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Scientific and technological density of regions : the impact on firms' competence to innovate

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Abstract

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The purpose of the paper is to present possible approaches of the innovative potential of the regions, with an empirical application concerning the relation between characteristics of regions (scientific and technological density) and the firm's competencies. Regions, which are territories with specific institutional and techno-economic characteristics, will be considered here as significant contexts for innovation processes.

By using the word "context", we want to underline the importance of regional characteristics, even in a globalised economy, but we are reluctant to speak of regional "system" without carefully analysing the possible meaning of such a notion. RIS is a useful concept if it one stresses its cognitive content – a way of interacting that leads to specific competence to innovate – but can be misleading if understood as an ex ante given network of actors and infrastructures.

An important characterisation of territorial specificity in evolutionary terms is the cognitive potential of actors. For instance, firms' capabilities vary to a large extent following the type of innovation under consideration : outcome of science-based R&D, particular competitiveness in marketing innovative products, incremental improvements through learning by using (N. Rosenberg) or other sort of learning by interacting (B-A. Lundvall). To give an empirical example, we will use the results of a survey of the French industry focusing on the innovative competence of the firms. We have developed an econometric model for testing the influence of the regional scientific and technological context on the nature of the "competence to innovate" declared by the firms in the inquiry. This study is an opportunity to cast light on the concept of critical interfaces evoked by K. Pavitt (1998), by underlining several schemes of industrial development according to specific characteristics of industries and regions. Designing differentiated regional policies on the basis of such an analysis seems to be possible.

INTRODUCTION

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economic characteristics, will be considered here as significant contexts for innovation processes.

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1. From economics of technological change to regional convergence

The first models in the literature on technical change referred to the knowledge production function formalised by Z. Griliches [1979]. Many empirical works confirmed this model by underlining the links between the inputs of knowledge and the outputs of innovation. These links were also tested at the level of industry [D.B. Audretsch, 1995], highlighting the role of externalities of knowledge. The question of geographical proximity was then essential to explain the spillovers [Jaffe, Trajtenberg & Henderson, 1993] because of the particular nature of knowledge which requires

sometimes interactions of a "face to face" type to be transmitted [von Hippel, 1994]. Several works [Jaffe, 1989; Feldman, 1994; Audretsch & Feldman, 1996] confirm the role of geographical proximity in the transmission of knowledge, in particular in industries where knowledge plays an important role [Audretsch & Feldman, 1996], such as biotechnologies [Prevenzer, 1997].

There is an apparent paradox in the new knowledge-based economy: to a certain extent, the trend of de-materialisation and the development of the techniques of communication should help the creative networks to get rid of distance; but at the same time it appears that complex cognitive processes need not only large flows of codified scientific and technical information, but also a lot of tacit knowledge for using and interfacing that information. Then proximity does matter, since building common tacit knowledge implies close contacts, at least at the beginning.

A logical implication of the preceding remarks is the increased importance of agglomeration effects linked to these externalities of knowledge. One cannot assume the possibility of duplication of strong innovation areas among many regions. The model of specialised regions (districts), each one having a specific advantage in some technology, is unfortunately no more acceptable, because innovation increasingly depends on a whole variety of knowledge, on interdisciplinary approaches, and requires a multiplicity of actors in the same big technological pole. The number of core-regions in the world is then probably limited and they will often compete one with another on similar fields. What will happen with the other regions? It is clear that different modes of development must be considered. The typology of regions, contrasting champions of high tech and science-based industries on one side and regions devoted to more classical production, more incremental innovation, etc. on the other side, does not necessarily lead to less "convergence". We must recognise the existence of differentiated patterns of development.

2. The characterisation of regional competence to innovate

Ihe non-linear (interactive) model of innovation developed by the evolutionists (following the seminal contributions of Nathan Rosenberg and publications like Dosi et al. [1988]), then enriched by the new approach of the knowledge creation (Argyris,

Schön, [1978], Nonaka [1994], Gibbons et al. [1997], Cowan, David, Foray [2000], etc.) and the approach of the learning economy (Lundvall, Johnson [1994]) shows the crucial role of scientific knowledge and general culture at every stage of the chain leading to innovation. It is not sure that the design of policies has completely taken into consideration that vision - no more than the current indicators of innovation and the methodology of evaluation, by the way[1].

The traditional indicators of innovation are not robust, and they cannot reflect the true nature of innovation. It is then necessary to complete the evaluation of the regional innovative potential with qualitative data. This is a crucial question because if more relevant observation of the innovative capacities of a region is not integrated in the analysis, it is not possible to design appropriate policies. One possible complement is qualitative information about the competencies of agents. Such data, particularly at the firmís level, could cast light on individual and collective learning capabilities located in the region, and therefore help the assessment of innovation policies in their very context, the regional system of innovation. Inside a RIS we can observe in particular interaction of firms and research institutions, each type of actors being characterised by specific competencies and capacities of interaction.

The French statistical framework has recently evolved, from our point of view, in the right direction, by issuing a new survey that focuses on innovative competencies in the industry. After presenting the database, we expose below our methodology (crossing this information about firmsí competencies with a typology of regions in terms of scientific production) and we precise the statistical model we want to test.

2.1 Presentation of the database

The database we will use in this empirical part results from an investigation carried out by the SESSI (a research department of the French Ministry of Industry) during the year 1997. The sample consists of 5000 industrial companies settled in France, with more than 20 employees. The response rate was 83% in number of units and over 95% in terms of turnover. To use the SESSI terminology, the firms answered a questionnaire

[1] Many evaluations, while speaking of the new concept of the innovation process, are still based on traditional measurements of innovation [Nauwelaers, Reid, 1995]

concerning their "possession of competencies" classified in a list of 73 items. These elementary competencies are aggregated into 9 complex competencies. The whole set is supposed to mirror the total competence of the company.

The competencies are measured at the level of the firm (the individual competencies are not considered). The question is to know if a firm has or does not have a given competence in relation to the process of innovation. The investigation assumes a relation between competencies and innovation and evaluates to what extent the firms are qualified to innovate.

Despite the richness of the database, criticism can be formulated on at least three points. First, the investigation does not make it possible to know if the questioned firms consider that a given competence is truly necessary, in its own case or more generally, to develop an innovation. Secondly, certain competencies are not specific to innovation. It is then difficult to determine the objectives for which the firms developed these competencies. In a general way, the question of the sources of competencies is not treated besides; only the possession of a repertory of competencies at a given time is required. Thirdly, insofar as the answers are binary (the questions relate only to the declared competence, without any reference to the position of the company as compared to its competitors), a direct comparison between two firms, having both a given competence proves to be difficult. One solution was to ask questions about the ì†possessed†î competence by introducing degrees such as "distinctive competence", "very good competence", "good competence", etc. The important assumption here is that the degree of pure subjectivity in the firmís response is not too large. Despite these limits, due to the qualitative and ì†declarative†î nature of the survey, the database remains quite valuable thanks to the fine information it gives about the various innovative facets of the firms.

The next section is devoted to a statistical analysis of the competencies according to the regional location of the firms.

2.2 Competence to innovate: methodology

We propose to examine the *innovative competence* of the French firms (by types of competence) according to two types of regions defined in terms of *scientific density* and *technological density*. The idea is to make a link between the relevant characteristics of the firms and of the research infrastructure in each region. The density is regionally

measured through the ratio scientific (publications/GDP) and technological density (patents/GDP). We refer to the typology of the regions proposed by OST (Observatoire des Sciences et Techniques, Paris) within the framework of the TSER programme [OST, 1998]. Our ranking is the following: regions with a strong scientific density (or technological) have a index higher than 200; regions of medium density (or technological) are those in the interval [15-200]; and the regions of low density (or technological) have a index lower than 15. The base of index is 100 for the average level of Europe.

To examine innovative competence, we propose an aggregation into to four categories: "organisational", "relational", "technical" competencies and those relating to the "means" for innovation (cf. Appendix 1 for a complete presentation of these categories).

- The first category includes elementary types of competence supporting the creation of new knowledge, notably related to the human capital, or concerning innovation as a transverse process inside the firm. All these types of competence correspond to organisational qualities of the firm (in the sense that they characterise the quality of the organisation, but not necessarily in relation with organisational innovation).
- The category of relational competence encompasses elementary types applying on the markets (relationships with the competing environment or the demand side) and various capacities to cooperate, to form alliances and to adopt/adapt external technologies.
- Technical competence corresponds to the capacity of managing in-house production and mastering own technologies.
- Competence in terms of "means" for innovation enables the firm to carry out R&D, to finance and/or sell innovation. Such capabilities mobilise the general means of the firm to develop an innovation and express its capacity to support the important costs which result from it (costs of innovation other than R&D expenses are sometimes relatively important).

Concretely, we build aggregates of types of competence to define these broad types. We consider that the firm has a competence if it possesses at least the number of elementary types of competence corresponding to the mediane of the whole population of the sample. For the competence "Transverse dimension of the innovation", we consider that the firm must at least have either the individual competence "Structuring the company around innovative projects", or the individual competence "Implication of all the services from the earliest phase of innovation".

It should be noted that to take into account the sectoral effects we refer to nomenclature NAF 36 of the industrial sectors except energy (cf Appendix 2).
For the aim of our study we have sorted the numerous elementary types of competence considered by the survey in nine clusters, defined in Appendix 1 and referred to with the names of the econometric variables listed in Appendix 3. These clusters are the following:

Table 1: Cluster of competences

"creation"	knowledge creation	Cat1: organisational type of competence
"organis"	organising the innovation	Cat1: organisational type of competence
"identif"	identification of knowledge	Cat1: organisational type of competence
"market"	market knowledge	Cat2: relational type of competence
"partners"	cooperation with institutions and other firms	Cat2: relational type of competence
"technic"	technical competence	Cat3: technical type of competence
"R&D"	R&D competence	Cat 4: means for innovation
"finance"	financing innovation	Cat 4: means for innovation
"selling"	selling innovation	Cat 4: means for innovation

2.3 The model

The model we propose aims at estimating the probability that a firm possesses a competence according to the type of region (regarding the criteria of scientific and technological density).

The variable $Comp_i$ represents a competence such as:

$$Comp_i = \beta_1 Tech + \beta_2 Scien + \varepsilon$$

We use a multiple regression to analyse the comparative influence of scientific and technological densities on the probability of having a competence of the i type.

All variables are quantitative. For the competence, we consider the sum of elementary types of competence. For the density, we directly apply the statistical index given by OST.

For an easier interpretation of the econometric results, we calculate the elasticity for each coefficient (see Appendix).

3. Econometric results

An interesting result of our empirical analysis relates to the inter-industrial differences. Aggregating all types of competence, one observes very important sectoral disparities with four types of profiles:

* The industries that are "based on science" according to the taxonomy of Pavitt (1984). They are those for which the scientific density is a major explanatory variable of the localization of competences, whatever the type of competence considered.

* The industries "based on technology", *i.e.* those for which it is more the technological density which plays a key role in the strategies of localisation.

* "Mixed" industries which have results differentiated according to the type of competence considered.

* "Neutral" industries, for which neither the scientific density nor the technological density apparently explains the localisation of competent firms.

3. 1 The "science based" industries

According to the analysis of Klevorick et al. (1995), which reinforces the pioneering work of PAVITT (1984) in identifying the science based sectors, industries related to chemistry and electronics are those which profit from important sources of opportunity, in particular of strong externalities related to public research. Our observations confirm also the phenomenon: the regional scientific intensity is a major explanatory variable of the detention of competence for 7 types of competence (on the 9 studied) in the field of chemistry and 8 types of competences in the field of electronic components. Moreover, elasticities are high (often higher than 10, reaching even respectively 29,04 and 26,17) when one takes into account competence related to the capacities of the firms to develop

co-operations with other companies and / or with public institutions. The specific close relationship between universities and science-based industries is clearly confirmed.
In a rather counter-intuitive way, the electrical engineering and electronic activities do not belong to this first cluster. But we should probably distinguish between components production and components assembly.

On the other hand, our analysis exhibits two science based sectors which until now were never identified as such, namely: the Automobile sector and that of Household appliances. Each one of these industries presents indeed 7 types of competence whose localisation is significantly influenced by the regional scientific density. The automobile sector presents even the highest degree of elasticity as regards institutional types of competence (38,6).
Curiously, except the production of Household appliances whose competence localisation of is also related to the technological intensity (6 significant effects out of the 11 studied types of competence), none of the industries which we identified as being based on science presents significant link with the regional technological intensity. As it is known that parachemical and pharmaceutical industries proceed much by the search for chemical analogues (search for minor modifications of the molecular structure of already known and often patented active principles), one can wonder why such technological impact is missing. More precisely this result raises the problem, in terms of diffusion of the skills, the relation between type of knowledge and geographical proximity.

A last point interesting to underline relates to the relational types competence. One observes significant results and high elasticities related to the areas of strong scientific density. Nevertheless, such a result, intuitive for "organisational" capabilities (which are dominating upstream innovative processes), is more surprising to observe for "relational" capabilities (downstream the same process), in particular those related to selling. Taking into account the relation suppliers/demand finds then a plausible explanation. Indeed, one can suppose that the markets of the "science based" products are more often located in areas of strong scientific intensity.

3.2. The industries "based on technology"

Only two sectors present a competence set whose localisation is significantly influenced by the regional technological density: Printing and publishing, and Household appliances (already related to the scientific density). In these two cases, one primarily observes organisational competence (understanding "new knowledge" and capability of "identification and evaluation of the individual and collective knowledge "), technical competence and capabilities in the field of "means to innovate" (financing the innovation and selling innovative products). Relational competence do not present significant impact. Let us note in addition that, compared to the science-based industries, elasticities are here in general much lower (from 0,92 to 7,62).

Such a result (weak impact of the regional technological density on the localisation of firms' competence) seems a priori relatively surprising, more especially as the sectors considered are not those where traditionally the firms are known strongly rely on patents to develop their strategies. As we already underlined, that raises the question of the intrinsic nature of the local knowledge spillovers.

Lastly, let us note that the activities of metal working have technological elasticities significantly negative with regard to R&D competence as well as "market" and "institutional" competence.

3.3. "Mixed" industries

Five industries present a mixed profile, i.e. the geographical localisation of competence according to the scientific and / or technological density is strongly dependent on the *type* of competence. These industries are: Clothing and leather products, Electric and electronic components, Textile, Mechanical appliances and pharmaceutical/parapharmaceutical (perfumery) industries.

In the first industry, only "selling" and "market" competence present significant link with the regional scientific and technological densities. In the second industry, the regional scientific density influences only competence related to "the identification and the evaluation of the individual and collective knowledge ". Concerning the third industry, only the technical skills depend on the regional scientific density. In

comparison with the results underlined in mechanical equipment, it is interesting to note that the scientific density exerts an influence on the localisation of the whole set of competence except those which seem most dependent with the process of creation of the innovation: organisational competence. Lastly, the link university/industry is typically found in pharmaceutical and parapharmaceutical industries since elasticities related to the scientific density are strong but for 3 types of competence only: competence related to the financing of the R&D (16,95), "selling" competence (13,89), and, of course, "institutional" competence (27,99).

For these five industries, it seems that the geographical localiation of the other types of competence is independent from the scientific and/or technological regional density. These industries thus adopt strategies of localisation differentiated according to the centers of competences considered.

3.4. "Neutral" industries

They are four, namely: shipbuilding, aeronautics and railways; mineral products; wood and paper; metal working. In each case, neither the regional scientific density, nor the technological density influences the firms' competence. This is true whatever the type of competence considered. These two elements seem to be absolutely not determining in the strategies of localisations of the firm.

4. Short conclusions

(a) The geographical localisation of competences generally appears dependent on the regional scientific density. We can stress the importance of the public research externalities for all types of competence when aggregating the sectors.

(b) The influence of technological density is weak concerning the localisation of competence. Only two sectors present significant statistical link.

(c) The results are highly significant in science based sectors, for the majority of the types of competence. In these industries, "competent" firms are clearly localised in areas of high scientific potential. Furthermore, the typers of competence are not restricted to the development of innovation, but concern its diffusion as well, probably because of the proximity of the applicant firms (also concentrated in "scientific" areas)

(d) In other cases than the science-based industries, the results are contrasted: dependent on the precise type of competence.

References

Audretsch, D. [1995], *Innovation and Industry Evolution*, Cambridge, MA : MIT Press.

Audretsch, D. & Feldman, M. [1996], "R&D spillovers and the Geography of Innovation and Production", *American Economic Review*, 86 (4), pp. 253-273.

Audretsch, D & Feldman, M. [1996], "Company-Scientist Locational Links : The Case of Biotechnology", *American Economic Review*, 86 (4), pp. 641-652.

Audretsch, D. [1999], "Knowledge Spillovers and The Role of Small Firms", International Conference *Knowledge Spillovers and the Geography of Innovation : A Comparison of National Systems of Innovation*, Université Jean Monnet, Saint-Etienne, July 1-2.

Carrincazeaux, C. Lung, Y. Rallet, A. [1999], "Proximity and Location of Corporate R&D Activities" International Conference, *Knowledge Spillovers and the Geography of Innovation : A Comparison of National Systems of Innovation*, Université Jean Monnet, Saint-Etienne, July 1-2.Saint-Etienne, July 1-2.

Cohen W.M. & S. Klepper [1996], "A Reprise of Size and R&D", *Economic Journal*, 106, pp. 925-951.

Cohen W.M. & R.C. Levin [1989], "Empirical Studies of Innovation and Market Structure", in Schmalensee R. & R. Willig (eds.), *Handbook of Industrial Organization*, Vol II, North-Holland, Amsterdam.

Cohen, W. M., Levinthal, D. [1989], "Innovation and learning: the two faces of R&D", *The Economic Journal*, 99, pp. 569-596.

Fransman, M. & S. Tanaka [1995], "Government, globalisation, and universities in Japanese biotechnology?" *Research Policy*, 24 (1), pp. 13-49.

Garvin, D. A., [1983], "Building a Learning Organisation", *Harvard Business Review*, pp. 78-91.

Gemünden, H. G, P. Heydebreck & Herden R. [1992], "Technological interweavement - a means of achieving innovation success" , *R&D Management*, 22, pp. 359-376.

Gemünden, H. G & P. Heydebreck [1995], "The influence of business strategies on technological network activities" *Research Policy*, 24 (6), pp. 831-849.

Griliches, Z. [1979], "Issues in Assessing the Contribution of R&D to Productivity Growth", *Bell Journal of Economics*, 10, pp. 92-116.

Héraud J.A. [1995], "Brevets et contexte institutionnel de la création technologique", in *Changement institutionnel et changement technologique*, M. Baslé, D. Dufourt, J.-A. Héraud & J. Perrin (eds.) CNRS Editions, Paris

Jaffe, A. B. [1986], "Technological opportunity and spillovers of R&D : Evidence from firms' patents, profits, and market value", *American Economic Review*, 76 (5), pp. 984-1001.

Jaffe, A. B. [1989], "Real effects of Academic Research", *American Economic Review*, 79 (5), pp. 957-970.

Jaffe, A. B., Trajtenberg, M. & R. Henderson [1993], "Geographic localization of knowledge spillovers as evidenced by patent citations", *Quarterly Journal of Economics*, 63, (3), pp. 957-970.

Kleinknecht A. & B. Verspagen [1989], "R&D and Market Structure : The Impact of Measurement and Aggregation Problems", *Small Business Economics*, 1, pp. 297-301

Klevorick, A. K, Levin, R. C, Nelson, R. R & S.G. Winter [1995], "On the source and significance of interindustry differences in technological opportunities", *Research Policy*, 24 (2), pp. 185-205.

Lundvall B.A. [1992], *National Systems of Innovation : An Analytical Framework*. London Pinter.

Mansfield E. [1981], "Composition of R and D Expenditures : Relationship to Size of Firm, Concentration, and Innovation Output", *The Review of Economics and Statistics*, n°63, pp. 610-615.

Nauwelaers C. & A. Reid [1995], *Innovative Regions? A comparative Review ofMethdological Evaluating Regional Innovation Potential*, RIDER Report (Interdisciplinary Research on Regional Development), European Commission DG XIII.

OST [1998] The dynamics of S&T Activities in the EU Regions, Rapport d'activité OST.

Pavitt K. [1982], "R&D, Patenting and Innovative Activities : A Statistical Exploration" *Research Policy*, Vol 11

Pavitt K. [1984], "Patterns of Technology Change : Towards a Taxonomy and Theory", Research Policy, 13, pp. 343-373

Pavitt K. [1998], "Technologies, Products & Organisation in the Innovating What Adam Smith Tells us and Joseph Schumpeter Doesn't ? *Industrial and Corporate Change* Vol. No 3

Pavitt K., M. Robson & J. Townsend [1987], "The Size Distribution of Innovating Firms in the United Kingdom : 1945-1983", *Journal of Industrial Economics*, Vol 35, pp. 297-316

Prevenzer, M. [1997], "The Dynamics of Industrial Clustering in Biotechnology", *Small Business Economics*, 9 (3), pp. 255-271.

Von Hippel, E. [1994], "Sticky Information and the Locus of Problem Solving : Implications for Innovation", *Management Science*, 40, pp. 429-439.

APPENDIX 1: CLUSTERS OF ELEMENTARY COMPETENCIES

Category 1: "organisational" competencies

Elementary competencies	Variable
Inventory of competencies of the company	comp106
Global vision of the company for each employee	comp107
Structuring of the company around innovative projects	comp301
Implication of all the services from the earliest phase of innovation	comp302
Joint work to innovate	comp304
Mobility between the services	comp305
Incentives to formulate new ideas	comp401
Autonomy of the individuals to innovate	comp402
Valorisation of the originality and the creativity of the individuals	comp403
Acceptance of creative behaviours that are not directly productive	comp404
Rewarding the original ideas that have been selected	comp405
Justifying the rejections	comp406
Pooling of knowledge	comp407
Comparative evaluation of the collective production of knowledge (*vs* competitors)	comp408
Evaluation of the contribution of each one to the production of the knowledge	comp409
Identification of the knowledge and strategic know-how	comp607
Identification of the persons holding strategic know-how	comp608
Making personnel aware of the strategic and confidential character of knowledge	comp609
Control over communication of strategic knowledge	comp610
Motivation of the persons holding the strategic knowledge	comp611
Localising the current and future specialists	comp701
Evaluation of the propensity to innovate during the recruitment procedure	comp702
Evaluation of the capacity to work in team during the recruitment procedure	comp703
Transparency of the evaluation for everybody and reward of the best	comp704
Transparency of the mobility rules	comp705
Assessment of the needs in training programmes (all personnel)	comp706
Making everybody aware of the need of adapted training	comp707
Evaluation of the impact of training on the innovation process	comp709

Reward for useful training	comp710

Clusters of "organisational" competencies are proposed on the basis of this list of individual competencies. Three clusters are considered: competencies supporting the creation of new knowledge by stressing the importance of the interactions between the individuals and of their autonomy (called creative competencies " of new knowledge ": comp304, comp305, comp401, comp402, comp403, comp404, comp405, comp407, comp611, comp704, comp705, comp710); competencies which support the transverse dimension of the innovation (called competencies for organising innovation: comp107, comp301, comp302)) and competencies of identification and evaluation of the individual and collective knowledge (comp106, comp408, comp409, comp607, comp680, comp701, comp702, comp706, comp709).

Category 2: "relational" competencies

Elementary competencies	Variable
Analysing competing products	comp201
Analysing patents of the competitors	comp202
Analysing publications of the competitors' engineers	comp203
Analysing the nature (segmentation) and the needs of the customers	comp204
Collecting customers reactions at after-sales services or retailers	comp205
Using the product as a source of information about the customers satisfaction	comp206
Testing the ultimate consumer	comp207
Identifying new behaviours and pioneering consumers	comp208
Knowing competitors technologies	comp501
R&D alliances with other companies	comp506
R&D partnerships with public organisations	comp507
Joint-ventures, various strategic alliances and forms of cooperation	comp511

For the "relational" competencies, we distinguish those concerning the market and the comparisons with competitors (comp201, comp202, comp203, comp204, comp205, comp206, comp207, comp208, comp501) and those concerning the capacity to co-operate with public organisms or institutions (comp506, comp507, comp511).

Category 3: "technical" competencies

Elementary competencies	Variable

Effectiveness and quality control of the production	comp101
Technological evaluation of the products which the company is likely to produce	comp102
Evaluation of the processes the company is likely to adopt	comp103
Evaluation of the organisations the company is likely to adopt	comp104
Performing a technological assessment of the company	comp105
Test of innovating products and processes in their operational context	comp303
Analysing flaws and breakdowns of the new processes	comp306
Fast adoption of the technologically new equipment	comp307
Fast adoption of the technologically new supplies	comp308
Technology survey	comp502
Test of external technologies	comp503
Subcontractor of highly technological components	comp512
Absorption capacities of the knowledge incorporated in the innovating equipment and components	comp513

Category 4: competencies concerning the" means" for innovation

Elementary competencies	Variable
R&D	comp504
Subcontracting or acquisition of R&D	comp505
Using external inventions (patents, licences)	comp508
Recruitment of employees of high scientific qualification to innovate	comp509
Partial or total purchase of companies (motivated by innovation)	comp510
Anticipation of the whole set of the costs of innovation	comp801
Ex post evaluation of the cost of old innovations	comp802
Knowing the private and public modes of financing innovation	comp803
Communication strategy towards potential financial partners of innovation	comp804
Special offers for new product s	comp901
Determination of the target, the media, and the type of message for advertising new products	comp902
Company 's innovation image	comp903

We distinguish three clusters of competencies expressing the capacities of the company to supply the "means" for the innovation. R&D competencies explicitly refer to the capacities of the company to carry out R&D, to use external inventions, to sub-contract or acquire R&D and to hire highly qualified personnel (respectively, competencies comp504, comp508, comp505, comp509). Financing innovation supposes the capacity

to evaluate/anticipate the costs of innovation, to know the modes of financing, to find financial partners and to buy companies for the sake of innovation (respectively competencies comp801, comp802, comp803, comp804 and comp510). Selling innovation means the capacity to market, make the promotion and diffuse its innovation (comp901, comp902, comp903).

APPENDIX 2: FRENCH NOMENCLATURE OF ACTIVITIES (NAF36)

C1	Clothing, leather
C2	Printing, publishing, reproduction
C3	Pharmacy, cosmetics
C4	Household appliances
D0	Car industry
E1	Shipbuilding, aeronautics and railway s building
E2	Mechanical equipment
E3	Electric and electronic equipment
F1	Mineral products
F2	Textile industry
F3	Wood and paper industries
F4	Chemical industry and plastics
F5	Metallurgy and metal working
F6	Electric and electronic components

APPENDIX 3: ECONOMETRIC RESULTS

TABLE 1: ALL SECTORS

Ind. Var	**Dep. Var**			
Competence	**Density**	**BETA**	**t-student**	**elasticity**
Organisation	techno	0,0264926	1,6266820	0,9598193
	science	0,0477765	2,9335394	3,4281817
Identification	techno	0,0066185	0,4065895	0,0937313
	science	0,0603516	3,7075053	1,6927606
Creation	techno	0,0167652	1,0293564	0,1416405
	science	0,0495842	3,0443808	0,829671
Technic	techno	0,0052866	0,3246693	0,0418483
	science	0,0550518	3,3809304	0,8630948
R&D	techno	-0,013138	-0,809458	-0,525523
	science	0,0932365	5,7441983	7,3860498
Finance	techno	0,0058968	0,3620384	0,1895205
	science	0,0491637	3,0184005	3,1294183
Selling	techno	-0,011349	-0,697761	-0,515534
	science	0,0686587	4,2211109	6,1767779
Market	techno	-0,023863	-1,469919	-0,358411
	science	0,0872530	5,3744845	2,5954365
Partners	techno	0,0005936	0,0366203	0,0408021
	science	0,1084140	6,6875681	14,757508

TABLE 2: CLOTHING, LEATHER

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,0652007	0,9716756	2,3621955
	science	0,0942544	1,404659	6,7631732
Identification	techno	-0,081689	-1,218209	-1,1568673
	science	0,0096381	0,1437311	0,2703319
Creation	techno	0,0178233	0,2655406	0,1505790
	science	0,0841686	1,2539896	1,4083562
Technic	techno	0,023125	0,3437885	0,1830557
	science	-0,020011	-0,297497	-0,3137373
R&D	techno	-0,013467	-0,200075	-0,5386424
	science	-5,7E-05	-0,000847	-0,0045185
Finance	techno	0,0250255	0,3718962	0,8042964
	science	-0,001394	-0,020715	-0,0887307
Selling	techno	0,1191453	1,795769	5,4120012
	science	0,2028221	3,0569527	18,246569
Market	techno	0,025475	0,3843312	0,3826126
	science	0,1871141	2,8229123	5,5659098
Partners	techno	0,0019027	0,0282688	0,1307720
	science	-0,012569	-0,186733	-1,7108548

TABLE 3: PRINTING, PUBLISHING, REPRODUCTION

Ind. Var	**Dep. Var**			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,1740879	2,8559732	6,3071405
	science	-0,013694	-0,22466	-0,982627
Identification	techno	0,1044356	1,6948508	1,4790068
	science	0,0115394	0,1872683	0,3236592
Creation	techno	0,1377691	2,2484295	1,1639359
	science	-0,027104	-0,442346	-0,453520
Technic	techno	0,1171083	1,9177966	0,9270196
	science	-0,095244	-1,559735	-1,493214
R&D	techno	0,0483275	0,7812317	1,9330162
	science	-0,010392	-0,167986	-0,823214
Finance	techno	0,1153088	1,8767649	3,7059202
	science	-0,032705	-0,532304	-2,081761
Selling	techno	0,0504086	0,8147529	2,2897349
	science	0,0100448	0,1623539	0,9036641
Market	techno	0,0228127	0,3688147	0,3426267
	science	-0,043553	-0,704129	-1,295538
Partners	techno	0,0920015	1,4911863	6,3232034
	science	0,0230853	0,374173	3,1424091

TABLE 4: PHARMACY, COSMETICS

Ind. Var	**Dep. Var**			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,0413675	0,4737669	1,4987273
	science	0,089723	1,0275658	6,4380246
Identification	techno	-0,004211	-0,048017	-0,059634
	science	-0,021523	-0,245432	-0,603692
Creation	techno	-0,08605	-0,987339	-0,726989
	science	0,0661319	0,7587971	1,1065548
Technic	techno	-0,007993	-0,091502	-0,063269
	science	0,090237	1,0330516	1,4147207
R&D	techno	0,012754	0,1488256	0,5101368
	science	0,2140565	2,4978153	16,957210
Finance	techno	0,0466945	0,5336423	1,5007200
	science	0,0563427	0,6439057	3,5863832
Selling	techno	-0,029729	-0,343338	-1,350395
	science	0,1544581	1,7838253	13,895578
Market	techno	-0,088524	-1,015562	-1,329546
	science	0,0607492	0,696928	1,8070500
Partners	techno	-0,126547	-1,490342	-8,697477
	science	0,2056734	2,4222165	27,996614

TABLE 5: HOUSEHOLD APPLIANCES

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,1060246	1,6344765	3,841232289
	science	0,1013547	1,5624843	7,272648566
Identification	techno	0,1598109	2,492496	2,263225131
	science	0,1657559	2,5852182	4,649171345
Creation	techno	0,11912	1,8433933	1,006379931
	science	0,1330034	2,0582392	2,225485948
Technic	techno	0,1572039	2,4382475	1,24441276
	science	0,1121341	1,7392106	1,758020325
R&D	techno	0,0747267	1,1583815	2,988935213
	science	0,166499	2,5809983	13,18978314
Finance	techno	0,2186772	3,4344127	7,028086555
	science	0,1472927	2,3132908	9,375618159
Selling	techno	0,1679155	2,6272539	7,627316177
	science	0,1823255	2,8527164	16,40262528
Market	techno	0,1469702	2,2728579	2,207363517
	science	0,0834453	1,2904616	2,482170992
Partners	techno	0,0432994	0,6680188	2,975938395
	science	0,1357325	2,0940687	18,47613989

TABLE 6: CAR INDUSTRY

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	-0,007047	-0,078352	-0,255294522
	science	0,0758226	0,843085	5,440611899
Identification	techno	0,1017687	1,1518967	1,441238387
	science	0,1878371	2,1260847	5,26851103
Creation	techno	-0,027233	-0,307904	-0,230080179
	science	0,1909092	2,1584385	3,194398735
Technic	techno	0,0419248	0,4744373	0,331873259
	science	0,201784	2,2834655	3,163537379
R&D	techno	0,0817255	0,9306855	3,268875476
	science	0,2244556	2,556089	17,78101139
Finance	techno	0,0215669	0,2424998	0,693141831
	science	0,1684369	1,8939135	10,72151059
Selling	techno	-0,04559	-0,506021	-2,070872386
	science	-0,024185	-0,268435	-2,175745182
Market	techno	-0,011378	-0,128168	-0,170891391
	science	0,1753205	1,9748597	5,215097307
Partners	techno	0,0488912	0,5648534	3,360259303
	science	0,2836171	3,2767087	38,60645713

TABLE 7: SHIPBULDING, AERONOTICS AND RAILWAYS BUILDING

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	-0,199545	-1,638473	-7,229432848
	science	-0,057689	-0,473685	-4,13942331
Identification	techno	-0,012863	-0,103994	-0,182162603
	science	0,0575211	0,4650464	1,613367984
Creation	techno	-0,145262	-1,185444	-1,227239697
	science	0,0113622	0,0927239	0,190118931
Technic	techno	-0,097971	-0,795144	-0,775529065
	science	-0,096147	-0,780341	-1,507376777
R&D	techno	-0,019552	-0,158243	-0,782045238
	science	0,0689534	0,5580695	5,46237414
Finance	techno	0,048152	0,3911895	1,54756287
	science	0,1261622	1,0249482	8,030601613
Selling	techno	-0,12104	-0,984583	-5,498066762
	science	-0,105707	-0,859862	-9,509797892
Market	techno	-0,009624	-0,077665	-0,144540967
	science	-0,021477	-0,173325	-0,638869714
Partners	techno	0,0012546	0,0102156	0,086224669
	science	0,1352929	1,1016664	18,41630939

TABLE 8: MECHANICAL EQUIPMENT

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	-0,007965	-0,192924	-0,288554184
	science	0,0641192	1,553142	4,60084152
Identification	techno	0,0169655	0,410185	0,240263892
	science	0,0148047	0,3579428	0,415247806
Creation	techno	0,0183003	0,4435956	0,154609032
	science	0,0733228	1,7773315	1,226877255
Technic	techno	0,0033835	0,0822756	0,026783528
	science	0,109123	2,6535106	1,710812944
R&D	techno	0,014225	0,3466472	0,568975278
	science	0,1266644	3,0866677	10,03415122
Finance	techno	-0,034416	-0,837839	-1,106112771
	science	0,1125325	2,7395105	7,163029809
Selling	techno	-0,028233	-0,685294	-1,282445973
	science	0,085692	2,0799806	7,709149408
Market	techno	0,0023162	0,0564537	0,03478675
	science	0,1285798	3,1339771	3,824744566
Partners	techno	0,031496	0,7647381	2,164701998
	science	0,0902827	2,1921054	12,28943489

TABLE 9: ELECTRIC AND ELECTRONIC EQUIPMENT

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	-0,001471	-0,021595	-0,0533093
	science	0,0161525	0,2370561	1,159014948
Identification	techno	-0,007819	-0,1155	-0,110729981
	science	0,1141882	1,686785	3,202784549
Creation	techno	0,041463	0,6101298	0,350298329
	science	0,064228	0,9451167	1,074697738
Technic	techno	0,0079551	0,1172821	0,062971882
	science	0,0966508	1,4249236	1,515275173
R&D	techno	-0,01725	-0,253523	-0,689952419
	science	0,0524596	0,771016	4,155764925
Finance	techno	-0,009189	-0,135166	-0,295319552
	science	0,0684741	1,0072413	4,358577116
Selling	techno	0,0417494	0,6156454	1,89640398
	science	0,0918335	1,354197	8,261656127
Market	techno	0,0143661	0,2118464	0,215766875
	science	0,0984968	1,4524563	2,929893834
Partners	techno	0,0977493	1,4456415	6,718249292
	science	0,0827809	1,2242695	11,26827898

TABLE 10: MINERAL PRODUCT

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,06077	0,9187908	2,201672717
	science	0,0081814	0,1236952	0,587048635
Identification	techno	0,0046833	0,0707015	0,066324005
	science	-0,023656	-0,357119	-0,663499498
Creation	techno	0,0646292	0,977679	0,546016773
	science	-0,014574	-0,220471	-0,243863575
Technic	techno	-0,11389	-1,730017	-0,901542105
	science	-0,035313	-0,53642	-0,553637573
R&D	techno	-0,066226	-1,002623	-2,64893161
	science	0,0337702	0,5112594	2,675218684
Finance	techno	-0,094831	-1,437523	-3,047798031
	science	-0,021447	-0,325114	-1,36518542
Selling	techno	-0,065184	-0,986535	-2,960869086
	science	-0,049481	-0,748875	-4,451446426
Market	techno	-0,118966	-1,808134	-1,786758307
	science	-0,004037	-0,061365	-0,120098726
Partners	techno	0,0406894	0,6156452	2,796558736
	science	0,0654525	0,9903185	8,909501986

TABLE 11: TEXTILE INDUSTRY

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,049451	0,7385546	1,791592996
	science	-0,029883	-0,446304	-2,144237567
Identification	techno	0,0401402	0,5987878	0,568461263
	science	0,0105695	0,1576698	0,296456785
Creation	techno	0,029511	0,440416	0,249321902
	science	-0,033928	-0,506336	-0,567703112
Technic	techno	0,0103784	0,1558105	0,082154502
	science	0,1208668	1,8145696	1,894930912
R&D	techno	-0,033208	-0,495286	-1,328270067
	science	-0,017295	-0,257947	-1,370078851
Finance	techno	0,0316387	0,4719378	1,016838172
	science	0,0278674	0,4156838	1,773843312
Selling	techno	-0,064122	-0,958884	-2,912634375
	science	-0,062525	-0,935008	-5,624969015
Market	techno	-0,063418	-0,947372	-0,952489177
	science	0,0099135	0,148092	0,294887367
Partners	techno	0,036201	0,5407928	2,488071137
	science	0,0630136	0,9413355	8,577513541

TABLE 12: WOOD AND PAPER INDUSTRIES

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	-0,012934	-0,199187	-0,46860933
	science	-0,028738	-0,442554	-2,06206109
Identification	techno	-0,042217	-0,65045	-0,59786982
	science	-0,015432	-0,237766	-0,43283982
Creation	techno	0,0028802	0,0444421	0,024333475
	science	-0,069505	-1,072473	-1,16300335
Technic	techno	-0,029889	-0,460531	-0,23660237
	science	0,0311326	0,4796848	0,488091991
R&D	techno	0,0883302	1,3652466	3,533051228
	science	-0,015484	-0,239327	-1,22663426
Finance	techno	0,0519141	0,8035076	1,668471902
	science	-0,087572	-1,355415	-5,57424665
Selling	techno	-0,038102	-0,587591	-1,73074172
	science	-0,05055	-0,77955	-4,54763972
Market	techno	-0,016949	-0,260934	-0,25455895
	science	-0,009799	-0,150858	-0,29148216
Partners	techno	0,0261149	0,4021128	1,794862996
	science	-0,001957	-0,030136	-0,26641544

TABLE 13: CHEMICAL INDUSTRY AND PLASTICS

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,0378029	0,7469399	1,369583929
	science	0,0616141	1,2174215	4,421086916
Identification	techno	-0,049891	-0,995819	-0,70654752
	science	0,1454884	2,9039478	4,08070341
Creation	techno	-0,056497	-1,128922	-0,47731205
	science	0,1497305	2,9919134	2,505372997
Technic	techno	-0,053365	-1,068962	-0,42243035
	science	0,1657758	3,3206979	2,599007013
R&D	techno	-0,084944	-1,711837	-3,39760271
	science	0,1834753	3,6975015	14,53461803
Finance	techno	-0,087331	-1,732733	-2,80672924
	science	0,0672609	1,334527	4,281354596
Selling	techno	-0,050659	-1,004971	-2,30111757
	science	0,0970739	1,9257427	8,73309928
Market	techno	-0,063993	-1,284214	-0,9611249
	science	0,1715493	3,4426377	5,102919275
Partners	techno	-0,077038	-1,561295	-5,29479389
	science	0,2133775	4,3244111	29,04531753

TABLE 14: METALLURGY AND METAL WORKING

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	0,0341171	0,7928633	1,236051389
	science	0,0178544	0,4149266	1,281133964
Identification	techno	-0,014046	-0,326273	-0,19891266
	science	0,0126398	0,2936168	0,354525343
Creation	techno	-0,007083	-0,164523	-0,05984393
	science	-0,011624	-0,269983	-0,19449843
Technic	techno	-0,025401	-0,590282	-0,20107036
	science	-0,028599	-0,664614	-0,44837682
R&D	techno	-0,087553	-2,042366	-3,50195454
	science	0,0215086	0,5017375	1,703878015
Finance	techno	-0,047168	-1,096778	-1,51593513
	science	0,0074864	0,1740776	0,476529769
Selling	techno	-0,00481	-0,111713	-0,21848365
	science	-0,008056	-0,187114	-0,72478087
Market	techno	-0,073876	-1,721601	-1,10955513
	science	0,0258733	0,6029481	0,769628976
Partners	techno	-0,104148	-2,441142	-7,15800137
	science	0,0697702	1,63536	9,497234533

TABLE 15: ELECTIRC AND ELECTRONIC COMPONENTS

Ind. Var	Dep. Var			
Competence	Density	BETA	t	elasticity
Organisation	techno	-0,072949	-0,99779	-2,64293222
	science	0,1961479	2,6828753	14,07448583
Identification	techno	-0,120611	-1,654649	-1,70808726
	science	0,1829504	2,5098665	5,131446544
Creation	techno	-0,027353	-0,367851	-0,23108707
	science	0,111291	1,496695	1,862183255
Technic	techno	-0,109374	-1,490294	-0,86579233
	science	0,1550031	2,1120282	2,430113461
R&D	techno	-0,042438	-0,588317	-1,69745855
	science	0,2605693	3,6122373	20,64187733
Finance	techno	-0,030427	-0,411745	-0,97788351
	science	0,1551935	2,1001401	9,878526708
Selling	techno	-0,170625	-2,351145	-7,75037305
	science	0,1618567	2,2303269	14,56118743
Market	techno	-0,135622	-1,855304	-2,03692150
	science	0,1562042	2,1368702	4,646461658
Partners	techno	-0,031902	-0,434677	-2,19261317
	science	0,1922742	2,6198024	26,17270194