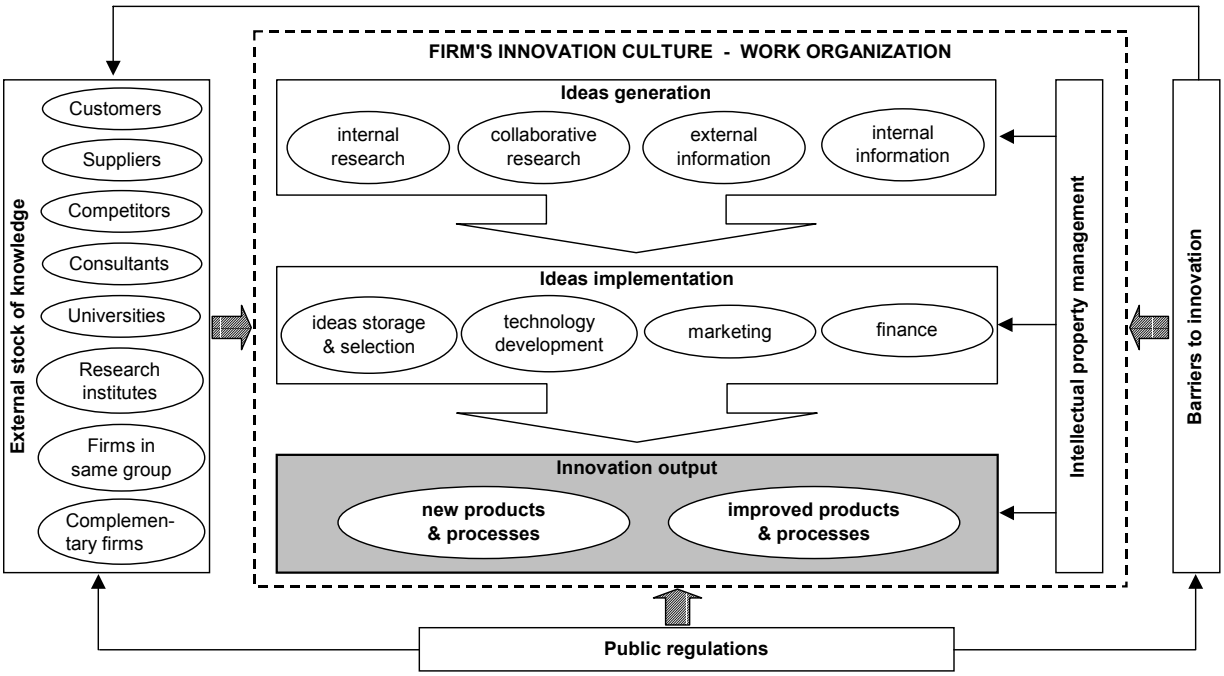
The paper is structured as follows. Section 2 defines the seven broad organizational competencies related to the innovation process. Section 3 presents the database and the methodology used to measure organizational competencies and innovation performances indicators, and to evaluate the relationships between them. The empirical results are provided in section 4. Section 5 concludes.

The empirical results show that the three indicators of innovation performance have different relationships with the seven broad organizational competencies. The number of patent is associated with most organizational competencies, whereas the R&D intensity is only correlated with a two of them.

Organizational competencies for innovation

In 2000 we launched a questionnaire that was sent to the largest firms based in Belgium, in each industry. The objective of this survey was to enter the innovation black box and get a better understanding of the innovation competencies coming into play. As described in Peeters and van Pottelsberghe (2003), the first step in order to build the questionnaire was to understand the innovation process and its environment. They are outlined in figure 1.

Figure 1: Mapping the organization of the innovation process



The box in dotted line represents the firm. Inside the box are the seven broad organizational competencies measured in the survey: the ability to develop a culture of innovation, the ability to set up a working organization favorable to innovation, the ability to generate ideas internally, the ability to use external information, the capacity to fund innovation, the capacity to select innovative projects, and the efficient management of intellectual property. Each of these seven broad competencies are composed of several sub-competencies presented in appendix 2. The firm's innovation competencies and performances are influenced by the external stock of knowledge (left hand side of the figure), the barriers to innovation (right hand side) and regulation aspects.

The firm's innovation culture surrounds all aspects of the innovation process so that the development of a culture of innovation becomes a competence in itself. Depending on the firm's culture, people will be more or less inclined to look for innovative ideas and try to develop them towards commercialization. Similarly, the firm's culture will influence the willingness to transform the firm's organization in a way that is convenient for innovation. The 10 sub-competencies that we have used to measure the ability to develop an innovation culture are presented in appendix 2. They include, amongst others, training programs for highly skilled professionals, the introduction of innovation in the global strategy, the reward of people for improved knowledge and innovation performances and innovation as an explicit corporate value.

Organizing the company for innovation is also a capability that surrounds the whole innovation process. Organizing efficiently in order to be capable of discerning new opportunities and profiting from them would even be more fundamental to firms than strategizing in order to beat competitors (Teece *et al.*, 1997). This broad organizational competence is composed of 5 sub-competencies. Working around projects and multidisciplinary teams, rather than according to the hierarchical functions, might for example constitute a better environment that increases employees' motivation to provide innovative efforts. Actually, a work environment where differently skilled people cooperate in a relatively non rigid structure has been found by Amabile and Conti (1997) to be positively related to creativity and innovation. Promoting the rotation of staff further increases knowledge sharing among workers. Rather than gaining a strong expertise in a specific field, employees develop a set of complementary valuable competencies and benefit from each others' knowledge. A projects organization coupled with a relatively high level of staff rotation might actually be fundamental for innovation since, even if ideas emerge in each people's mind, their implementation and further development into marketable technologies come from the interaction between employees (Nonaka, 1994). Paying attention to the exchanges between the technical and marketing department is of great importance too [Bonnet (1986), Gupta and Wilemon (1988 and 1990), Griffin and Hauser (1996), and Olson *et al.* (2001)]. If firms want to profit from their technological breakthroughs, they have to make

sure they develop products that customers want. Moreover, a good communication between marketers and scientists is crucial if firms want to avoid marketers to conceive new products that perfectly answer the customers' needs but are technologically infeasible. Finally, favoring teamwork and organizing brainstorming sessions might be useful to the successful completion of the innovation process.

The innovation development process begins with the generation of ideas. In order to generate ideas firms can develop an internal research capacity, form collaborative research agreements, and/or use various external and internal information sources. Internal research can be divided into three main activities: basic research, applied research and development activities[2]. The questionnaire asks firms the percentage of their R&D budget that is allocated to these three activities, in addition to the total share of sales allocated to R&D. In this paper the latter variable is considered as an innovation performance indicator. Firms can also develop their research capacity in collaboration with other firms or institutions (Tether, 2002). This is traditionally recognized as having a positive effect on the firms' performances (Ritter and Gemünden, 2002), and to be complementary to the firms' technological competencies (Tyler, 2001). Several partnerships are proposed in the questionnaire: with competitors, vertical partners, universities, consultants, complementary firms and other firms of the same group. These institutions form an external stock of knowledge that can be used by firms. In addition to the generation of ideas, the firm's own research activities help to improve its absorptive capabilities of own and external R&D (Cohen and Levinthal, 1990). Seven mechanisms to generate innovative ideas internally are assessed in the questionnaire. These include the recruitment of people that are likely to bring new skills to the firm, the use of competitive intelligence processes, the use of information from patent databases, scientific literature, and from benchmarking practices and market surveys.

[2] *Basic research* is experimental or theoretical work undertaken primarily to acquire new knowledge without any particular application or use in view. *Applied research* is also original investigation undertaken in order to acquire new knowledge, but it is directed primarily towards a specific practical aim or objective. *Experimental development* is systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed (Frascati Manual, 1993).

The fourth broad competence concerns the ability to use external information. Any innovative project requires the use of knowledge already existing outside the firm's boundaries. This competence is composed of six sub-competencies related to the ability to use information from customers, suppliers, competitors, and academic research institutions (see appendix 2).

The next step is the implementation of some of the innovative ideas previously generated. This requires the ability to select the most promising ideas and the ability to fund the development of these ideas. Firms need an efficient ideas selection process enabling them to track down the projects to push forward [Montoya-Weiss (2000), Cooper et al. (2001), Nemati et al. (2002), and Tidd and Bodley (2002)]. After an innovative project has been selected, the required technology can be developed internally, bought externally (licenses, trademarks, rights to use patented inventions…) or acquired by R&D projects subcontracting [Pisano (1990), Veugelers (1997), Bounfour (1999), and Veugelers and Cassiman (1999)]. The ability to select innovative projects is the fifth broad competence that is used in the empirical analysis. It is composed of four sub-competencies including the systematic storage of innovative ideas, the codification of knowledge, the evaluation of the success probability of an innovative idea and the assessment of potential barriers to innovative projects beforehand.

The sixth broad competence is related to the funding of innovative projects. Only a small share of the pool of ideas that have been generated will receive the necessary resources to enter the development step. And much fewer will go until large scale production and commercialization. The financing capacity of the firm is an important aspect of the ability to implement ideas (Adam and Farber, 1994). A firm can finance an innovative project internally by allocating a share of its profits to it. It can also use external funding sources, from the private (bank loans) or public (subventions) sectors.

The capacity of the firm to protect its intellectual property is important all over the innovation process. If the firm does not succeed in protecting its intellectual capital, it might not be able to appropriate the rents necessary to compensate for the costs of development it has supported. Firms have therefore to develop an active intellectual property strategy that must be linked with their technology and business

strategies. This is the last broad competence used in the empirical analysis. The six sub-competencies concern their ability to effectively protect their inventions, to manage their patents portfolio, and to assess the barriers to systematic patenting of their significant inventions.

Methodology

The questionnaire was sent to the CEO's of 1301 large firms active in all sectors in Belgium. A total of 148 questionnaires were filed and sent back. This represents a response rate of 11%, significantly higher for the largest firms (22% for firms with more than 500 employees). An extensive statistical analysis of the survey results can be found in Peeters and van Pottelsberghe (2003).

Assessing the link between all questions related to the innovation competencies and all measures of innovation performances would lead to a huge number of results, almost impossible to handle and present in a readable way. Therefore, we built 7 indicators of broad organizational competencies. Each of them is based on several sub-competencies (see appendix 2). For each of the seven competencies a principal component analysis including all the sub-competencies and the three innovation performance indicators were run. This empirical method allows first to test whether the sub-competencies are developed similarly (or are correlated) across companies. Second, it allows to interpret the main (or the two main) factorial axes in terms of firms' innovation competencies. The major competencies that are to be analyzed are (see the previous section and appendix 2):

- Developing a culture of innovation
- Organizing the company for innovation
- Generating ideas through internal mechanisms
- Using external information sources (commercial and scientific)
- Implementing an efficient selection process of innovative projects
- Funding innovation (external and internal sources of funds)
- Protecting intellectual property (IP)

The objective of this paper is to investigate the relationship between the firms' innovation competencies and their innovation performances. Three main indicators are used to approximate the innovation performances. The first is the share of sales allocated to R&D, an indicator of input into the innovation process. The second indicator is the firms' number of patent applications. The third

innovation performance indicator is an output indicator: the share of sales due to innovative products and processes. On average, firms allocate 7.6% of their sales to R&D, among which 3.3% go to basic and applied research. Only one firm has applied for more than 100 patents in 2000, while most firms have not applied for any patent at all, or only a small number. This highly skewed distribution shows that patents data are not only an indicator of innovative effort and reflects partly the technological performances of firms. The last indicator of innovation performance concerns the share of new products, processes and services in the firm's turnover. It can be split into improvement activities and radical innovation. On average 19% of firms' sales consist of improved products and processes, and 14% consist of radically new products and processes.

The three performance indicators are introduced in the study as illustrative variables. These variables do not enter in the computation but have their coordinates on the factorial axes. This allows to derive a visual interpretation of the relationship between firms' innovation performances and their innovative sub-competencies. The three illustrative variables are:

- RDSALESx : the percentage of total revenue devoted to research and development activities ;
- NBPRIORITYx : the number of patent applications in 2000 ;
- NEWTURNx : the percentage of sales accounted for by new products and processes

Each illustrative variable is subdivided into four quartiles (x=1, ...,4), according to the distribution of its value across firms. It goes from 1 (group of firms with the lowest values for the performance indicator) to 4 (the highest value). The quartiles are determined such as to form 4 equivalent groups of firms.

Empirical Results

This section presents the results of the 7 principal components analyzes related to the 7 major organizational competencies. For each competence, two graphs are provided[3]. The first one enables to interpret the factorial axes in terms on innovations sub-competencies. The second one plots the illustrative variables representing the innovation performance indicators on the plan defined by the first two factorial axes. Linking the different quartiles of a same innovation performance indicator allows to easily assess the relationship with the innovation sub-competencies.

The development of a culture of innovation (10 sub-competencies)

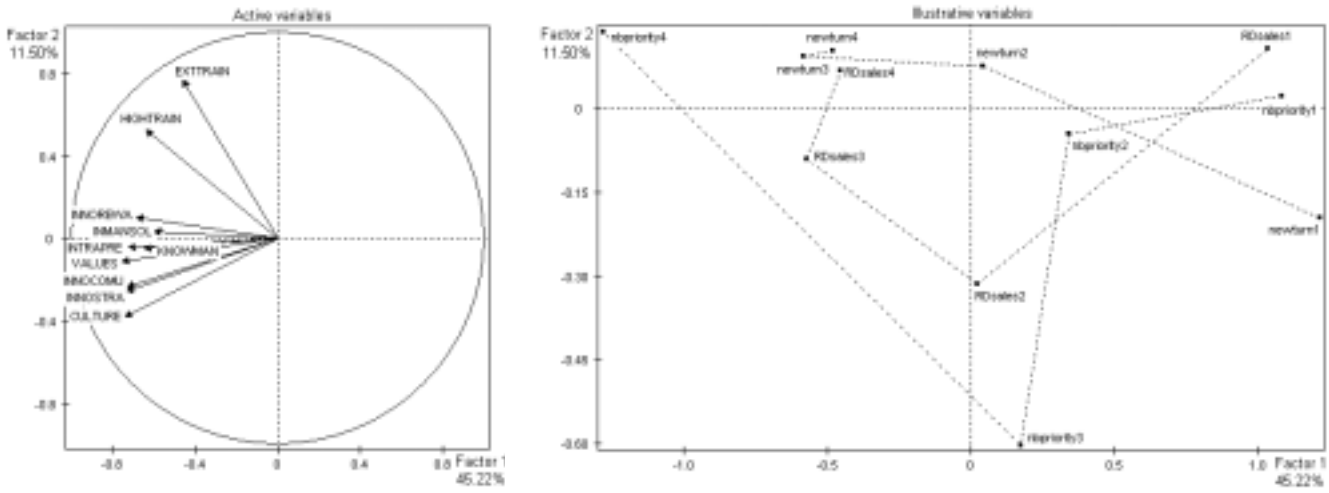
Ten sub-competencies relate to the development of a culture of innovation in firms[4]. Most sub-competencies are correlated across firms. This is reflected by the high variance explained by the first factorial axis (45%). Although associated with a low explanatory power (12%) the second factorial axis seems to witness an opposition between the firms that claim to have an innovation culture and strategy on the one hand and the firms that heavily rely on external training and highly trained staff on the other.

All three indicators of innovation performance seem to be positively associated with the first factorial axis. The firms with the lowest values of performance are concentrated on the eastern side of the graph, whereas the firms with the highest value are concentrated on the western side of the graph. This confirms the representation of the innovation process we provided in figure 1, with the innovation culture surrounding all steps of the innovation process. Actually, developing values that encourage innovation and learning, introducing innovation objectives in the firm's global strategy and communicating them to all employees, and promoting intrapreneurship strongly relate to the firms' innovation performances in terms of R&D, patent applications and sales of new products and processes.

[3] Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1.

[4] A definition of all sub-competencies variables is provided in appendix 2.

Graphs 1 and 2: PCA -Development of a culture of innovation[1]

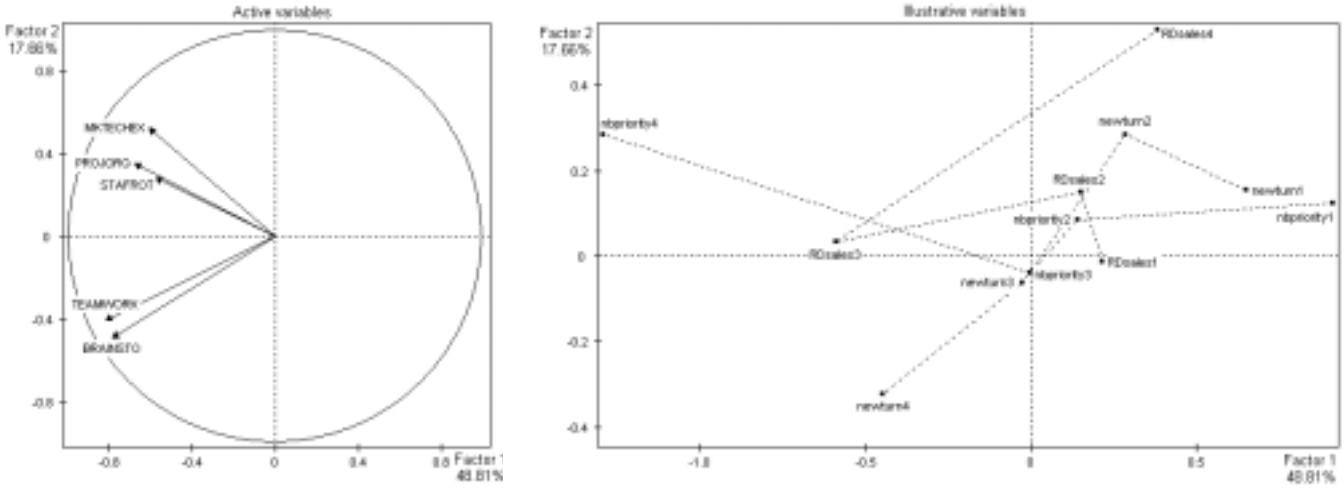


1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

A company's organization favorable to innovation (5 sub-competencies)

The way a firm is organized is also very important for the successful implementation of innovative ideas. The first factorial axis is negatively related to the five sub-competencies of the company's organization for innovation and accounts for 49% of the answers variance. The second one distinguishes the sub-competencies related to the general organization of the company (exchanges between the marketing and technology departments, organization around projects and staff rotation) from the sub-competencies more related to the day-to-day working habits of the different teams (teamwork and brainstorming sessions). It explains 18% of the answers variability.

Graphs 3 and 4: PCA – Company's organization favorable to innovation[1]



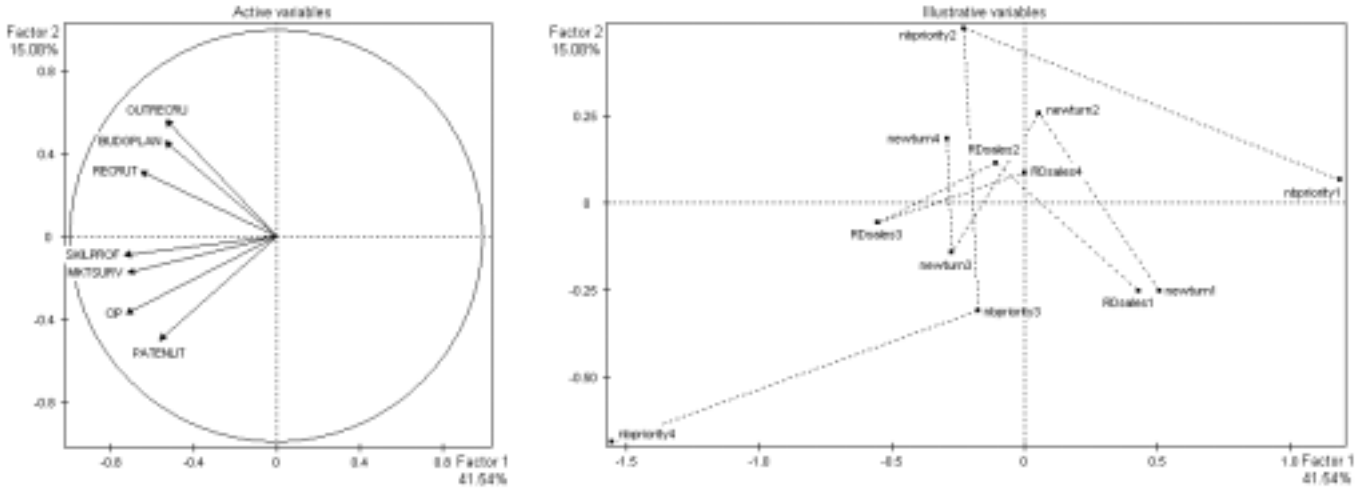
1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

The company's organization does not seem to be linked to the firms' performances in terms of R&D, as shown in graph 4. Conversely, there is a positive relationship between the innovation output indicators (patent applications and innovative sales) and the development of a company's organization favorable to innovation. Organizational issues appear therefore to be less important during the early stage of the innovation process when the focus is on research than at later production and commercialization stages. Another interesting distinction arises from graph 4 between the patenting performances more linked to the general organization of the company (upper-left of the graph-, and the innovative sales more related to the day-to-day work organization (lower-left of the graph).

Internal mechanisms to generate ideas (7 sub-competencies)

Firms can use several mechanisms to generate ideas internally. This can pass through their recruitment process, through the information they get from market surveys, benchmarking practices, patent databases, or through the use of more complex competitive intelligence processes.

Graphs 5 and 6: PCA - Internal mechanisms to generate ideas[1]



1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

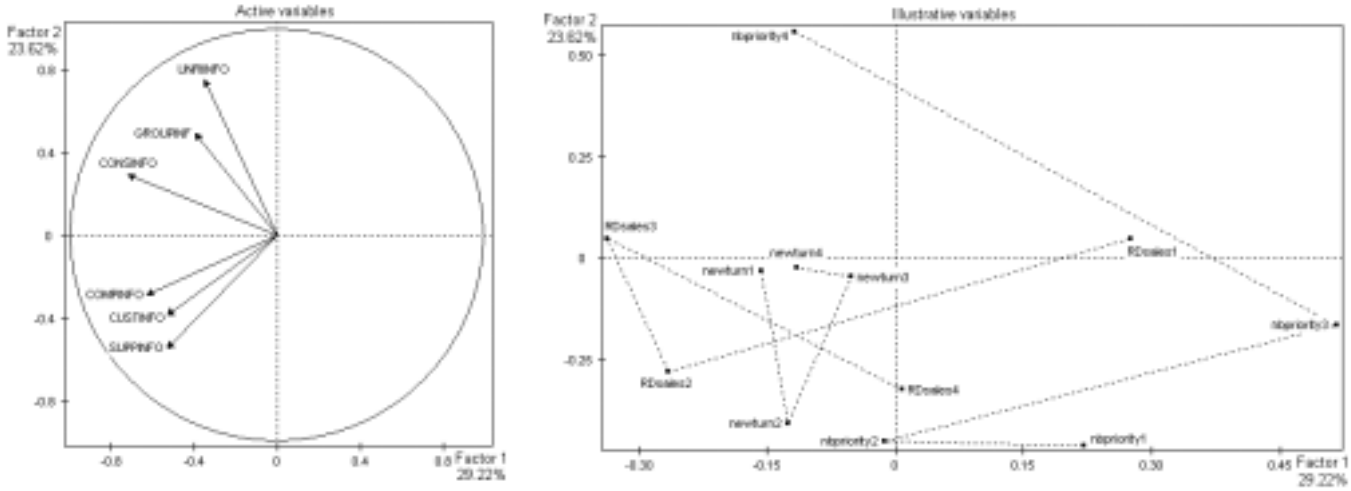
The first factorial axis in graph 5 explains 42% of variance and is negatively related to the generation of ideas through internal mechanisms. The second axis has a lower explanatory power (15%) and mainly differentiates firms that use their recruitment process to generate innovative ideas, from those that do not.

The internal mechanisms and information sources a firm uses are positively linked to the indicators of output of the innovation process, i.e. the number of patent applications and the percentage of turnover coming from innovative products and processes. The relationship with the R&D intensity is more ambiguous. Indeed, highest scores for the internal ideas generation competence are associated to intermediate levels of R&D intensity. Firms that allocate the largest share of sales to R&D do not stress the internal mechanisms to generate ideas much.

External information and knowledge sources (6 sub-competencies)

As presented in the second section, there is an external stock of knowledge that can be useful to the firms' own innovation activities. This stock of knowledge belongs to other institutions. They can be competitors, customers, suppliers, consultants, universities, research institutes or sister companies of the same group.

Graphs 7 and 8: PCA - External information and knowledge sources[1]



1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

The interpretation of both the first and the second factorial axes is important in order to understand the link between the use of external information sources and the firms' innovation performances. The first axis explains 29% of the answers variance and is negatively linked to all external information sources. The second axis accounts for 24% of the variance. It witnesses a distinction between firms that look for scientific information from universities or research institutes and firms that look to commercially related partners (competitors, customers and suppliers).

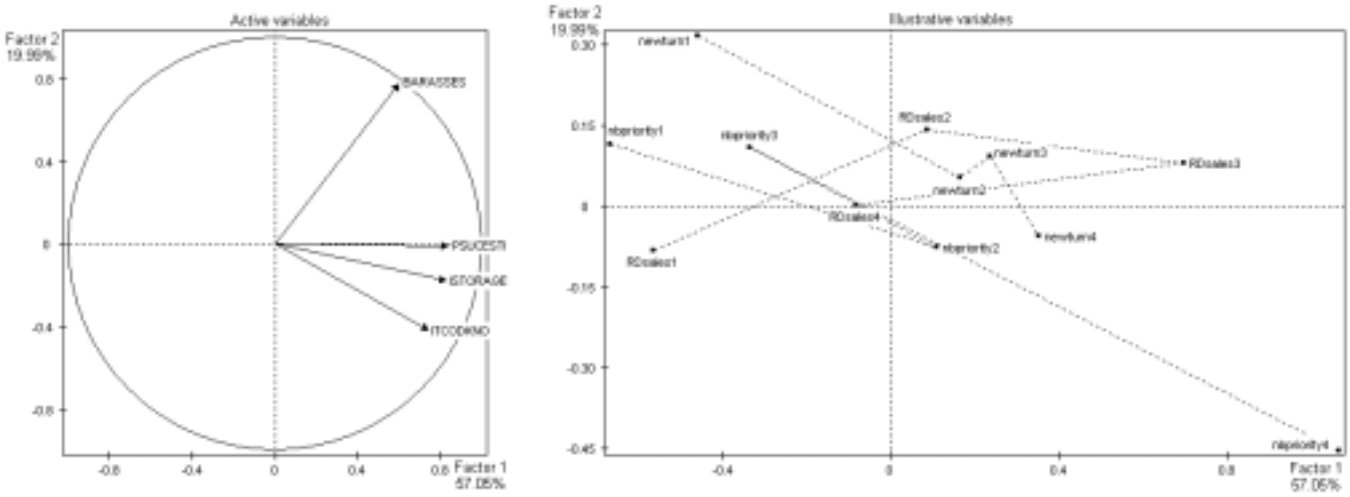
Looking at graph 8, it is hard to find a clear relationship between the recourse to external sources of information and the firms' innovation performances. Patenting performances are correlated with the second factorial axis, i.e. the use of universities and research institutes as information source. This result suggests that when firms exchange information with scientific institutions, it concerns more radical innovations that are more likely to be patented. Similarly to the internal mechanisms to generate ideas, the relationship between the R&D intensity and the external information and knowledge sources is ambiguous. There is no clear link between the search for knowledge from either commercially related firms or scientific institutions, and the firms' sales of new products and processes.

Selection of innovative projects (4 sub-competencies)

Four sub-competencies concern the processes firms implement to select the innovation projects to push forward. In this principal components analysis (graph 9), the first factorial axis explains 57% of the answers variance. It is positively linked to the ability of firms to store, codify and evaluate their innovative ideas through success probability estimation procedures and IT-based ideas storage and codification systems. The second factorial axis has less explicative power. It represents the tendency of firms to assess the potential barriers to the project implementation beforehand. This is not specific to each innovative project and reflects a rather general attitude of firms with respect to innovation. It explains 20% of the answers variance.

There is a positive relationship between the capacity of firms to select the most promising innovation projects and their innovative sales. The link is not linear but globally positive for the number of patent applications too. It must be noticed that the 3 sub-competencies defining the first factorial axis are highly correlated. They form a coherent set of capabilities firms should focus on to optimize the output of their innovation activities. Here again the best performers in terms of projects selection have intermediate levels of R&D intensity. The most R&D intensive firms actually have a relatively poor score in terms of projects selection.

Graphs 9 and 10: PCA – Selection of innovative projects[1]

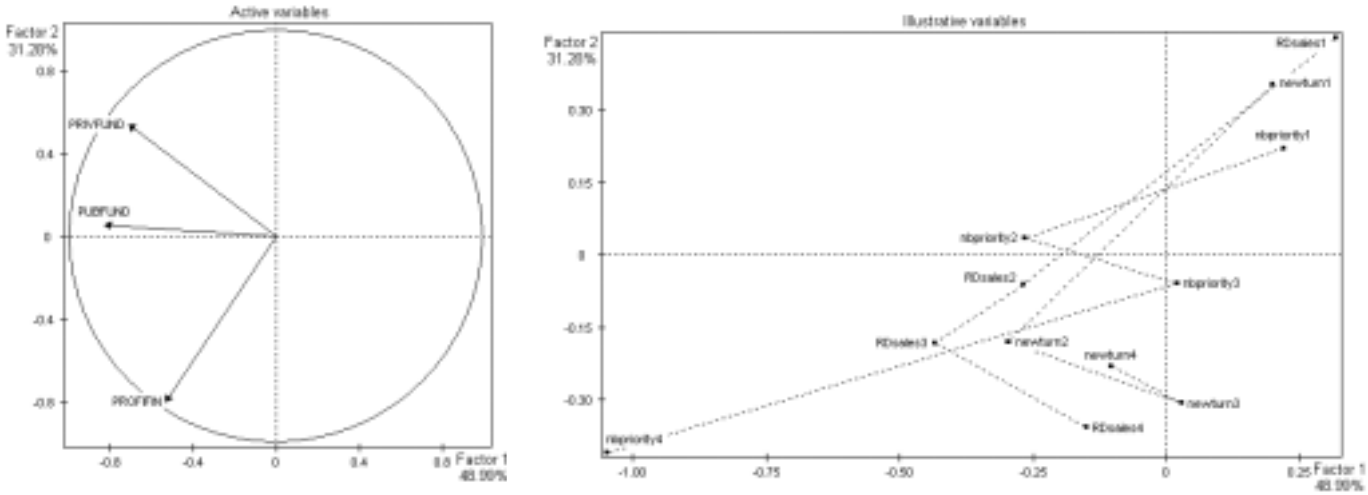


1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

Innovation funding (3 sub-competencies)

Three questions concerning the way firms finance their innovation projects are used here. The first one measures the extent to which firms allocate their own financial profits to innovation. The next two ones relate to their use of private bank loans and public funds. Both the first and second factorial axes are of importance to assess the link between the sources of funding and the firms' innovation performances. Graph 11 shows that the first one negatively relates to the recourse to external funding sources and explains 49% of the answers variance. The second one distinguishes firms that use their own funds from firms that favor external private funds. It has an explanatory power of 31%.

Graphs 11 and 12: PCA - Innovation funding[1]



1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

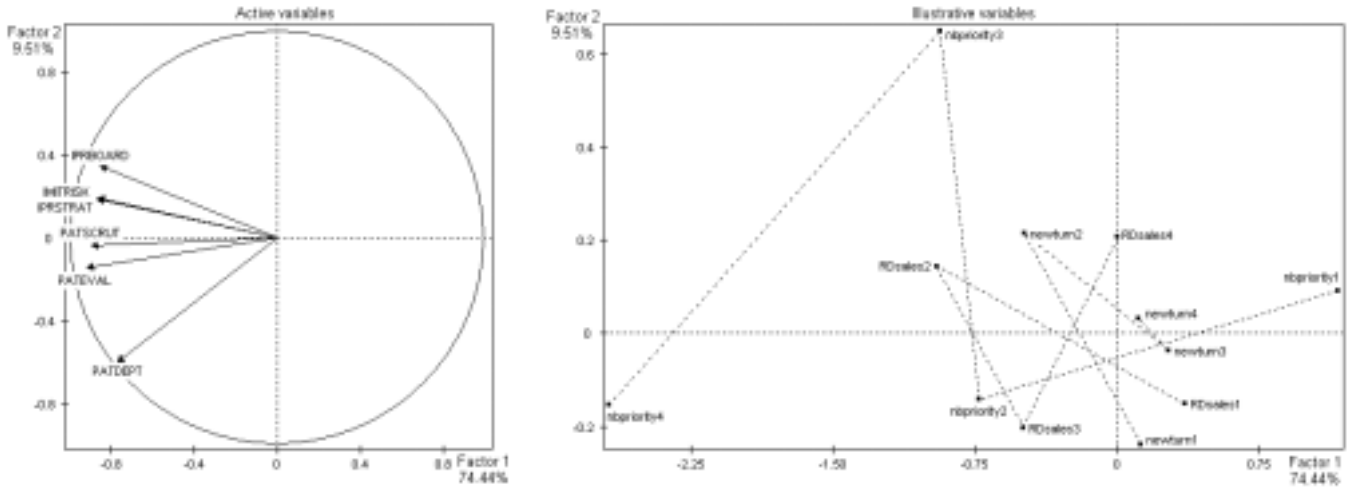
Graph 12 shows that all innovation performance indicators positively relate to the funding sources of firms. It is also interesting to note that these indicators are globally more closely linked to the firms' own profits allocated to innovation (2nd factorial axis, North to South) than to the public subsidies and private external funds (1st factorial axis, East to West). The number of patent applications is the only indicator that is also correlated with the importance of public funds to finance innovation projects. Actually, public funds are traditionally directed towards firms active in R&D and for radical innovation projects. These firms are more likely to develop breakthrough innovations that have a higher probability to be patented than more incremental innovations. The high degree of uncertainty associated with innovative projects reduces the banks propensity to support them financially. This can explain the lack of relation between the private external funds and the firms' innovative performances.

Intellectual property (6 sub-competencies)

A single factorial axis enables to explain 74% of the answers variance concerning IP protection. All six sub-competencies are indeed highly correlated: interest of the board into IPR matters, systematic

integration of the imitation risks, sustaining an active IPR strategy, scrutiny of the competitors' patent applications, evaluation of the patentability of inventions, and patent coordination through a centralized patent department.

Graphs 13 and 14: PCA - Intellectual property[1]



1. The left-hand side graph plots the organizational sub-competencies (active variables) on the plan defined by the first two factorial axes. The right-hand side graph plots the innovation performance indicators (illustrative variables) on the plan defined by the first two factorial axes. Tables with the correlation between all sub-competencies and the factorial axes, and with the percentage of variance explained by each axis are presented in appendix 1. A definition of all sub-competencies variables is provided in appendix 2.

The importance firms give to the protection of their intellectual capital, especially through the recourse to the patent system, is only associated with the number of patent applications, not with the other innovation performance indicators. The development of an IP protection competence is therefore specific to firms active in patenting.

The correlation matrix of the firms' coordinates on the factorial axes representing the broad organizational competencies is provided in table 1. It gives an insight about the relationship between the seven broad competencies: Which of them tend to develop together and which of them evolve independently? The first result to be highlighted is the lack of correlation between the recourse to

scientific information sources and the other innovation competencies. The same applies to both the internal and external innovation funding sources, which are barely correlated with other competencies.

Table 1: Correlation coefficients between the innovation competencies[1]

	Company's culture	Company's organization	Ideas generation	Information sources: commercial	Information sources: scientific	Projects selection	Funding sources: external	Funding sources: internal	IP protection
Company's culture	1	0.67*	0.56*	0.67*	-0.06	0.63*	0.35	0.43	0.46*
Company's organization		1	0.63*	1.00*	0.00	0.55*	0.34	0.25	0.46*
Ideas generation			1	0.63*	-0.08	0.59*	0.35	0.23	0.57*
Commercial information				1	0.00	0.55*	0.34	0.25	0.46*
Scientific information					1	-0.04	-0.17	0.08	-0.22
Projects selection						1	0.43	0.43	0.56*
External funds							1	0.00	0.51*
Internal funds								1	0.28
IP protection									1

1. Correlation coefficient between the firms' coordinates on the main factorial axes of each broad organizational competence.
* indicates the parameters that are significant at a 5% probability threshold.

There is a significant correlation among several organizational competencies: the development of a culture of innovation, the internal mechanisms to generate ideas, the projects selection process and a work organization favorable to innovation. Organizing a company for innovation is a complex issue that requires the coherent development of various capabilities. Moreover, these organizational competencies strongly relate to the recourse to information from commercially related companies (customers, suppliers, competitors). Finally, the firm ability to protect its intellectual property is related to almost all other major innovation competencies. Even if, in terms of innovation performances, IP protection is only related to the firms' patenting performances, it is related to most other innovation competencies. Therefore, it probably acts as a complementary factor important for the firms' global innovation performances. A simple correlation matrix does not allow to infer anything about causality. Nevertheless, it could make sense to think that the protection of IP is an important competence only when other innovation competencies develop in parallel.

In a nutshell

Table 2 summarizes the empirical findings on the link between firms' innovation competencies and performances. It is based on the results of the seven principal component analyzes presented here above.

Table 2 : Synthetic table of empirical results[1]

	Company's culture	*Company's organization*	*Internal ideas generation*	*External commercial information*	*External scientific information*	*Projects selection*	*Innovation funding*	*IP protection*
R&D Intensity	+	0	0	0	0	0	+	0
Patent Applications	+	+	+	0	+	+	+	+
Innovative Sales	+	+	+	0	0	+	+	0

1. The table gives the observed relationships between the 3 innovation performance indicators (in rows) and 7 innovation competence indicators (in columns). 0 = no link; + = positive link.

The competencies related to the culture and funding of innovation are positively linked to all innovation performance indicators. Without internal funding no innovative projects could be achieved. Promoting innovation through explicit corporate values, communicating the strategic goals of innovation to all employees and rewarding their innovative efforts, staying open to new management solutions, paying attention to training, all what makes a company's culture favorable to innovation, has a strategic importance in terms of innovation performances too.

A second relevant result is that there is no relationship between the external sources of information used by firms and their innovation performances, except between the scientific information from universities and research institutes and the number of patent applications. Nevertheless, even if the commercially related information sources are not directly linked to innovation performances, they have an indirect link with the patenting and innovative sales performances, through their positive relationship with other organizational competencies (company's culture and organization, internal mechanisms to generate ideas and projects selection).

Third, the IP protection competence is only linked to the firms' patent applications, not to the R&D intensity, nor to the percentage of sales from new products and processes. However, it has been shown that IP protection is a complementary competence, developed in parallel to other competencies. Therefore, in the long run, we might expect IP protection to play a crucial role since firms unable to appropriate their innovation rents would have less incentives to further invest in knowledge creation.

Finally, there is almost no correlation between the firms' innovation competencies and their R&D performances. Conversely there is a strong link with the output of the innovation process, measured either by the patent applications or by the sales from new products and processes. Actually R&D is only one aspect of innovation. Even if it is of great importance for most firms willing to develop breakthrough technologies, it seems to evolve quite independently from the other competencies.

Concluding Remarks

The main lesson of this empirical analysis is that innovation is not only a matter of R&D and technological capabilities. Several organizational competencies come into play, and translate into improved performances in terms of innovative sales and patent applications. Actually, the innovative effort of firms, proxied by their R&D investment as a share of sales, is barely correlated with their organizational competencies. This means that firms with a large R&D department consider less than others the opportunity to develop other complementary organizational competencies associated with the innovation process. On the other hand, patenting performances and innovative sales are highly correlated with most organizational competencies.

Some organizational competencies are barely related with any of the three innovation performance indicators. This is the case for the use of external information sources and the ability to manage intellectual property. The reverse is true for the development of a culture of innovation and the ability to fund innovation, which are two organizational competencies that are linked to all innovation performance indicators. Other organizational competencies are also correlated to the firms' patent applications and innovative sales. They are the company's working organization favorable to innovative projects, the internal mechanisms implemented to generate ideas and the projects selection process.

Undoubtedly, being at the top for all organizational competencies involved in the innovation process would be the best for firms. Nevertheless, the possibilities for competencies development might be limited, and therefore internal strategic choices have to be made. In this respect, the lessons provided by this study in terms of correlation between the innovation competencies, and between the innovation competencies and performances, might provide some useful tracks to managers.

The present study does not allow to draw strong conclusions about the causality link between organizational competencies and innovation performances. Is it because you are more competent that you innovate more, or is it because you innovate that you develop particular innovation competencies, or both? In order to shed some light on this question, an interesting issue for further research would be the econometric evaluation of the relative importance of the seven major organizational competencies analized here, in determining the evolution of firms' innovation performances.

We also observed that firms' patenting performances are related to all innovation competencies. The IP protection competence is also correlated to most other organizational competencies. It seems that the ability to protect IP, and the number of patent applications, do not develop independently from all other innovation competencies useful to the innovation process. A closer look to the determining factors of the patenting performances would therefore be of interest. This goes beyond the scope of this paper but will be the issue of further research.

References

Adam, M-C and Farber, A. (1994) *Le financement de l'innovation technologique - Théorie économique et expérience européenne*, GESTION, Presses Universitaires de France, Paris, 195p.

Amabile, T.M. and Conti, R. (1997) Environmental Determinants of Work Motivation, Creativity, and Innovation: The Case of R&D Downsizing, in *Technological Innovation - Oversights and Foresights*, Garud R., Nayyar P.R. and Shapira Z. B. (Eds.), Cambridge University Press, 111-125.

Baldwin, J. R., Diverty, B. and Johnson, J. (1995) Success, Innovation, Technology and Human Resources Strategies - An Interactive System, Communication to a *conference on the Affects of Technology and Innovation on Firm Performance and Employment*, Washington, May 1-2, 1995.

Baldwin, J.R. and Johnson, J. (1996) Business strategies in more- and less-innovative firms in Canada, *Research Policy*, 25(5), 785-804.

Bonnet, D.C.L. (1986) Nature of the R&D/Marketing Co-operation in the Design of Technologically Advanced New Industrial Products, *R&D Management*, 16(2), 117-126.

Bounfour, A. (1999) Is Outsourcing of Intangibles a Real Source of Competitive Advantage?, *International Journal of Applied Quality Management*, 2 (2), 127-151.

Cohen, W.M. and Levinthal, D.A. (1990) Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly*, 35, 128-152.

Cooper, R., Edgett, S. and Kleinschmidt, E. (2001) Portfolio management for new products development: results of an industry practices study, *R&D Management*, 31 (4), 361-380.

Crépon B., Duguet E. and Mairesse J. (1998) Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level, *NBER Working Paper*, 6696.

Geroski, P., Machin, S. and Van Renen, J. (1993) The profitability of innovating firms, *RAND Journal of Economics*, 24(2), 198-211.

Grant, R. M. (1991) The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation, *California Management Review* (Spring), 114-135.

Griffin, A. and Hauser, J. R. (1996) Integrating R&D and marketing: a review and analysis of the literature, *The Journal of Product Innovation Management*, 13 (3), 191-215.

Gupta, A.K. and Wilemon, D. (1988) Why R&D Resists Using Marketing Information, *Research Technology Management*, 31(6), 36-46.

Gupta, A.K. and Wilemon, D. (1990) Improving R&D/Marketing relations: R&D's perspective, *R&D Management*, 20(4), 277-290.

Lööf, H. and Heshmati, A. (2002) Knowledge Capital and Performance Heterogeneity: An Innovation Study at Firm Level, *International Journal of Production Economics*, 76, 61-85.

Montoya-Weiss, M. M. and O'Driscoll, T. M. (2000) From Experience: Applying Performance Support Technology in the Fuzzy Front End, *The Journal of Product Innovation Management*, 17 (2), 143-161.

Nemati, H.R., Steiger, D.M., Iyer, L.S. and Herschel, R.T. (2002) Knowledge warehouse: an architectural integration of knowledge management, decision support, artificial intelligence and data warehousing, *Decision Support Systems,* 33 (2), 143-161.

Nonaka, I. (1994) A Dynamic Theory of Organizational Knowledge Creation, *Organization Science*, 5 (1), 14-37.

OECD (1993) *Frascati Manual – Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris, 223p.

Olson, E.M., Walker Jr., O.C., Ruekert, R.W. and Bonner, J.M. (2001) Patterns of Cooperation during New product Development among marketing, operations and R&D: Implications for project performance, *The Journal of Product Innovation management*, 18 (4), 258-271.

Peeters, C. and van Pottelsberghe de la Potterie, B. (2003) Measuring Innovation Competencies andPerformances – A Survey of Large Firms in Belgium, Hitotsubashi University, Institute of Innovation Research, IIR WP, 03-16, September 2003, 23 p.

Pisano, G.F. (1990) The R&D Boundaries of the Firm: An Empirical Analysis, *Administrative Science Quarterly*, 35, 153-176.

Prahalad, C.K. and Hamel, G. (1990) The Core Competence of the Corporation, *Harvard Business Review*, May-June 1990, 79-91.

Ritter, T. and Gemünden, H. G. (2002) The impact of a company's business strategy on its technological competence, network competence and innovation success, *Journal of Business Research*, forthcoming.

Teece, D.J., Pisano, G. and Shuen, A. (1997) Dynamic Capabilities and Strategic Management, *Strategic Management Journal*, 18(7), 509-533.

Tether, B. S. (2002) Who co-operates for innovation, and why - An empirical analysis, *Research Policy*, 31, 947-967.

Tidd, J. and Bodley, K. (2002) The influence of project novelty on the new product development process, *R&D Management*, 32 (2), 127-138.

Tyler, B. B. (2001) The complementarity of cooperative and technological competencies: a resource-based perspective, *Journal of Engineering and Technology Management*, 18, 1-27.

Veugelers, R. (1997) Internal R&D expenditures and external technology sourcing, *Research Policy,* 26(3), 303-315.

Veugelers, R. and Cassiman, B. (1999) Make and Buy in innovation strategies: evidence from Belgian manufacturing firms, *Research Policy*, 28(1), 63-80.

Appendix 1 : Description of the factorial axes

Table A.1. The development of a culture of innovation (10 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
VALUES	-0.75	-0.11	0.13
KNOWMAN	-0.64	-0.05	-0.44
INNOSTRA	-0.73	-0.26	-0.25
INNOCOMMU	-0.72	-0.23	-0.35
INTRAPRE	-0.72	-0.04	0.28
CULTURE	-0.73	-0.38	0.26
INNOREWA	-0.68	0.11	-0.15
INMANSOL	-0.60	0.03	0.61
HIGHTRAIN	-0.63	0.52	-0.02
EXTTRAIN	-0.46	0.77	-0.05
% variance explained	45.22	11.50	9.43

Table A.2. A company's organization favorable to innovation (5 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
TEAMWORK	-0.82	-0.41	0.10
BRAINSTO	-0.78	-0.49	0.00
STAFROT	-0.58	0.28	-0.76
MKTECHEX	-0.61	0.52	0.35
PROJORG	-0.67	0.35	0.21
% variance explained	48.81	17.66	15.25

Table A.3. Internal mechanisms to generate ideas (7 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
RECRUT	-0.65	0.31	0.54
BUDGPLAN	-0.54	0.46	-0.32
OUTRECRU	-0.53	0.56	-0.27
PATENLIT	-0.57	-0.50	-0.23
MKTSURV	-0.72	-0.18	-0.29
CIP	-0.72	-0.38	-0.01
SKILPROF	-0.73	-0.09	0.43
% variance explained	41.54	15.08	11.35

Table A.4. External information and knowledge sources (6 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
CUSTINFO	-0.53	-0.38	-0.04
SUPPINFO	-0.53	-0.54	-0.36
COMPINFO	-0.63	-0.29	0.43
CONSINFO	-0.72	0.29	0.16
UNRIINFO	-0.35	0.75	0.27
GROUPINFO	-0.40	0.49	-0.69
% variance explained	29.22	23.62	14.76

Table A.5. Selection of innovative projects (4 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
ISTRORAGE	0.83	-0.18	0.31
ITCODKNO	0.74	-0.42	-0.53
PSUCESTI	0.84	-0.01	0.31
BARASSES	0.60	0.77	-0.21
% variance explained	57.05	19.99	12.90

Table A.6. Innovation funding (3 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
PROFIFIN	-0.53	-0.80	0.27
PUBFUND	-0.82	0.06	-0.56
PRIVFUND	-0.71	0.54	0.45
% variance explained	48.99	31.28	19.82

Table A.7. Intellectual property (6 sub-competencies)

Variables	Correlation variable - factor		
	Factor 1	Factor 2	Factor 3
IPRSTRAT	-0.87	0.19	0.33
IPRBOARD	-0.85	0.35	0.16
PATDEPT	-0.77	-0.60	0.09
PATEVAL	-0.92	-0.14	0.05
IMITRISK	-0.86	0.19	-0.34
PATSCRUT	-0.90	-0.04	-0.28
% variance explained	74.44	9.51	5.71

Appendix 2 : Description of the active variables

The development of a culture of innovation (10 sub-competencies)

VALUES: Your BU has explicit corporate values which encourage innovation and learning (0 to 5)
KNOWMAN: Your BU has a knowledge management process (0 to 5).
INNOSTRA: Innovation is explicitly introduced in your global strategy (0 to 5).
INNOCOMMU: The strategic goals for innovation are communicated to every employee (0 to 5).
INTRAPRE: Your BU promotes internal entrepreneurship to develop ideas (0 to 5).
CULTURE: The culture in your BU can be characterized as innovative rather than rigid (0 to 5).
INNOREWA : People are explicitly rewarded for improved knowledge or innovation (0 to 5).
INMANSOL : Your organization is open to innovative management solutions (0 to 5).
HIGHTRAIN : Your BU has a training program for highly-skilled professionals (0 to 5).
EXTTRAIN: You allow yourself time for your own external education or training (0 to 5).

A company's organization favorable to innovation (5 sub-competencies)

BRAINSTO: Your BU favors brain storming sessions and/or face-to-face contacts (0 to 5).
MKTECHEX: Your BU favors exchanges between marketing and technology departments (0 to 5).
PROJORG: Your BU is organized around projects and multidisciplinary teams (0 to 5).
STAFROT: Your BU fosters staff rotation (0 to 5).
TEAMWORK : Your BU favors team-work to generate new ideas (0 to 5).

Internal mechanisms to generate ideas (7 sub-competencies)

RECRUT: Your BU's recruiting process brings new skills to your BU (0 to 5).
BUDGPLAN: New ideas/concepts are also generated during the budgeting/planning process (0 to 5).
OUTRECRU: Your BU recruits executives from outside your main business sector (0 to 5).
PATENLIT : Your BU uses patent literature as a source of ideas and information (0 to 5).
MKTSURV: Your BU regularly relies on market surveys and benchmarking practices (0 to 5).
CIP: Your BU intensively uses competitive intelligence processes (0 to 5).
SKILPROF: Your BU successfully manages to attract highly skilled professionals (0 to 5).

External information and knowledge sources (6 sub-competencies)

CUSTINFO: Importance of information from customers (0 to 5).
SUPPINFO: Importance of information from suppliers (0 to 5).
COMPINFO: Importance of information from competitors (0 to 5).
CONSINFO: Importance of information from consultancy firms (0 to 5).

UNRIINFO: Importance of information from universities or research institutes (0 to 5).
GROUPINFO: Importance of information from other companies within the group (0 to 5).

Selection of innovative projects (4 sub-competencies)

ISTORAGE: Your BU stores innovative ideas in a systematic way (0 to 5).
ITCODKNO: Your BU has an IT-based Intranet system for codifying knowledge (0 to 5).
PSUCESTI: Your BU formally estimates the probability of success of an innovative project (0 to 5).
BARASSES: Your BU assesses the potential barriers to innovation beforehand (0 to 5).

Innovation funding (3 sub-competencies)

PROFIFIN: An important part of your BU's profits is used to finance innovation projects (0 to 5).
PUBFUND: Your BU uses public external funding sources for research (0 to 5).
PRIVFUND: Your BU uses private external funding sources for research (0 to 5).

Intellectual property (6 sub-competencies)

IPRSTRAT: Your BU has an active IPR strategy (0 to 5).
IPRBOARD: Questions about IP are regularly discussed by your BU's top management (0 to 5).
PATDEPT: Your company has a centralized patent department (0 to 5).
PATEVAL: Your BU has an evaluation process for the patenting of its inventions (0 to 5).
IMITRISK: Your BU systematically integrates the risk of imitation of its inventions (0 to 5).
PATSCRUT: Your BU regularly scrutinizes patent applications made by competitors (0 to 5).