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CHOOSING ACCURATELY: COMPETITIVE INTELLIGENCE ON PROSPECTING PARTNERS FOR TECHNOLOGICAL COOPERATION

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ABSTRACT

The paper discusses the results of a project aimed at developing and testing a method for identifying, qualifying, and classifying capabilities of Brazilian research groups (RGs) in technologies applicable to the automotive industry. The project was commissioned by the largest R&D centre of a multinational corporation in the business of car manufacturing. The point of departure is the literature pointing out the need for firms to manage their external sources of innovation systematically rather than empirically. Regarding routines for prospecting and qualifying external R&D (Research and Development) partners, an important function in managing external sources, the paper introduces the concept of strategic search (competitive intelligence). The paper proposes a new use for the snowball sampling method. Snowball sampling was originally used to map risk groups (**hidden populations** usually belonging to both social extremes: the deprived and the elites), i.e., carriers of the AIDS (SIDA) virus, drug addicts, chemical dependents, etc. The key steps of the method, which were developed and tested by the authors, are described. The method is presented as a tool for strategic search. The result of its implementation is a database with quantitative and qualitative information on Brazilian technological competencies applicable to the automotive industry in the technological areas of Materials, Powertrains and Fuels, Manufacturing Technologies, On-board Electronics, and Ergonomics. The database comprises 265 research groups in various science and engineering disciplines. Some of its aggregate results are presented and illustrated.

Keywords: Mapping out technological capabilities; Snowball sampling; External sources of innovation management; Strategic search of external partners; Technological cooperation.

1. INTRODUCTION

The importance of the contribution of external sources of knowledge for innovation in manufacturing and services companies is widely recognized as a distinctive feature underlying the current forces driving competition (Anthony, Johnson, Sinfield, & Altman, 2011; Bueno & Balestrin, 2012; Chesbrough, 2007, 2012a, 2012b; Huston & Sakkab, 2006; Nooteboom, 2004; Organisation for Economic Co-operation and Development [Ocde], 2008; Takahashi, 2011; Tidd, Bessant, & Pavitt, 2008). Yet, few corporations have adopted a systemic approach to managing external sources of innovation, be they related to routines for prospecting and selecting sources and partners or to designing and managing partnership agreements. The literature emphasizes that companies lack such capabilities, but it also lacks the proposition of concepts, tools, and methods to fill the gap. This paper intends to contribute to this debate by presenting and discussing a method by which firms can prospect and qualify potential external R&D partners. It discusses the results of a project aimed at developing and testing a method for identifying, quantifying, and classifying capabilities of Brazilian research groups (RGs) in technologies applicable to the automotive industry.

The paper is based on an on-going research project commissioned by Renault to the research group composed by the authors (This is the project **Capabilities and opportunities involving technologies applicable to the automotive sector mapping out of the Brazilian research institutions**); the objective of the project is to map research competencies in Brazilian Research Institutions (RIs). Data refer to research groups in Brazilian universities and research labs, most of them working on frontier technological issues in disciplines such as Chemistry, Physics, and Materials, Chemical, Mechanical, and Metallurgical Engineering. The data was collected between 2004 and 2006 by means of structured questionnaires sent to approximately 570 research groups, out of which we have received 287 replies.

The paper is organized in five sections, including the Introduction. Section (2) introduces the discussion on companies that lack the capabilities to organize and manage their external sources of innovation and the need for a systemic approach to such management. Regarding the prospecting of external innovation partners , which is a key phase in the management of external sources, the paper introduces the concept of strategic search. Section (3) is the core of the paper, as it presents the basic steps of the method, which is a tool for strategic search, and discusses some of the critical difficulties in each step: 1. definition of scope, strategy and concepts of the mapping out method; 2. identification of the potentially relevant research groups; 3. methods for approaching informers and collecting data; and 4. data treatment: database organization . The result of implementing the mapping out method is a database with quantitative and qualitative information on technological competencies applicable to the automotive industry in the technological areas of Materials, Powertrains and Fuels, Manufacturing, On-board Electronics and Ergonomics. The databank comprises 265 research groups in various science and engineering disciplines. Section (4) explores these and other features of the database. Finally, section (5) draws conclusions addressing the method's applicability in other countries and business contexts.

2. THEORETICAL FRAMEWORK

2.1 The importance of managing the external sources of innovation and strategic search for external partners

Many corporations lack the capability to identify and manage external sources of knowledge and innovation as a crucial process for their businesses, when such sources complement and contribute to strengthening innovation (Bueno & Balestrin, 2012; Chatterji, 1996; Chesbrough, 2007, 2012a, 2012b; Tidd et al., 2008). Common questions managers ask when dealing with such issues are: How do we identify and select partners and how do we manage links with them? How do we manage well the distinctiveness of external innovation partners, who change from business oriented suppliers to knowledge oriented research partners? What is the actual contribution of external partners to innovation?

Innovation surveys carried out in Europe and the U.S. in the past two decades, such as the CIS – European Community Innovation Survey (in 1993, 1997 and 2000), have shed light on understanding of the requirements, restrictions and determinants influencing the contribution of external sources to the company's innovation process, particularly with regard to research sources such as universities and public labs. Possiblythe most important finding of such surveys is that the capability for searching and selecting external sources of innovation depends on building internal technological capabilities. This is because the knowledge that is relevant to technological innovation is sector and company specific; thus, only an interested company would be able to make choices between alternatives. Knowledge accumulated by the company is a sound basis for sustaining a focused and organized search and selection. Moreover, such knowledge is a requisite for learning from the external partnership.

The literature on innovation surveys has also revealed structural determinants or conditioning factors affecting the quality and intensity of links between companies and universities. Among such factors are the influence of the company's size and age , the particularities of the business sector, the nature of the innovation process and the science area involved. For instance, Cohen, Nelson, and Walsh (2002) have drawn on the Carnegie Mellon Survey to suggest that public research is more critical to industrial research in certain industries, particularly regarding the advance of sciences such as biology and physics. The study also showed that rather than outsourcing research to generate new innovation ideas, companies are likely to use public research to complement their capabilities and knowledge in on-going projects or in problem-solving. In this respect, Santoro and Chakrabarti (2002) see a clear cut difference between large and small companies, as the latter would be interested in finding solutions for their crucial problems, rather than building long-term complementary capabilities in core areas. Cohen et al. (2002) also pointed out that, although large companies are generally more inclined to source public research than small ones, research institutions are very important for science-based start-ups.

However, such studies are limited as they focus exclusively on the company's structural aspects , leaving aside the central issue regarding strategic and managerial choices. Laursen and Salter (2004) suggest that, although structural aspects such as size and age do play a role in determining the propensity to search for links with universities and the chance of success, these decisions are also related to strategic choices regarding the management of innovation activities.

Even though an increasing number of large firms are stepping up their outsourcing and external linkages with universities and public labs, most of them have not adopted systematic practices to manage them . Their approach is more informal, imitative and empirical (Linder, Jarvenpaa, & Davenport, 2003). Yet, organized practices comprising the identification, selection, monitoring and assessment of external research links are critical for making sure the best choices are made and to warrant the desired integration of research partners into the internal process of innovation. Although universities and public labs have been increasingly sought after as partners in corporations' global innovation strategies, both in developed economies and emerging economies, there is scant evidence when it comes to companies systematically managing the search for sources of innovation and linking their use of public sources to their strategic innovation objectives (Lauersen & Salter, 2004). Other authors (Carvalho, Santos, & Barros, 2013, 2011; Chesbrough, 2007, 2012a, 2012b; Gomes & Kruglianskas, 2005; Huston & Sakkab, 2006; Linder et al., 2003; OCDE, 2008; Tidd et al., 2008) emphasize that most businesses lack strategic direction to command their search for external partners, as well as a holistic approach to managing the various sources of innovation. Linder et al. (2003) introduce the idea of managing external sources as channels of innovation-related ideas and knowledge (**innovation channels**) in the same way as they deal with specific distribution channels to reach end . Such an approach suggests the importance of dealing differently with external partners, which are distinctive in nature, culture and objectives.

This paper is concerned with a particular aspect of practices for managing external sources, i.e., prospecting and identifying opportunities for partnering in R&D with universities and public labs. This is part of the routine Chatterji (1996) points to as identifying and coordinating innovation opportunities through formal and informal external networks in his model for managing external sources of innovation (see also Bueno & Balestrin, 2012; Chesbrough, 2007, 2012a, 2012b; Huston & Sakkab, 2006; Tidd et al., 2008). The paper presents a method for mapping out technological competencies and opportunities in universities and research labs, which is adequate to the Brazilian S&T (Science and Technology) environment. It is a tool that has been developed with the intent of supporting the strategically oriented search for external sources of scientific and technological knowledge to be used in innovation.

An approach to prospecting and selecting R&D partners, which has been disseminated in various countries, including Brazil, is the adoption of an Internet-based search. There are two basic groups of practices, based on an Internt search: practices based on information mining of databases, which are in most cases public databases organized by government agencies in the field of S&T policy. The most important in Brazil is the CNPq Lattes database (CNPq - National Council for S&T Development), which will be discussed in the next section. Such data mining may focus on distinctive aspects of a company’s interest, such as patents, publications and other qualifications of the researchers and research groups registered in such databases. Conversely, government agencies and private corporations in Brazil have been increasingly relying on building open innovation portals, for the purpose of matching supply and demand of technological competencies. The most recent and significant case in Brazil is the Portal Inovação developed by the Ministry of Science, Technology and Innovation (http://www.portalinovacao.mcti.gov.br/pi/#/pi). This tool relies primarily on the spontaneous offer/submission of competencies by researchers and research groups attached to universities and public labs, even though the government Portal de Inovação also uses information from the Lattes database. The objective of this type of portal is to intermediate the contact between companies and institutions in need of competencies and the **owners** of such competencies.

However, the spontaneous, offer-oriented construction of such portals may allow an unaware search to their users, but is not likely to be enough to allow strategic search. Inspired by authors such as Bueno and Balestrin, 2012, Chesbrough, 2007, 2012a, Huston and Sakkab, 2006, Lauersen and Salter (2004), Linder et al. (2003) and Tidd et al., 2008, regarding the need for companies to adopt a systemic approach to the management of external innovation sources, we distinguish the strategic search of external sources, which is aligned to strategic innovation objectives and requires a more pro-active management of the search, identification, qualification of and interaction with external partners, from an unaware search, which is based on empirical and informal methods. Even though portals that rely on spontaneous offering are not empirical or informal in terms of their construction procedures , the consequences for strategic search may lead to results similar to the typical unaware search.

In the following section, a method for strategic search of R&D partners is presented and discussed. It is a method for mapping out technological competencies and opportunities in universities and research labs, which is adequate to the Brazilian S&T environment. It is result of a project commissioned by Renault's R&D centre, in Paris, to the team composed by the authors. The project aimed at developing, testing, and implementing procedures for mapping out, qualifying, and classifying the capabilities of Brazilian research groups (RGs) in technologies applicable to the automotive industry that are relevant to Renault's innovation objectives. Although the method was developed with the automotive industry and the Brazilian ST&I (Science, Technology and Innovation) environment in mind, we suggest that the guidelines could also be used in other institutional and business contexts.

3. THE METHOD FOR MAPPING OUT TECHNOLOGICAL OPPORTUNITIES AND RESEARCH COMPETENCIES AND PROSPECTING RESEARCH PARTNERS

This section presents the method used in the joint research project between Renault and the group of authors and aimed at developing and testing a method for mapping out technological capabilities and opportunities applicable to the automotive industry in Brazilian research institutions/groups (RIs/RGs). The project was commissioned by the Research Strategy and International Networks division of Renault to the Research Group composed by the authors. It commenced in March 2004 and the final results were presented in July 2006. The project team comprised one professor, two PhD researchers, one PhD student, and two undergraduate engineering students. The aim of the project was to identify and characterize major scientists and research groups that work in Brazilian research institutions on technologies potentiallyapplicable to the automotive industry. The search was oriented by Renault's initial indication of relevant technologies and a permanent, systematic widening of the scope of technological opportunities during the course of data collection. The project intended to look not only at researchers' competencies, but also identify possible technological opportunities they have developed through their work.

The section describes the the method's key steps and discusses some of the critical difficulties in each step: 1. definition of scope, strategy and operational variables ; 2. identification of the potentially relevant research groups; 3. methods for approaching informers and collecting data; 4. data treatment and organization of databank and 5. method validation .

3.1 Definition of operating variables, scope and strategy of the mapping out method

The preliminary decisions faced by the research team were critical for the definition of the method's steps . They refer to the initial definitions adopted to guide its development : the operationalization of the research competency concept , the definition of analysis unity , and the research scope and strategy .

The capabilities/competencies adopted in the project were operationalized by means of a wide range of indicators referring to both inputs (researchers' background, size of research group, grants obtained, lab facilities, and so on) and outputs (patents, publications and major scientific and technological achievements) of the research groups. This decision guided the preparation of the research tools described below. Another important aspect is that the goal of the project was not only to identify researchers' competencies applicable to the automobile industry, but particularly the ones that were willing to engage in research partnership with the industry. For that reason, it was important that the characterisation also took into account the partnership background of the researcher/research group.

Another important methodological decision was to take research groups (RGs) as the smallest identifiable part of research to be considered in the project. RG here refers to organized unit of research involving one or more senior(s) scientist(s), their students, associate researchers and technicians. RGs do not necessarily require an S&T certification, such as the one the Brazilian CNPq (the National Council for S&T Development) grants to groups registered in its research group directorate (although most of the selected groups have been registered). What makes a RG distinct is its capability to mobilize competencies and resources on a scale that substantially raises research productivity . Adopting RG as the unit investigated in the project facilitated the identification and the characterisation of competencies.

The scope of research referred to the areas and technologies to be investigated, as well as the type of research institutions to be included in the mapping . At the very beginning, it was agreed with Renault that the search for and documentation of RGs should be oriented to five major technological fields: Materials, Powertrains and Fuels, Manufacturing technologies, On-board electronics and software and Human/machine interface (Ergonomics). Indeed, this definition helped organize the method's implementation and upgrading as the project evolved through steps, or modules, each one addressing a major technological field. Before mapping a given field, Renault provided a detailed list of the field, identifying the technologies the company was interested in. No restriction was adopted regarding Science and Engineering areas or disciplines. Yet, in terms of type of institutions, an important value for Renault was scientific excellence, which restricted the research to Brazilian universities and few outstanding public research labs.

The research strategy , understood as the combination of investigation methods and sources, comprised one basic definition: given the objective of the project, relying on data-mining in secondary sources was not enough. Having knowledge of the Brazilian data sources on S&T activities and institutions, it was clear that the mapping out method required some form of primary data produced by means of direct contact with research groups.

3.2 Identification of potentially relevant research groups

The approach to making the concept of capabilities (competencies) and the adopted unit of analysis operational, the next challenge was defining procedures for finding and selecting the relevant RG to be surveyed. Our learning process led to the adoption of a mix of techniques comprising searches in databases (mainly CNPq's Lattes database and CAPES - The Ministry of Education's Committee for Post-graduation Policies database), interviews with experts in the respective technological fields to be investigated and the snowball sampling technique, in this case, snowball of peers (Atkinson & Flint, 2001).

Among the Brazilian S&T databases, CNPq's Lattes Platform (Plataforma Lattes) is the most extensive and complete. The Lattes Platform is a digital information system designed and managed by the federal National Council for S&T Development(CNPq), used as an information tool for implementing its S&T funding programmes. Supporting on-line services related to research funding, the Lattes Platform comprises a database of RGs, namely the Research Group Directory (Diretório de Grupos de Pesquisa) and individual researcher CVs (Sistema Eletrônico de Currículos), which can be accessed through CNPq's web portal. By inserting broad keywords related to technologies and science areas, lists of researchers can be produced for specific technology fields. This information can be complemented with group leaders' CV information drawn from Lattes. Even though this information has been interesting in terms of getting a broad picture of research in a given technological field, it is not detailed enough to produce precise clues to find the most interesting groups working with new technologies applicable in the automotive industry (or any other given business area).

The effective selection of RGs to be surveyed for the project database required expert help in the various technology domains and specific technologies that were relevant to this research. Yet, organizing expert support to **read** the available S&T databases would be very costly and time consuming. An alternative way of gaining expert support was adopted, which has proved to be relatively fast and less expensive: the snowball sampling to reach the population of researchers working on the relevant technologies and issues that have potential application in the automotive industry.

In its simplest form, snowball sampling consists of identifying respondents who are then used to refer researchers to other respondents (Atkinson & Flint, 2001). The technique takes advantage of the social networks of identified respondents and is particularly useful in finding **hidden populations**, usually belonging to both social extremes: the deprived and the elites. In this project, the population to be **uncovered** comprised researchers/research groups whose achievements and capabilities were potentially applicable to the automotive industry. It seemed to be an effective and inexpensive means to engage experts in our search: a snowball of scientists and technology researchers referring to their peers, in each specific technology domain.

However, the adoption of this method required a good starting point – the first list of RG/researchers to begin the snowball sample to guarantee the completeness, diversity of schools and academic representativeness of the final sample. How could we make sure that a large part of the most relevant researchers in Brazil, in a given technological field, were included in the databank? How could we assess the level of seniority and maturity of the researchers included? The solution was to introduce a further procedure in picking out researchers for the starting list , based on the level of academic seniority/importance. For the starting list in each domain, we adopted a search based on the crossing of the two major Brazilian academic criteria for quality: the classification of researcher seniority by CNPq and the CAPES classification of grades given to postgraduate programmes. Thus, the typical initial list of the snowball consists of researchers filling both requisites: being ranked in the two most senior researcher level at CNPq (levels 1A and 1B) and belonging to the researcher/lecturer staff of postgraduate programmes with grades 5, 6 or 7 at CAPES, in the specific technological area/discipline, provided his or her research work was pertinent to our search.

3.3 Approaching informers and collecting data

As the procedure to find relevant respondents was defined, data collecting was planned to be undertaken in two phases: 1. Designing the first version of questionnaire, approaching procedures and forms of data collection aimed at testing and validating in a small sample (at the University of Campinas); and 2. Adopting improved and validated methods of data collection in a wider sample.

Designing the questionnaire was the most important step in the development of research methods . It implied a choice of issues to be investigated and a structure and hierarchy of information to be collected. It should be sharp enough as to guarantee that the information would allow the project's objectives to be attained and lean enough to attract the good will of respondents.

The following guidelines were defined as a way to guide the design of a questionnaire; in fact, they warranted that the resulting data was in line with project objectives:

- To characterize the main features of the RG to be able to measure its academic excellence and importance;
- To identify the major technological and scientific advances/attainments of the group;
- **To** identify the applicability of the RG's competences and achievements in technologies applicable to the automotive industry;
- To map out the RG's experience in technological cooperation with corporations and its willingness to engage in such cooperation.

We soon realized that Brazilian secondary sources were good enough to provide the basic information regarding the RG's publications (Lattes), patents (INPI – the Federal Institute for Intellectual Property) and the status of the group at CNPq. Moreover, the RG's web pages worked as complementary sources, when available. Thus, we adopted the procedure of consulting secondary sources before interviews, so that interviewers met the respondent with previous and considerable knowledge of the RG's features, publications and patents. This also helped to increase the respondents' good will , as it reduced the amount of time spent on the interview.

With regard to approach and type of interview, researchers/RGs were initially contacted (in the first four months of collecting) by an email that presented the project's objectives, the partnership with Renault, and the need for the researcher to give our project researchers a live interview. The questionnaire was attached, so that the researcher could get a clear idea of what the interview would be about. After receiving electronic confirmation of of having read the questionnaire, a phone call was made to schedule the interview appointment.

After this period, an additional approach and type of data collection began to be implemented: electronic questionnaires. This was used mainly (but not exclusively) to get information from respondents outside the state of São Paulo (location of the University of Campinas). In this case, a separate e-mail message was sent, asking researchers to send back the completed questionnaires by e-mail. In the case of electronic questionnaires, phone calls were made during the follow-up. Indeed, they were decisive in establishing a trusting relationship with the respondents, assuring them of confidentiality and the ethical use of the information. Questions concerning the RG's contribution to scientific and technological progress in their respective research domain might raise doubts regarding the project's true objectives . This is a critical and exhausting phase in which "researchers may encounter initial hostility and suspicion from targeted individuals" (Atkinson & Flynt, 2001, p. 3). Eventually, the phone calls worked well, although it was difficult, time consuming, labour intensive and expensive to make long distance calls to researchers in all states. In the case of respondents who did not reply to the first email, additional e-mails were sent and more calls were made until a positive or negative answer could be obtained. The rate of reply [(electronic questionnaires filled + no useable)/total questionnaires sent] was 50.7% (Table 1).

Table 1 - Rate of respondent replies: materials, powertrains and fuels, manufacturing, on-board electronics and ergonomics

All technologies	Frequency	%
Electronic questionnaire completed	265	46.9
No answer yet	199	35.2
Participation refused	55	9.7
Problems in making contact	25	4.4
Not useable	22	3.9
Total	**566**	**100.0**

Source: Developed by the authors.

Following the interviews or after receiving a completed electronic questionnaire, an acknowledgement email was sent to respondents with a message asking the researcher's permission for further contact, if necessary, to solve any doubts about the information .

3.4 Data tabulation and organization of a database

Data on individual RGs obtained from questionnaires, as well as secondary source information, was organised, in English, in a database designed for MS Access. In terms of information blocks, the structure of the database followed the same guidelines presented in section 3.3 with descriptions of technologies and functional areas provided by Renault. Information on each RG mapped in the survey should be fitted to the same structure.

The Renault team gave suggestions on how to simplify the first version, which led to the current form of the database. In its current version, it is possible to generate reports by combining the following filters:

- technology of interest
- research institution (university)
- patent according to World Intellectual Property Organization (WIPO) code

Two types of reports can be produced: a simple one (only basic RG information, technologies and patents) and a complete one (all information regarding the RG). The database format meets the project’s objectives and is user- friendly in terms of entering new information and creating new reports.

4. SOME FINDINGS OF MAPPING OUT: TECHNOLOGIES, INSTITUTIONS, REGIONAL LOCATION AND RESEARCH GROUP CONTRACTS

4.1 General characterisation of the database sample

This section is based on information regarding the 265 research groups belonging to the technological fields of Materials, Powertrains and Fuels, Manufacturing, On-board Electronics and Ergonomics. tHE main characteristics of the Research Groups are shown in relation to Research Institutions, Knowledge Areas, States, Patents and Research and Services Contracts with companies in the auto industry (suppliers and assemblers). The distribution of research groups by major technological fields is interesting: manufacturing technologies, with 73 RGs, and Ergonomics, with 26 RGs, represent the two poles in terms of numbers of groups, which reflect the relative maturity and consolidation of the respective domain of technological research in Brazil (Table 2). The research groups in the database are distributed in 53 distinct research institutions (universities and public laboratories), which are located in 14 Brazilian states.

Table 2 - Database overview: frequency of research groups, research institutions and states by major technological field

Technology	Research Groups	Research Institutions	State
Materials	50	12	5
Powertrains and Fuels	53	19	6
Manufacturing	73	24	10
On-board Electronics	63	25	14
Ergonomics	26	13	8
Total	**265**	**53**[1]	**14**[2]

1. Refers to the total number of Research Institutions covered in the fieldwork.
2. Refers to the total number of States covered in the fieldwork.

Source: Developed by the authors.

The RGs were distributed in 18 disciplines or knowledge areas (Table 3), showing the diversity of knowledge areas dedicated to research in technologies relevant in this project. The largest share of RGs covered in the data base is in the engineering disciplines: Mechanical Engineering (79 RGs), Electrical Engineering (39 RGs), Materials and Metallurgy Engineering (32 RGs), Production Engineering (27 RGs) and Electronics, Automation and Control (20RGs). These are followed by significant shares presented by Chemistry (15 RGs), Design and Ergonomics (13RGs), Chemical Engineering (10 RGs), Computer Engineering (10 RGs) and Physics (7 RGs). It is important to point out that the Mechanical Engineering knowledge area alone accounts for 30% of the database RGs, which are distributed between all key technological fields considered. This is possibly a consequence of the prominence of the metal-mechanic industry in Brazil.

Table 3 - Database overview: frequency of research groups by knowledge area

Knowledge Area	Group Frequency
Mechanical Engineering	79
Electrical Engineering	39
Materials and Metallurgy Engineering	32
Production Engineering	27

Electronics, Automation and Control	20
Chemistry	15
Design and Ergonomics	13
Chemical Engineering	10
Computer Engineering	10
Physics	7
Agricultural Engineering	3
Mechatronics Engineering	3
Food Engineering	2
Architecture	1
Energy	1
Environment Health	1
Naval Engineering	1
Physical Education	1
Total	**265**

Source: Developed by the authors.

Another important structural outcome of the database is the concentration of research in both regional concentration and institutional terms. Research identified in the database is concentrated in a few states, particularly in the southeastern (181 RGs) and southern (59 RGs) regions . Indeed, this situation reflects the concentration of economic development in Brazil, as industrial activity, post-graduate education and research are concentrated in these two regions. Moreover, the concentration of the database RGs is particularly strong in the state of São Paulo (133 RGs or 50%). This is so partly due to the fact that there may be some bias stemming from the fact that the project's research team is located there . However, it should be noted that research concentration in the state is proportionally greater than economic concentration. While São Paulo accounts for approximately 40% of the Brazilian manufacturing industry , researchers working in universities and labs account for 50% of the scientific output (publications) (Fundação de Amparo à Pesquisa do Estado de São Paulo [FAPESP], 2005).

Institutional concentration is even more pronounced. Out of the 265 RGs mapped out, 148 (56%) belong to only 6 leading research institutions, which accounted for 10 or more RGs each: the 3 São Paulo state universities [USP (São Paulo University), UNICAMP (Campinas University) and UNESP (Paulista University)], the Federal University of Santa Catarina, the Federal University of São Carlos and the Federal University of Rio de Janeiro. The average number of 25 RGs per institution in this elite group of universities is remarkably contrasted with the average of 2.5 RGs per institution in the remaining universities. Even taking into account the bias related to data collection being centered in the State of São Paulo, these figures reflect the concentration and control of research in Brazil by just a few institutions, which has been pointed out by recent S&T indicators (FAPESP, 2005).

As might be expected, patenting activity of Brazilian RGs is quite timid, although this has changed somewhat in recent years, particularly in the elite group of institutions. The total number of patent submissions identified in data collection is 256, which leads to an average of less than 1 patent per group. The technological field of Materials presents an average that is double the general average of patents per group. In Materials, half the RGs own at least 1 patent (Table 4). In line with the concentration of RGs, the same 6 elite universities account for the largest share of patents. Three federal labs – INT (National Institute of Technology) and CTA/ITA (Centro Tecnológico Aeroespacial / Instituto Tecnológico da Aeronáutica) – are the only non-university institutions that have submitted patent applications to the Brazilian federal patent office.

Table 4 - Database overview: frequency of patent owner groups and of patents by major technological field

Technology	Total of Research Groups	Patent Owner Groups	Patents	% of Owner Groups
Materials	50	26	100	52
Powertrains and Fuels	53	22	37	42
Manufacturing	73	18	48	24
On-board Electronics	63	22	45	33
Ergonomics	26	8	26	31
Total	**265**	**96**	**256**	**36**

Source: Developed by the authors.

Results of the investigation of RGs also revealed that the frequency of contacts and contracts between companies and RGs and their research institutions/RI, which is related to outsourcing R&D and services, is much larger than generally acknowledged (Table 5) and even more so with regard to the automotive industry. The database identified more than 400 service contracts and 360 research contracts between RGs and manufacturing or service companies, covering the 2000/2005 period. As most of these contracts were funded by the companies themselves (and not by government sources), they may prefer not to disclose this type of information . Certainly, the fact that the focus of our research and peer recommendation method was the applicability of competencies and technologies to the auto industry has introduced a major bias in favor of contracts with that industry: 31% of the service contracts and 18% of the research contracts. That is why we cannot compare frequencies between industrial sectors. However, it is interesting to observe that frequencies are relatively high in other industries , such as oil , steel and aluminum, chemical, aircraft and food . The fragile links between companies and RI seem to be more in the intensity and continuity of the link than in their frequency .

The first sign of the latter point is that the overall frequency of service contracts is much higher than that of research contracts. This is even more pronounced in contracts with the automotive sector: service contracts are almost double. Second, the continuity of research funded by a company is rare. There are few research contracts continuing beyond two years. Moreover, in the case of assemblers, we spotted at least three cases of 2-3 year research projects that have been discontinued (and have not rendered applications).

It is interesting to see that the overall distribution shows a balance between assemblers and suppliers in terms of the total number of RG contracts with the automotive industry. There is some concentration of such contracts in the fields of Powertrains and Fuels and Manufacturing technologies. While RGs working in Materials are in greater demand by suppliers, assemblers are more interested in Ergonomics research . The RGs working on On-board electronics are in less demand. This seems to be the result of the combination of two factors. As this is a less consolidated and perhaps more strategic research area , there is a tendency for greater concentration of electronics-related research in the headquarters and major international R&D centres of corporations in the automotive business. It may also reveal the fact that Brazilian research in electronics is less well known by companies. However, considering the total number of contracts in all industries, the RGs in On-board electronics are more in demand for research contracts as compared to services contracts, which seems to indicate a potential for further contribution of these groups to innovation in the auto industry.

Table 5 - Frequency of Research/Development contracts outsourced by assemblers/suppliers (and total contracts) to Brazilian research groups by major technological field[1]

Technologies	Assemble		Suppliers		Automoti.		Total	
	S_2	R_2	S	R	S	R	S	R
Materials	7	4	19	10	26	14	85	61

Powertrains and Fuels	21	12	21	12	42	24	85	64
Manufacturing	18	11	16	9	34	20	74	104
On-board Electronics	6	1	2	5	8	6	62	116
Ergonomics	14	4	3	0	17	4	101	17
Total	**66**	**32**	**61**	**36**	**127**	**68**	**407**	**362**

1. Refers to contract_frequency and not the number of companies.
2. R: research; S: service

Source: Developed by the authors.

We conclude this section with an illustration of the content of the contracts RGs have declared to have (or have had) with assembler and supplier companies, by showing the declared subject of part of the contracts in the field of Materials. Although the number of contracts involving assemblers is smaller than the frequency among auto-parts companies, the assemblers' experience is quite revealing. Indeed, longer term and less immediately applicable research outsourced by assemblers has been rare and entirely related to experiments with biomaterials (Figure 1). However, it is interesting to note that services refer more to advanced engineering services or developments rather than short term outplacement of small services, like testing. Two examples underline this argument: the development of safety under-rides for trucks, which is a major line of development of a research group at UNICAMP, and the development of a corrosion inhibitor powder.

Figure 1 - Research/Development contracts outsourced by assemblers to Brazilian research groups

Firm	Technology/Content of project	Functional area	Type of project
General Motors	Composites based on biomaterials	Weight reduction; environment	Research (2 years)
	Development of engine components using sinterized technology	Durability	Research
	Simulation of mechanical fracture and fatigue	Durability	Service (2 years)
	Under-ride truck guards	Safety	Service (2 years)
Volkswagen	Carburator corrosion	Durability	Service
	Corrosion inhibitor	Durability	Service
	Biodegradable polymer	Environment	Research (3 years)
Daimler Chrysler	Composites based on biomaterials	Weight reduction; environment	Research
	Under ride truck guards	Safety	Service (2 years)

Source: Developed by the authors.

The diversity of contracts, areas of outsourcing and research outsourcing presents higher profile as regards suppliers (Figure 2). Starting with the latter point, research outsourcing from suppliers goes beyond biomaterials to include the development of new metal alloys, major changes in manufacturing processes and corrosion control technologies. There are two cases of outsourced research that have received support from Brazilian S&T funds: the Pematech-UNESP project on biomaterials and the Agrostahl-USP project on new Ni alloys. These are recent projects reveal an emerging good-will and interest in Brazilian automobile companies and RI to increase outsourcing (if not technological cooperation). In both cases, projects are supported by new Brazilian S&T institutions and funds (e.g., the FundoVerde-Amarelo), which have given priority to technological and industrial applied research. The case of Pematech is also interesting because it involves the indirect participation of VW (VolksWagen do Brasil) and the support of FINEP (Financiadora de Estudos e Projetos), the main federal agency for funding applied research in companies. Pematech has developed curauá fiber-based fillings for the interior of the VW Fox. The application technology and fiber production requirements led Pematech to establish a partnership with a major research group at UNESP , which specializes in natural fiber agriculture and its industrial application. The project received considerable support from FINEP to fund the university's part of the development, in addition to the investment made by Pematech.

Figure 2 - Research/Development contracts outsourced by suppliers to Brazilian research institutions

Firm	Technology/Content of project	Functional area	Type of project
Eaton	Ultra-fine grain steel - application	Weight	Service
	Plasma nitritation in metals	Durability	Service
	Adhesive development	Durability	Service
Pirelli	Modification in copper wire manufacturing	Weight reduction,cost	Research (2 years)
	Analysis of corrosion in components	Durability	Service
Bosch	New types of fuels	CO2 reduction	Service
Sabó	Development of innovations in high performance elastomers	Durability	Research
Agrostahl	New NiCrAlC alloys	Durability	Research (2 years)
	Surface treatment – friction reduction	Durability, cost	Service
Pematech	Biomaterial composite development	Environment, weight reduction	Research (2 years)
Teksid	Simulation of mechanical fatigue-fracture	Durability	Service
Tupy-FrasLe	Characterisation of wearing factors (metals)	Durability	Service
Sifco	Ultra-fine grain steel - application	Weight reduction	Service
Mangels	Quality in casting	Cost, durability	Service
Mahle-Cofap	Analysis of corrosion	Durability	Service
Toro	Biomaterial composite development	Environment, weight reduction	Research
Lord	Adhesives for aluminum	Safety	Service

Ourofino	Manufacturing of under-ride truck guard	Safety	Service
Non-disclosed	Metal casting and solidification development	Weight reduction	Service
Non-disclosed	Equipment development for corrosion control	Durability	Research (3 years)

Source: Developed by the authors.

Service outsourcing contracts to Brazilian RGs also present greater diversity amongst suppliers than assemblers. Again, it is important to emphasize that services here are generally related to what could be called engineering with science fundamentals rather than short-term, testing-like services. The typical situation is one in which the adaptation or improvement in a given component requires materials technology knowledge, which is beyond the capabilities of the company's Brazilian product development team (usually in a multinational corporation). Thus, in such contracts, the Brazilian RG works as if it were a replacement for the company's central R&D lab, supplying solutions to the Brazilian engineering team. There are various reasons why this is so, some of which the authors have recently discussed with supplier product development engineers. First, there are specificities involving applications, cost parameters, and implications of the weather and temperature in Brazil, all of them with implications for materials technology, which make it difficult and costly for central labs to provide prompt, efficient solutions. Second, central labs are often too busy attending the corporation's priorities and cannot afford to dedicate the time the Brazilian subsidiary requires. In the case of domestic suppliers, the explanation is similar, the difference being that there is no central lab to turn to and problems arise either from the adaptation of licensed technologies or from new technology development, as in the case of Pematech.

5. CONCLUSIONS

Why do companies work together? How to identify, qualify and select potential partners to take part of collaborative activities? Which elements are important for a successful alliance between companies and partners? Which elements may lead an alliance to fail? How to manage external partners for innovation? How to measure and evaluate the contribution of external sources of knowledge for innovation?

Considering a competition-based environment, companies have to develop and learn (how to learn) from an innovative structure and culture so that they may be successful. This is crucial because the shortening of a product's lifecycle obliges companies to innovate often and develop technologies, processes, products and/or services more efficiently. Furthermore, there is an increase in costs and risks to innovate owing to the rising complexity of products, technologies and processes. a fact that increases the uncertainty and pressures on the R&D (Research and Development) budget (Anthony et al., 2011; Bueno & Balestrin, 2012; Chesbrough, 2007, 2012a, 2012b; Huston & Sakkab, 2006; Takahashi, 2011; Tidd et al., 2008). At the same time, there is a growing need for interdisciplinarity through cooperation (OCDE, 2008).

Technological innovation is more than a technical process ; it is an uncertain, risky and complex social process, based on learning and knowledge , both external and internal to the company. Also, it depends on the development and exploration of core competencies, resources and capabilities (Barney & Hesterly, 2008; Prahalad & Hamel, 1997) and the integration and participation of multiple actors (Carvalho et al., 2013; Lazonick, 2005; Pavitt, 2005).

The essence of innovation is the ability to mobilise and coordinate resources/capabilities (financial, physical, human and organizational) and actors internal to the company, as well as resources/capabilities and actors outside the company (customers, suppliers, research institutions, and funding agencies), neutralize threats and, above all, explore opportunities aligned to the company's strategic priorities (Barney & Hesterly, 2008; Carvalho et al., 2011, 2013).

This multidimensional process – which has to be learnt, controlled and continuously improved – comprises negotiation, selection of decisions from alternatives, strategic choices as well as behavioral patterns (routines) that also have to be learnt, integrated, internalized and reinforced (Tidd et al., 2008). When these patterns are structured and embraced in the daily practices of a company's staff (and its partners), they become second nature.

Thus, strategies, routines and organizational forms, based on the competitive intelligence for the technological cooperation and the strengthening of the company-university interaction, should be developed and used by companies to foster and facilitate technological innovation.

This paper has drawn on the methodological developments and implementation results of an applied research carried out by the authors for the Technocentre of Renault SAS. It has tackled an important problem faced by the assembler regarding the implementation of the recently adopted policy of increasing the outsourcing and off-shoring of R&D, including emerging country research institutions as possible partners. The questions posed to Renault are similar to the ones we presented in section 2: how to manage the search of eternal partners for R&D? How to prospect and qualify potential partners?

The method developed and implemented by the authors is a response to these questions, which is intended to allow a strategic search by the company, as the database produced presents features that seem to assure this target. First, it is oriented towards the technologies that are considered relevant for the company's innovation objectives. Second, it is comprehensive and representative of the primary technological fields to which such technologies belong. Third, the scope and methods of data collection allow for emerging, not-yet-known technological opportunities to be mapped and influence the definition of strategic R&D objectives. Finally, the method can be reproduced and transferred to other countries and lead to other surveys for updating the database.

Although the content of the survey carried out for Renault is very industry specific, we suggest that the lessons and procedures learnt while developing this mehtod can be applied in mapping out technological research competencies in other business contexts. The most relevant lessons are listed below:

1. It is very important to start by deciding on the critical dimensions of the search: scope of the search, concepts and indicators for operationalizing the relevant dimensions of the search (for instance: a clear operationalization of the team competencies), strategy of data collection and unit of investigation;
2. The partner identification phase (either RGs, researchers or institutions) requires good knowledge of the research environment and of S&T institutions that will allow for the definition of procedures, thus assuring the comprehensiveness and representativeness of the identification;
3. The phase of approaching partners and collecting information requires good communication skills and infra-structure, patience and persistence, good planning and well-organized follow-up;
4. The organization and tabulation of data (the database) should be kept as simple as possible; retrieving simple reports rather than complicated cross tabulations is what best fits the process of learning how to use these tools;
5. Finally, it is important to validate the results of the method's implementation, i.e., demonstrate the comprehensiveness and representativeness of such results, so that users will more confidence when applying it.

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ESCOLHENDO COM PRECISÃO: INTELIGÊNCIA COMPETITIVA NA PROSPECÇÃO DE PARCEIROS PARA COOPERAÇÃO TECNOLÓGICA

RESUMO

O artigo discute os resultados de um projeto cujo objetivo foi desenvolver e testar uma metodologia para a identificação, qualificação e classificação das competências dos grupos de pesquisa brasileiros em tecnologias aplicáveis à indústria automotiva. O projeto foi encomendado pelo centro de P&D (Pesquisa e Desenvolvimento) de uma grande empresa multinacional no ramo de fabricação de automóveis. O argumento central do trabalho aponta para a necessidade de as empresas gerenciarem de forma sistemática, e não empiricamente, suas fontes externas para inovação. O artigo introduz o conceito de pesquisa estratégica - espécie de inteligência competitiva - nas rotinas voltadas para a gestão das fontes externas, especialmente, com foco em prospecção e qualificação de parceiros externos para P&D. A contribuição deste trabalho é a proposição de um novo uso (estratégico) para a metodologia Bola de Neve, originalmente empregada para mapear grupos de risco. O resultado da aplicação da metodologia é um banco de dados (com 265 grupos de pesquisa) com informações quantitativas e qualitativas sobre competências tecnológicas aplicáveis à indústria automotiva nas áreas tecnológicas de Materiais, Motores e Combustíveis, Manufatura, Eletrônica Embarcada e Ergonomia (interação homem/máquina).

Palavras-chave: Mapeamento de capacidades tecnológicas; Metodologia Bola de Neve; Gerenciamento de fontes externas para inovação; Busca estratégica de parceiros externos; Cooperação tecnológica.

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