ELISA THOMAS

THE ROLE OF INTERMEDIARIES IN COLLABORATIVE RESEARCH AND DEVELOPMENT PROJECTS

Thesis submitted to the Universidade do Vale do Rio dos Sinos (UNISINOS) in partial fulfilment of the requirements for the degree of Doctor in Management.

Supervisor: Prof. Dr. Alsones Balestrin
Co-supervisor: Prof. Dr. Jeremy Howells – University of Southampton

2014

Ficha Catalográfica

T454r Thomas, Elisa.
The role of intermediaries in collaborative research and development projects. / by Elisa Thomas. – 2014.
184 f. : il. ; 30cm.

Tese (doutorado) — Universidade do Vale do Rio dos Sinos, Programa de Pós-Graduação em Administração, São Leopoldo, RS, 2014.

"Orientação: Prof. Dr. Alsones Balestrin, Ciências Econômicas; Co-orientador: Jeremy Howells, University of Southampton".

1. Administração – Empresa – Intermediários. 2. Colaboração. 3. Inovação aberta. 4. Transferência de tecnologia. 5. Pesquisa e desenvolvimento – P&D. 6. Núcleo de Inovação Tecnológica – NIT. I. Balestrin, Alsones. II.Howells, Jeremy. III. Universidade do Vale do Rio dos Sinos – Unisinos. III. Título.

CDU 658

Catalogação na Publicação:
Bibliotecária Camila Quaresma Martins - CRB 10/1790

APPROVAL FORM

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Approved in May 2014.

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ABSTRACT

It has long been stated in the literature the effects of collaboration to innovation, especially regarding research and development (R&D) activities. However, these are dynamic empirical fields. Therefore theoretical approaches face constant challenges to understand and explain the new evidences. Due to the limited scope and scale of organizations to search and identify partners with complementary knowledge and resources, and to select those with potential to effectively cooperate for R&D, there is an increasing emergence of agents who provide these services in the market. Called intermediaries or brokers, they influence the interaction among organizations with the common goal of innovation. Still, the literature has reported that the intermediary may play an important set of functions for R&D projects not limited to the search of partners.

This thesis is therefore mainly concerned with the influence of innovation intermediaries in the context of collaborative R&D projects, suggesting a conceptual framework on the role of intermediaries. The framework emphasises that R&D collaboration goes beyond dyadic relationships usually highlighted in the literature. The roles of intermediaries provide an important additional dimension in collaborative R&D projects.

The empirical part of the thesis explored three case studies: Force for Elastomers, from the Federal University of Rio Grande do Sul in Brazil; the Orange Service Call and Reward project undertaken by the National Endowment for Science, Technology and the Arts (NESTA) for Orange; and the StarStream project from the University of Southampton, both in the United Kingdom.

The results confirmed the influence of innovation intermediaries in most of the critical elements of a R&D project. The study advances the understanding of the influence of intermediaries for the beginning of a new project between partners. The analyses also show that intermediaries influence especially through the search for possible partners and the management of the relationship. However, the activities of research and knowledge production as well as activities of development and prototyping were not directly influenced by intermediaries. The stage after R&D, when the partners had reached positive results from activities, received a major influence from intermediaries who helped the firms to protect the inventions and to value and commercialize the new technology. Research outcomes still reveal that there is still a lack of measurements about intermediaries' effectiveness and therefore firms involved in partnerships cannot fully evaluate their role.

Keywords: intermediary, broker, open innovation, R&D, collaboration, partnership, intellectual property commercialization, technology transfer.

ACKNOWLEDGEMENTS

This thesis has been a rich and rewarding experience and would not have been possible without the help of some people and institutions.

I would like to thank my supervisor Prof. Dr. Alsones Balestrin, who provided me with guidance and insights, and for sharing his experiences. Also, I am grateful for the supervision of Prof. Dr. Jeremy Howells, from the University of Southampton, during a year of stimulating discussions for theoretical framework development and data collection in the United Kingdom.

I am thankful to CAPES of Brazil for providing the financial support that has made the research in the United Kingdom possible.

I would like to express my sincere gratitude to all research respondents who took out time to provide data and were very polite, open and sincere. Without their valuable information, this research would not have been possible.

Finally, I would like to thank my friends and family members, especially my parents, for the constant support and encouragement throughout this long and often overloaded period of time.

Thank you all very much!

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LIST OF ABBREVIATIONS

CM: collaboration manager

IOR: inter-organizational relationship

IP: intellectual property

NESTA: National Endowment for Science, Technology and the Arts

NPD: new product development

NSI: National System of Innovation

OI: open innovation

OSCR: Orange Service Call and Reward

R&D: research and development

R&IS: Research and Innovation Services

SEDETEC: Secretary for Technological Development

SMEs: small and medium companies

TTO: technology transfer office

UFRGS: Federal University of Rio Grande do Sul

UK: United Kingdom

1. INTRODUCTION

Innovation is a key factor for the competitiveness of an organization in the market. More than that, especially in industries where products have short life cycles and the competitive environment rapidly changes, the ability of a company to get involved in severe continuous change has a direct impact on its survival (BROWN; EISENHARDT, 1997). However, the technological development of products and process is complex and risky, demanding high investments and the integration of a range of activities. The complexity of innovation comes from varied reasons, including economic, social and technologic elements added to the diversity of types of firms and environments where the organization may be inserted in.

Even within this scenario, the generation of knowledge has been happening through increasingly faster dynamics; but despite considerable investments to develop new products, the success rates of research and development (R&D) activities are generally below 25% (EVANSCHITZKY *et al.*, 2012). The global expansion of markets, and therefore the increasing competition, caused an end to stable competitive advantages and also caused the exhaustion of the traditional hierarchical firm that used to create new products and processes in-house, according to what Chandler (1990) had declared a way of providing a barrier to entry.

The growing complexity of current technological products and processes, coupled with their short life cycles, results that a single organization may not have all the skills needed to perform R&D activities. Aiming at fulfilling these gaps of knowledge and resources, the innovation process has become more open and collaborative. Internally generated and financed research is giving way to external R&D collaboration among previously unaffiliated organizations (CHESBROUGH, 2003; POWELL, 1987). To reach the desirable result, R&D activities may require the participation of several organizations with the goal of generating complementary knowledge and resources needed to make the development of new products and processes possible.

Through cooperation between firms, the cost of R&D becomes cheaper, and the generation of new ideas may be increased as well as the quality and

effectiveness of R&D activities and the speed of discoveries. The challenge then is to establish effective relationships with partners that complement resources and knowledge, resulting in the development of new products and processes. Therefore, while firms identify advantages of working together with other organizations, they become dependent on their ability to identify partners with complementary expertise and resources, to select those with potential to effectively cooperate and, when the relationship is established, to carry out joint actions and the performance of R&D activities.

Therefore, one of the barriers to the formation of networks for innovation identified by Pittaway *et al.* (2004, p.146) is the lack of technical and commercial skills to attract partners when firms have just few connections. Complementing, Kotabe and Swan (1995, p.623) argue that “it is difficult to attract willing partners because revolutionary innovations and cooperative ventures are fragile, vexatious to manage, and often fail”. These facts may explain why collaborative initiatives for R&D still struggle to effectively happen in the market. According to these authors social institutions may influence the formation of relationships by offering cultural conditions and infrastructure, and by acting as intermediaries in the formation of inter-organizational network.

As a consequence of the limitation in the search of individual firms for partners, the market faces the increasing emergence of agents who provide service for the search and selection of other organizations with which the innovator may collaborate, fostering the interaction among organizations with the common goal of innovation (CHESBROUGH *et al.*, 2006; HOSSAIN, 2012). Called intermediaries, brokers or innomediators (HACIEVLIYAGIL *et al.*, 2007), they organize the formation of relationships that would not exist if there was no need for complementary knowledge and resources among organizations involved in the development of new products (DNP) or no need for negotiation and coordination of joint projects. Thus, the intermediary may play an important set of functions within the innovation system as mediator or facilitator of the process of cooperation (HOWELLS, 2006).

The entire understanding of the intermediation is still unclear due to the diversity of types of agents who perform brokerage roles and who influence collaborative initiatives. Bessant and Rush (1995, p.101), for example, list technology brokers, university liaison departments, regional technology centres and innovation

agencies as intermediaries. Van Der Meulen and Rip (1998) add research councils, funding agencies and research institutes also as intermediaries. Considering this diversity, it is hard to achieve an encompassing concept of the intermediary. In this thesis, intermediary is the type of organization located between the source and the seeker of knowledge and resources needed for R&D, not always belonging to the network of organizations that perform R&D activities.

The literature on collaboration for R&D has reported fundamental activities to inter-organizational relationships promoted by a third party acting as an intermediary (GASSMANN *et al.*, 2011; GIANIODIS *et al.*, 2010; WINCH; COURTNEY, 2007), even though its performance has not been completely understood by scholars. Concerned primarily with the activity of selecting the right partners, the literature contains separate studies, indicating the lack of a holistic approach that covers the range of activities undertaken by the intermediary in joint R&D projects. Agogue *et al.* (2013) say that beyond solely brokering and networking, intermediaries may also take an active role in the process of joint exploration and creation of knowledge. The empirical field evidences the growing occurrence of these initiatives, but not as effectively and often as they could be. If, on the one hand, the literature is advanced regarding the benefits of collaborative R&D, on the other hand, there is a gap to be answered on to the role of intermediaries in these projects. Therefore, in order to achieve this understanding, the study sought to answer the question:

How are intermediaries influencing collaborative R&D projects?

Given the context of the problem, the central proposition of the study is that collaborative R&D projects may be facilitated by intermediaries. This proposition leads to the following general objective of the research:

To propose a conceptual framework explaining how intermediaries influence collaborative R&D projects.

Complementary to the general intent, there are some specific goals to be achieved during the research:

a) To understand characteristics of innovation intermediaries;
b) To analyse the role of intermediaries in identifying potential partners, and in promoting the interaction among organizations for collaborative R&D projects;

c) To analyse the role of intermediaries in the access of resources needed for R&D as well as their role directly in R&D activities performed jointly by organizations; and
d) To analyse the role of intermediaries in coordinating collaborative R&D projects as well as in helping the decisions about the results of the project.

To answer the research question, a multiple case study was performed with intermediaries in Brazil and in the United Kingdom. Different profiles of intermediaries were researched in order to achieve a better understanding on how they influence collaborative R&D projects. Therefore, private and public organizations acting as brokers were the objects of study. Recognizing that key elements for R&D are systemic and non-sequential in nature, a conceptual framework derived from the process of innovation approach guides this research.

1.1 RATIONALES FOR THE RESEARCH

The present thesis sets out to contribute to theoretical studies in the organizational area, to the practical management of interorganizational cooperation for R&D and also to the personal and professional growth of the researcher.

The facts expressed previously in this Chapter show an open ground for conducting research in the field of intermediaries for cooperation regarding new technology development. On the one hand, there is the theoretic evolution of new social and organizational relationships from the recent increase of intermediaries who do not perform R&D activities in a network (CHESBROUGH *et al.*, 2006; GIANIODIS *et al.*, 2010; HOSSAIN, 2012), which, by itself, justify specific research on the subject. On the other hand, there are the advances of this approach and the study of the dynamics considering the influence of the intermediary on ongoing collaborative projects, and not only the focus on the intermediary itself. The importance of understanding the specifics of this process, as well as its elements and influencers, is to allow the possibility to explain part of the creation of technologies in the economy nowadays. The combination of these two aspects results in a unique research

opportunity which combines contemporary theoretical advances with its empirical verification.

Therefore, from the theoretical point of view, the results achieved can complement the existing knowledge with respect to the intermediation of activities specifically in the area of management of interorganizational arrangements and of innovation. Although challenging issues, this research will contribute to the growth of theory, promoting the debate on the subject and discussing the empirical problems of intermediation.

Empirically, this research is justified by the contributions it may bring to the practical management of interorganizational projects for R&D. Innovation can generate economic results impacting the competitiveness of a company in the marketplace. In Brazil, one may see that 88.4% of industrial enterprises and 86.8% of service providers from innovative companies claimed to have obtained some sort of significant impact (high or medium degree) because of innovation, according to analyses of the Survey of Technological Innovation (Pintec) between 2006 and 2008. Among the major impacts, one may see those associated with: the company's position in the marketplace (kept or expanded its share - 76.0% and 68.3%, respectively, in industry, and 80.6% and 70.5% in services); improving the quality of goods or services (75.2% in industry and 79.0% in services); and the increase in production capacity (68.0% in industry and 68.8% in services) (IBGE, 2010).

In order to achieve innovation, the activities are performed in cooperation with other organizations. However, from the industrial side, cooperation is not an established practice for most companies seeking to innovate. The amount of partnerships with external organizations amongst the companies that implemented innovation in different periods of time is presented in Table 1.

Table 1 - Total innovative companies, and with cooperation

Period	Total of companies that implemented innovation in the production industry	With cooperation with other organizations
2001-2003	27,621	1,041 (3.8%)
2003-2005	29,951	2,139 (7.1%)
2006-2008	38,364	3,790 (9.9%)

Source: Survey of Technological Innovation (IBGE, 2003,2005,2010)

Table 1 shows that cooperation for innovation has been increasing over the years – from 3.8% to 9.9% over the analysed periods. Even though, there is still a large space to grow. From the researched companies in the production industry, many of the innovative ones stated having problems and obstacles to innovate. More than a third of companies that have implemented innovations in industries, services and R&D stated *little chance of cooperation with other firms or institutions* as one of the obstacles (IBGE, 2010). Among product innovation in industrial organizations, 19,472 affirmed that *the firm itself* was the main responsible for the product development, while only 1,756 said that the main responsible for developing the good was the company *in cooperation* with other firms or institutes, as shown in Table 2. The data refers to the period between 2006 and 2008.

Table 2 – Main responsible for product development in Brazilian innovative industrial enterprises

Main responsible for product development in innovative companies	
The firm	The firm in cooperation with other organizations or institutes
19,472	1,756

Source: Pintec (IBGE, 2010).

Internationally, the growth of collaboration in R&D is also recorded. This is reflected in the stronger emphasis given to the role of relations between the innovator and other organizations in the third edition of the Oslo Manual (OECD, 2005), the main global reference for research on innovation activities. Compared to previous versions of the Manual,

> Evaluation of linkages is expanded because of the importance of knowledge flows among firms and other organizations for the development and diffusion of innovations. This helps to highlight the role of organisational structures and practices that promote the sharing and use of knowledge and interaction with other firms and public research institutions (OECD, 2005, p.11).

In the United Kingdom, nearly half (47%) of 14,342 researched broader innovating enterprises[1] had co-operation arrangements on some innovation activities

[1] A “broader innovator” is considered a business that has engaged in 1) the introduction of a new or significantly improved product (good or service) or process; 2) innovation projects not yet complete or

in the period from 2008 to 2010.

> The majority of goods and service innovations are developed within the business (41 per cent and 49 per cent respectively). Around a fifth of service innovations are also developed by the business with other businesses or organisations (slightly less than goods innovations at 16 per cent) with just under a tenth of goods and services developed by other organisations (both 9 per cent). (BIS, 2012, p.8)

In a Japanese study involving 1,577 small and medium enterprises, 478 of them (30%) said they had cooperated with other organizations in the three previous years, and 315 companies (20%) participated in cooperative R&D. On this group, the vast majority (255 companies) manifested that cooperation in R&D was more important than other types of cooperation in production or sales, for example. However, even with the increased occurrence of collaborative R&D, less than half of these &D projects in small and medium Japanese companies succeeded (OKAMURO, 2007).

As can be seen from the data, collaborative R&D has become an organizational practice over the years. Although firms are increasingly aware of the potential benefits of innovation outsourcing including access to creative input and accelerated speed of new product developments, their ability to exploit them appears to be far more limited (TRAN *et al.*, 2011). Moreover, the management of relationships among organizations for R&D activities is being altered by the services of intermediaries. Therefore, this research is justified by the contributions it generates by empirically identifying the intermediaries' influence on collaborative R&D projects and by introducing a conceptual framework about the key elements of collaborative R&D influenced by third parties.

Additionally, this research is also justified by deepening the author's previous studies, representing a personal and professional growth. Prior research on cooperation for innovation has shown the existence of intermediated relations between R&D personnel and external partners such as customers and suppliers.

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abandoned; 3) new and significantly improved forms of organisation, business structures or practices and marketing concepts or strategies; and 4) activities in areas such as internal research and development, training, acquisition of external knowledge or machinery and equipment linked to innovation activities (Bis, 2012, p.6)

1.2 THESIS STRUCTURE

This thesis is organized into six Chapters. Following this Introduction Chapter, the theoretical basis of the research is presented in Chapter 2; the organization of the research with a section with the conceptual framework and a methodological section make Chapter 3; the empirical study is described on Chapter 4; the cross-case analysis is presented on Chapter 5; and Chapter 6 is a conclusion containing suggestions for future research, followed by the list of references and an appendix.

After the Introduction, which presents the objectives and the rationales behind the study, Chapter 2 develops the theoretical basis that provides the foundation for the research. It deals with innovation as a strategy for differentiation and survival of firms in the market as well as for the development of countries and regions. Then, cooperation as an organizational strategy is discussed, followed by the process of collaborative R&D, considering joint activities of research and development among organizations. The Literature Review narrows the focus to the intermediary and to the elements that form a collaborative R&D project, highlighting the influence of the intermediary on them. The premise here is that organizations, especially in high-technology segments, do not have all the resources and knowledge to innovate, and that relationships among organizations are a key factor for the effectiveness of R&D activities, because they allow the complementarity of these resources and knowledge. Therefore, performing activities for the development of new products (DNP) in partnership with other organizations is considered a strategy that leads to innovation, as well as to reduction of time and cost of DNP.

The next part, Chapter 3, brings the organization of the study. It presents the research propositions arisen from the literature review, as well as a conceptual framework representing the major key roles of intermediaries. It also presents the method and procedures used in the study, including the choice of research method, the units of analysis, sources of data and research phases.

The empirical research is presented in Chapter 4. There is one sub-chapter for each R&D project that received influence from the services of intermediaries. Subsequently, Chapter 5 extracts the significant findings from the three cases, presenting a cross-case analysis that discusses each of the research propositions

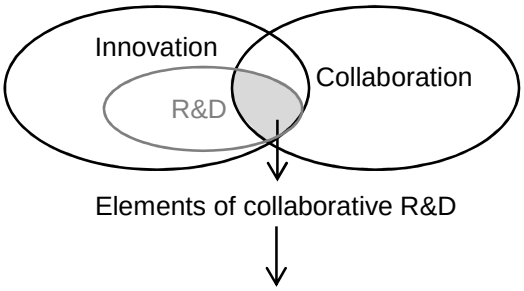
according to the empirical findings. Chapter 6 presents the conclusions, with a new framework based on the evidences and literature, contributing to theoretical deepening on the subject. In addition, it brings some recommendations with empirical implications for practitioners both intermediaries and firms engaged in collaborative R&D. Finally, the chapter considers the limitations of the research and provides some suggestions for future researches. The Conclusions chapter is followed by the list of references used in the thesis and an appendix.

This chapter provided a brief overview of the thesis focusing on the main idea, objectives and rationales of this research. The next chapters present the literature review on innovation and cooperation focusing on the discussion about intermediaries influencing key elements for collaborative R&D projects.

2. LITERATURE REVIEW

This chapter presents the theory review with the main authors and studies that raised propositions about the subject of intermediaries of collaborative R&D projects. Figure 1 shows how the literature review develops from the field of innovation, specifically research and development activities, and the field of collaboration into the general focus of the research.

Figure 1 – Development of the literature review



Each individual subject included in Figure 1 would have several aspects to be addressed, especially the fields of innovation and collaboration. Innovation may be researched through different focuses, considering characteristic that foster its achievement as knowledge, its processes and activities or its management. Furthermore it could address analyses of its different impacts for organizations and countries. For this research, we focus on R&D projects within the wide range of innovation subjects. Cooperation is also a wide field, which may generate studies about its motives, its formats or its different results for organizations involved. Moreover, each of its fundamental elements could be deeper analysed by itself. The focus of this research is the intermediary of relationships for collaborative R&D; the state-of-art therefore converges to this issue.

2.1 INNOVATION

Innovation is considered a factor of competitiveness and survival of firms. Tidd *et al.* (2005) affirm that competitive advantage started growing for organizations that are able to mobilize knowledge and technological advances and develop new products and services instead of having a competitive advantage coming from the size of the firm.

The positive results of investment in innovation are recognised by a wide range of scholars. Firstly, they identify macroeconomic benefits to countries and regions which invest in innovation. Pavitt (1984, p.343) acknowledges that the production, adoption and spread of technical innovations are essential factors in economic development and social change. For technological innovations to be developed and disseminated, Dosi (1988) states that it does not depends only on people or companies, but also on other institutions such as government agencies, universities and financial institutions. Then Lundvall (1992) presents the same proposition, developing the concept of Innovation Systems constituted by elements and relationships which interact in the production, dissemination and utilization of new and economically useful knowledge for the creation of technological innovations. Also according to Freeman and Perez (1988), the diffusion of new technologies does not mean only incremental improvements or the extension of the production capacity, but it involves a major change in various sectors of the economic system.

The National System of Innovation (NSI) is designed to be a driver of technological progress, seeking to narrow the technology gap with the international frontier (NELSON, 1993). The NSI is an institutional construction, consisted of planned actions involving firms, government agencies, universities, research institutes and other actors, with the common interest in innovation (LUNDVALL, 1992). According to Fagerberg (1988, p.371), there is a positive relationship between the level of innovation activities on productivity in different countries. He emphasizes that technological competitiveness is one of the main factors influencing differences in international competitiveness and growth across countries. That is why innovation management has received increasing attention not only from scholars and private companies, but also from the public administration. As a matter of fact, the concept of

innovation for firms and for public administration may present more than one meaning considering its results.

2.1.1 Concept and typologies of innovation

According to the Oslo Manual's definition (OECD, 2005, p.46), "innovation is the implementation of a new or significantly improved product (good or service), or a process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations". This concept follows the line of Schumpeter (1942, p.105), which identifies innovation as new consumer goods, new methods of production or transportation, new markets and new forms of industrial organization, explaining business cycles and the dynamics of economic growth. With the same view, Fagerberg (2005, p.4) defines innovation comparing it with the concept of invention: "invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice". However Freeman and Soete (1974) add to the concept of innovation the focus on technology getting diffused at the marketplace, not only its first introduction. The authors emphasize that the widespread diffusion of numerous innovations based on a new infrastructure is what matters for a major upswing and transformation of the economy in terms of new investments and employment. After them, Dosi (1988, p.222) endorses the adoption of the innovation in the marketplace. He says that "innovation concerns the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organizational set-ups".

Moving from the concept to the management of activities that lead to innovation, Lazonick (2005, p.30) emphasizes that innovation requires knowledge about technology and about the management of its own activities in order to be successful. He says that "innovation requires learning about how to transform technologies and access markets in ways that generate higher quality, lower cost products". Also Adams *et al.* (2006, p.21) present a synthesis of the process of managing innovation, consisting of seven categories: "inputs management,

knowledge management, innovation strategy, organizational culture and structure, portfolio management, project management and commercialization".

With the review, it becomes possible to observe that the concept of innovation is being modified as a consequence of years of organizational experience and academic studies. Different results from activities are considered innovation. However, not all innovations are the same. The Oslo Manual (OECD, 2005) divides innovation into four areas: product, process, marketing and organization. In comparison, Tidd *et al.* (2005) categorize innovation in different four forms: product, process, position and paradigm. Regardless of the difference in types identified in the cited references, the focus of this research thesis is placed on product innovation, as the following definition:

> A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics (OECD, 2005, p.48).

Evidences of new processes development are usually found when analysing product innovation, characterizing the result of technological activities. Moreover, an innovation may be considered a new product for the developer firm, and at the same time, it may be used as a new process for its clients.

Garcia and Calantone (2002) say that an abundance of typologies to identify innovations resulted in the same name being used for different types of innovations and the same innovation being classified under different typologies. As such, innovation can be classified according to its degree of newness: new to the firm, new to market and new to the world (OECD, 2005, p.57). Furthermore, it can be related to the impact that it causes to the marketplace and to economic activity of firms. In this regard, the Oslo Manual (OECD 2005) calls radical or disruptive innovation; however Tidd *et al.* (2005, p.31-32) rank the impact "from small incremental improvements to really radical changes that transform the way we use or see things. Sometimes these changes are common in some sectors or activities, but sometimes they are so radical and so beyond that will change the very basis of society". On the other hand, Utterback (1996, p.200) states that a discontinuous or radical innovation is the change that eliminates "much of a firm's existing investment in technical skills and

knowledge, designs, production technique, plant and equipment". From Utterback's position, continuous or incremental innovations result in standardization and *status quo* within the business or the industry.

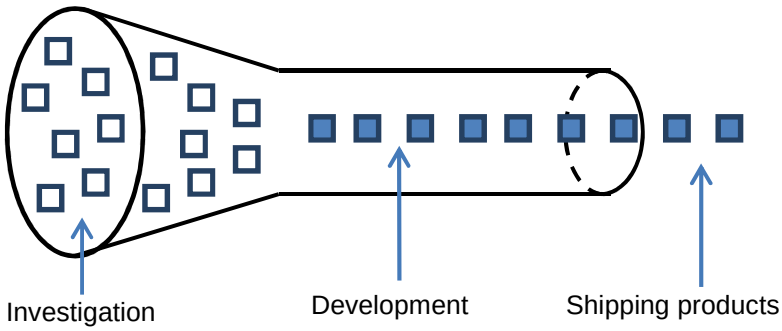
Considering that the innovation new only for the company refers to something already in the marketplace, it is not the object of this research, because relationships to the development of new products are justified by the need for complementarity of knowledge and resources. Thus, collaborative R&D proves to be fundamental for the development of new products to the marketplace or to the world. The next section presents some processes and projects' models of performing R&D activities for innovation.

2.1.2 Process of innovation

Different projects for the DNP pass through some common activities, what indicates a similar process in all cases. Most of them undergo from idea generation, through R&D activities to reach the expected result. Before its conclusion, a R&D project may include activities of scientific, technological, organizational, financial and commercial features.

Wheelwright and Clark (1992) suggested a graphic structure called the *funnel of innovation* illustrating how projects for new products and processes move from idea to reality, as illustrated at Figure 2.

Figure 2 – Funnel of the DNP process



Source: Wheelwright and Clark (1992).

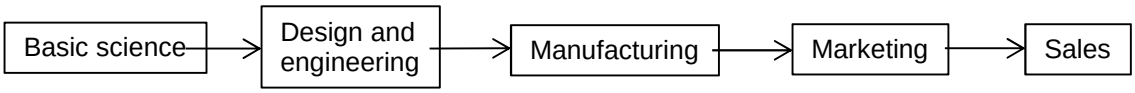
Firms ideally identify many ideas, select the few most promising for development, and then focus resources to get them into the marketplace. Figure 2 shows blank squares representing ideas for investigation and dark squares indicating ideas that are developed.

According to Clark and Wheelwright (1993, p.293), “a variety of different product and process ideas enter for investigation, but only a fraction become part of a full-fledged development project. Those that do are examined carefully before entering the narrow neck of the funnel, where significant resources are expended in transforming them into a commercial product and/or process”. Figure 2 does not detail the activities performed by the firm to transform an idea into a product or a process. There are other models that complement Wheelwright and Clark’s approach. Traditionally, the innovation process has been characterized by a linear model, based on the assumption that innovation is applied science, as explained by Fagenberg (2005):

> It is ‘linear’ because there is a well-defined set of stages that innovations are assumed to go through. Research (science) comes first, then development, and finally production and marketing. Since research comes first, it is easy to think of this as the critical element (FAGERBERG, 2005, p.8).

The linear flow begins with the discovery of a novelty from basic science (i.e. pure research), which is not intended to practical application. Then it goes through applied research or “design and engineering” in the words of Rothwell (1994), stage that identifies the economic potential of the discovery and finds it a practical use. The next phase is the development of the new process or product to be manufactured and commercialized, culminating in the production of a prototype. Finally, the flow of innovation follows to the manufacturing and marketing of the novelty to be sold and diffused in the marketplace, as illustrated at Figure 3.

Figure 3 - Linear flow of innovation activities



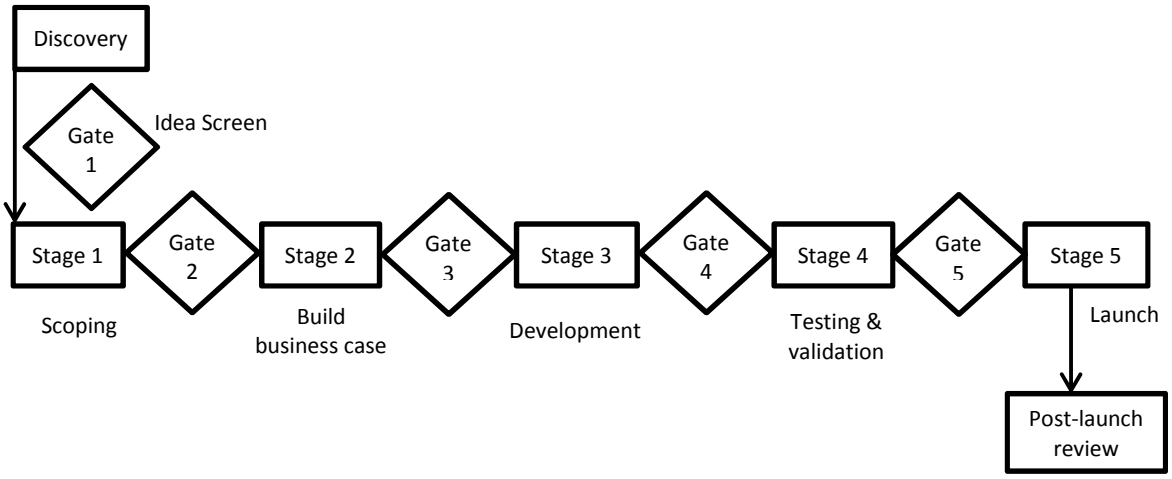
Source: Rothwell (1994)

According to the flow shown at Figure 3, the success of basic research, design and engineering is reflected in the sales' success of the new product of process launched. The model assumed that more R&D would result in more successful new products in the market. When the flow starts from a discovery through basic research, it is called *technology push*, meaning that a new invention is launched to the market through R&D, without primarily considering users' need. This model is also called the first-generation innovation process by Rothwell (1994). In contrast, a *market pull* innovation is developed by R&D to meet an identified market demand. In this flow, the innovation can present the absence of technological progress in comparison with the *technology push* flow. On the other hand, the resulting innovation will probably get diffused easier on the marketplace for emphasizing user's demands. Rothwell (1994) addresses this flow as the second-generation innovation process.

More detailed than the models just described, the stage-gate model was developed by Robert Cooper throughout the eighties and is still being improved. Focusing on industrial innovation, it illustrates the activities for the DNP, as can be seen at Figure 4. The model describes the innovation process since the discovery of an opportunity for a new product (the idea) until its launch in the market, indicating the activities that must be performed at each stage and the criteria for evaluating these activities. From this model, the authors argue that it is possible to formally and systematically control the quality of activities' execution identifying the activities being poorly made and the gaps in the process of developing new products (COOPER; KLEINSCHMIDT, 1986). The stage-gate model illustrates common steps of the DNP; however, not all projects go through all stages. According to the complexity, size and

risk of the development, some phases may be removed or added. As an example, Phillips *et al.* (1999) describe the organization of the stage-gate in six companies (Kodak, General Electric, Bombardier, Rolls-Royce, Lucas and Motorola), indicating that the number of stages varied from four to ten.

Figure 4 - Stage-gate model



Source: adapted from Cooper (2008)

In general, each stage, illustrated at Figure 4, represents a group of activities; and each gate is a review and an evaluation point of the previous stage. The gates are moments of decision making in relation to the development process, using information generated from the activities undertaken at the previous stage.

Figure 4 shows a general flow for innovation activities, starting with the idea and ending with a review after launching the new product in the marketplace. Considering this Schumpeterian view of innovation since its beginning in the company until its successful marketing, the linear flow does not completely reflect the current reality of knowledge generation. That is because not all the beginnings of the R&D flow culminate in a successful commercial innovation in the marketplace. Therefore, to validate the success of R&D efforts only through a Schumpeterian view may be limited, because the return on investment in pure research is uncertain, however it contributes to scientific and technological developments.

Since 1979, Mowery and Rosenberg stated that technology-push and market-pull models were extreme and atypical examples of a general process of interaction between, on the one hand, technological capabilities and, on the other hand, market needs. According to them, “both the underlying, evolving knowledge base of science and technology, as well as the structure of market demand, play central roles in innovation in an interactive fashion, and neglect of either is bound to lead to faulty conclusions and policies” (MOWERY; ROSENBERG, 1979, p.105). In 1986, Kline and Rosenberg added that interactions between science and technology in the modern world are strong. They said that “not only innovation draws on science, but also that the demands of innovation often force the creation of science” (KLINE; ROSENBERG, 1986, p.287).

This interactive perspective is called by Rothwell (1994) as third-generation innovation process representing the confluence of technological capabilities and market-needs within the innovating firm. From the early 1980s to the early 1990s, the fourth-generation emerged with global strategies and rapid growth in the number of strategic alliances between companies. According to him, “not only large firms, but also innovative small firms were engaging in intensive external networking activity” (ROTHWELL 1994, p.11).

Lastly, the fifth-generation innovation process includes all the activities from previous generations with a growing concern over the degradation of the physical environment. He explains that

> leading companies remain committed to technological accumulation (technology strategy); strategic networking continues; speed to market (time-based strategy) remains of importance; firms are striving towards increasingly better integrated product and manufacturing strategies (design for manufacturability); greater flexibility and adaptability are being sought (organizational, manufacturing, product); and product strategies are more strongly emphasizing quality and performance features (ROTHWELL 1994, p.12-13).

As stated, there are several activities happening at the same time in a non-linear process. Bessant and Rush (1995) also say that models of innovation activities in firms are characterized by multiple interactions. Some flaws of the linear model were pointed out by Kline and Rosenberg (1986) when they affirm that the innovation process needs feedbacks paths, which do not exist in a linear organization of the

activities. They cite feedbacks within the ongoing work of development as well as from sales figures and from individual users. According to them, “all these forms of feedback are essential to evolution of performance, to formulation of the next steps forward, and to assessment of competitive position” (KLINE; ROSENBERG 1986, p.286). Even Cooper (2008), with his well-known stage-gate model, currently evidences flexibility of the innovation process. As he goes on to explain,

> The notion of a rigid, lock-stepped process is dead. Today’s fast-paced Stage-Gate is flexible, allowing the project team considerable latitude in deciding what actions are needed and what deliverables are appropriate for each gate, and adapting to dynamic information. (…) Flexibility is also incorporated into the process by employing the principle of “simultaneous execution”—activities that were traditionally done in a series overlap and are done in parallel (COOPER, 2008, p.7-8).

Even so, the linear flow is still being used by several studies with pedagogical reasons for its ease of visualization and understanding of innovation activities. As seen, it begins with a new idea, which depends on the generation of new knowledge (NONAKA; TAKEUCHI, 1995) either within the firm or from external sources. In the words of Cohen and Levinthal (1990, p.7) “outside sources of knowledge are often critical to the innovation process, whatever the organizational level at which the innovating unit is defined.”

Besides knowledge, other resources are needed to enable the achievement of innovation activities throughout the flow. Adams *et al.* (2006) identify inputs as one of the seven major areas of innovation activities, including financial, human and physical resources. Metrics commonly used for innovative activities, such as the percentage of expenditure on R&D or the number of employees in these activities are examples of resources. Brown and Svenson (1998) define resources as the raw material or the stimuli received and processed by a system. Specifically on the resources required to complete the activities in R&D facilities, the authors cite people, information, ideas, equipment, infrastructure and financing.

The variables “dedicated human resources and dedicated R&D resources” were considered strategic predictors of a new product performance by Henard and Szymanski (2001). Based on this study, Evanschitzky et al. (2012) found that the effects of dedicated human resources are stronger to the success of new products in high-tech markets than in low-tech markets. The commitment of other company’s

resources, patents and knowledge for example, to new product development initiatives was a variable included among the factors that determine the success of new products. In both studies, the definition of *dedicated human resources* is “focused commitment of personnel resources to a new product initiative”. Similarly, the variable *dedicated R&D resources* is defined as “focused commitment of R&D resources to a new product initiative”.

To conclude, as seen from previous literature, innovation process is not linear. It is systemic in nature, includes many factors and takes place within a broad system. Research at the frontiers of knowledge is inherent to high-technology sectors (KEEBLE; WILKINSON, 1999). So the discovery of a new thing may represent the success of research activities. Thus, it is not necessary to turn the discovery into a product and take it to the marketplace for the innovative effort to be positive. The achievement from basic research may result in theoretical knowledge or in an applied knowledge, without economic potential. The innovation success therefore is validated based on the findings of scientific research without immediate economic value, on the growth of techno-scientific basis of the country and the world, on identifying practical potential for scientific discoveries without its necessary market diffusion and on the implementation of non-for-profit innovations aimed at improving the quality of life. Table 3 summarizes the concepts identified in the literature as fundamental to innovation.

Table 3 - Key elements for innovation

Key elements for innovation	Concept of the element	References
Knowledge generation / research activities	Discoveries of novelties from basic science, pure research, not resulting in a direct application.	Cohen and Levinthal (1990) Fagerberg (2005) Keeble and Wilkinson (1999) Kline and Rosenberg (1986) Nonaka and Takeuchi (1995) Rothwell (1994)
Development activities	Where the practical use is found; design and engineering of a new product or process; production of a prototype.	Cooper (2008) Cooper and Kleinschmidt (1986) Phillips *et al.* (1999) Rothwell (1994)
Resources	Human and financial resources, as well as infra-structure as laboratories and equipment available for innovation activities.	Adams *et al.* (2006) Brown and Svenson (1998) Evanschitzky *et al.* (2012) Henard and Szymanski (2001)

As Table 3 shows, both research activities, with the generation of new knowledge, as development activities allow the generation of new products and processes. With equal importance, and not separated from R&D, human and financial resources and infrastructure are also key elements for innovation.

The next section discusses the cooperation as an organizational strategy, addressing benefits to organizations, achieved results, coordination of relationships, among other subjects.

2.2 COOPERATION

The subject of cooperation among organizations has raised many studies, either about the issues that precede the decision to form alliances, or about the result of partnerships. Several theoretical perspectives are used to address concepts and methods related to inter-organizational relationships, as the studies of resource dependence, power, economics and political science, transaction cost theory, agency theory, institutional theory, among others (HIBBERT *et al.*, 2008, p.392). Considering that cooperation among organizations is also an empirical field of knowledge, it is natural that theoretical perspectives overlap field analysis.

Traditionally, the activities in an organization can be performed internally or acquired in the market. The first option is vertical integration, in which a company performs all functions required for the production of goods, such Henry Ford's enterprises in the past. The other option for performing the activities is subcontracting, such as the management of the company Nike, in which the functions are carried out by other organizations, in a market traded relationship (JARILLO, 1993, p.13).

Following the theory of transaction cost economics (TCE), from Coase (1937) that presented the vertical firm and the market as two alternative methods for coordinating production, Williamson (1975) states that assets which are only valuable to particular sellers or buyers should be conducted inside the firm. Market transactions would be only justified for assets with low specificity. Economic theories of organization, in particular the TCE, consider organizations as systems of

governance, designed to reduce transaction costs by means of incentives, monitoring, and control. In this approach, “market and hierarchy” are the two institutional forms of organizing economic activities. However, Remneland-Wikhamn and Knights (2012) point out that

> the belief that hierarchical control automatically defeats opportunism and other ineffective transaction costs is very much questionable since transaction costs are unlikely to disappear just by establishing boundaries around certain organizing activities – especially regarding innovation work involving multiple actors (REMNELAND-WIKHAMN; KNIGHTS, 2012, p.287).

Market relations between firms generate transaction costs that arise from a) the companies’ need to protect themselves against possible opportunistic behaviour by the other economic actors, and b) the bounded rationality of the decision maker, because of its inability to predict all future changes in the market (SIMON, 1972). These situations should be prevented or minimized so that the relationship is efficiently performed. The way that companies try to get this reduction is drafting contracts. Nevertheless considering the bounded rationality of organizational subjects and unpredictability of R&D outcome, contracts may not cover the diversity and variation of the practices involved in innovation. R&D activities require a certain level of autonomy for their execution and may be difficult for managers to monitor. Noteboom (2008, p.609-610) explain that “rapid innovation increases uncertainty of contingencies and makes formal governance, especially governance by contract, difficult to specify, which increases the need for collaboration on the basis of personal trust”.

Thus, inter-organizational relations for innovation built on the basis of cooperation should add the component “trust” to reduce the risk of opportunistic behaviour among agents and minimizing the risks that may arise due to bounded rationality in drafting contracts. Supporting the benefits of relationships among organizations on the basis of cooperation is not the same as defending the absence of contracts, but it is a search for ways of addressing the deficiencies of this method of controlling relations. Hence cooperation among companies does not simply refer to a middle position of a continuum between market and hierarchy. It is a mode of governance itself (PROVAN; KENIS, 2005). This mixed-mode form of economic institution, called hybrid, “draws upon the capabilities of multiple, independent

organisations as they are organisational arrangements that use resources and or governance structures from more than one single firm, encompassing a broad range of organisational combinations" (CAGLIO; DITILLO, 2008, p.38).

Cooperative relations have different terminologies, though they often reflect concepts of similar actions. The term commonly used to name this type of formation, in which companies are related based on cooperation, is "networks". Simply put, Provan and Kenis (2005) define them as a set of actors or nodes, with relationships between these nodes as being either present or absent.

Unlike the approach stemming from the field of neoclassical economics in which the firm is an autonomous entity, even isolated, struggling to use its resources to compete against other entities also autonomous and independent, the network approach argues that firms access resources and skills through their various relationships with other organizations (GULATI, 1999). Naming them "strategic networks", Jarillo (1993) points out that cooperation is performed by independent organizations, with relatively unstructured functions, with contracts with undefined end and implied expectations of stable relationship. The motivation to join and remain in the network is "the belief that by working with others he or she will be more productive, and (at least part of) that productivity will be passed down to him or her" (JARILLO 1993, p.131). According to this author, the "strategic networks" are located in the type of cooperative approach to firms without the same owner.

The experience of working in a network with other organizations generates learning and improving of a company's own practice to cooperate. Therefore the ability to relate increases with previous experiences. Brass *et al.* (2004, p.802) explain that "firms that have more experience working with other organizations are more likely to form new and more diverse network ties and to become dominant players in networks". As an example, Powell *et al.* (1996) report that biotechnology companies that had more networking experience had more varied network portfolios, and became more central in collaborative networks. Also Beckman *et al.* (2004) found that large industrial companies and services in a market of great uncertainty were more likely to form alliances and share board members with companies with which they had previously been allied.

The learning generated from the inter-organizational relationships is not just about technical knowledge or on the industry. Firms learn also about the

management of relationships; and this knowledge makes them more attractive partner to form new partnerships (BRASS *et al*., 2004, p.802). The focus of this research is cooperation in the medium and long term, differing from market relations, as defined by Axelrod (1984):

> What makes it possible for cooperation to emerge is the fact that the players might meet again. This possibility means that the choices made today not only determine the outcome of this move, but can also influence the later choices of the players. The future can therefore cast a shadow back upon the present and thereby affect the current strategic situation (AXELROD, 1984, p.12).

The so-called "Prisoner's Dilemma" (AXELROD, 1984) argues that cooperation is born from gains that are impossible to be achieved by an isolated company. But Axelrod (1984, p.174) adds the factor "time" for the existence of cooperation. He says that "for cooperation to prove stable, the future must have a sufficiently large shadow". The foundation of cooperation therefore would not be trust, but the durability of the relationships.

Castells (1996, p.232) states that two fundamental attributes of a relationship are "connectivity, ie, the structural capacity of facilitating communication without noise among its components" and consistency, which means the existence of shared interests between the network and its components. However, for relationships to last long time, besides partners with common goals, mechanisms for managing activities are also necessary.

2.2.1 Management of relations

Hibbert *et al.* (2008, p.391) define the coordination of inter-organizational relationships (IOR's) as "a series of processes undertaken by a team of individuals, with various skills and capabilities, that are focused on defining both the direction to be taken by an inter-organizational entity (IOE) and the allocation and implementation of resources toward those ends". These forms of coordination allow managing the flow of contents and relationships in a network. The mechanisms enable and constrain the behaviour of actors. Different governance mechanisms

regulate through different ways, providing for example incentives for actions or directly regulating the behaviour through sanctions (EBERS, 1997).

Efficient means of coordination can be formal, as contracts, or informal, such as restrictions to behaviour implied to actors belonging to IOR's (BRASS *et al.*, 2004, p.795). Therefore, one may consider management controls and formal contracts as governance mechanisms, but also the trust, reciprocity and fairness of the relationship. Informal methods of coordination work mainly for preventing opportunistic behaviour by the actors arising from the inability to specify all possible conditions in contracts, in situations of uncertainty (GRANDORI; CACCIATORI, 2006).

An overview of different forms of cooperation has been made by Grandori and Soda (1995) to classify organizational collaboration associations according to whether the relationship is formalized or not, and whether there is a central coordinating firm or the partners are parity based. Caglio and Ditillo (2008) mention that bureaucratic collaboration forms include both the specifications on the organizational relationship between parties and the terms of the exchange. They affirm that "the strength of this form of relationships derives from the legal system which protects the parties' reciprocal rights to compliant behaviour" (CAGLIO; DITILLO 2008, p.5).

Long ago, Hobbes (1651 *apud* AXELROD, 1984) wrote that cooperation would not get developed without a central authority, but empirical examples have proven that there is no need of an authority to govern cooperation. The actors may cooperate without requiring an external command. So Bachmann and Zaheer (2008) argue that trust plays a role as a mechanism for coordination of relations. Furthermore, the authors state that the search for selfish results is more an exception than the rule, even in economic environments. The Oslo Manual (OECD, 2005, p.98-99) also puts trusts as a key factor for maintaining and improving relationships; so long-term relationships that involve mutual trust will likely be beneficial for all participants.

Trust is a tacit component that cannot be fully codified as rules to include in a contract. According to Bachmann and Zaheer (2008, p.536), trust is "the expectation that the counterpart will behave in a reliable, predictable and fair manner, particularly when the potential for opportunism is present". However, trust in a relationship does

not start from zero, because companies have their reputation in the market prior to the establishment of the relationship with another organization. Brass *et al.* (2004, p.803) name the fact that actors will use information from previous interactions to judge the trustworthiness of another actor as *relational trust*. Previous relationships are important in situations of uncertainty, such as R&D activities.

When the management of a relationship is well established, either based on contracts or based on trust, it helps the collaboration to reach partners' expected results.

2.2.2 Results from cooperation

According to the resource-based view, firms are fundamentally heterogeneous in terms of their resources and internal capabilities (PENROSE, 1959; PETERAF, 1993). When it comes to innovation, firms may not dominate all the necessary capabilities in a specific area, because strategic resources are heterogeneously distributed across firms (BARNEY, 1991). They also may not be able to generate the strategic resources in-house at a reasonable time and cost compared to more knowledgeable and better positioned competitors. Furthermore, not all resources and capabilities are susceptible of being negotiated, because they may be rooted in routines inside a firm and embedded in a firm's processes (TEECE; PISANO, 1994). So the result of cooperation among organizations would be justified by being a way of accessing and exploiting other firm's resources and capabilities.

Gains which are impossible to be achieved by an isolated company - as the already mentioned justification to work together - may be identified more specifically. Galaskiewicz (1985) cites four reasons for cooperating: acquire resources, reduce uncertainty, increase the legitimacy and reach common goals. In addition, long-term relationships provide the company access to "information, resources, markets, and technologies; with advantages from learning, scale, and scope economies; and allow firms to achieve strategic objectives, such as sharing risks and outsourcing value-chain stages and organizational functions" (ZAHEER *et al.*, 2000, p.203).

Some of the results of cooperation are found in several studies. Burt (2000, p.3) states that better connected people enjoy higher returns. Pittaway *et al.* (2004) adds the guarantee when gaps occur in contracts, including other positive outcomes:

> We find that the principal benefits of networking as identified in the literature include: risk sharing; obtaining access to new markets and technologies; speeding products to market; pooling complementary skills; safeguarding property rights when complete or contingent contracts are not possible; and acting as a key vehicle for obtaining access to external knowledge (PITTAWAY *et al.*, 2004, p.137).

Other researchers cite different benefits. The survival of start-ups is cited as a positive result from interfirm relations, while the lack of stable exchange relations and the lack of access to resources make new firms particularly prone to fail (BRASS *et al*. 2004, p.806). Recently, organizational learning is ranked as one of the major factors for the company to achieve competitive advantage. It helps create new knowledge to be embedded in products and processes turning them innovative. Learning comes from new information and knowledge which may arise from the relationship with other organizations. Pittaway *et al.* (2004, p.137) complement that "firms which do not co-operate and which do not formally or informally exchange knowledge limit their knowledge base long term and ultimately reduce their ability to enter into exchange relationships".

Knowledge sharing across the border of a business is conducted by researchers aiming to innovate. Several studies report that formal collaborative relationships among organizations increase the result of innovation in start-ups in biotechnology (BAUM *et al.*, 2000; POWELL, 1998; SHAN *et al.*, 1994). Von Hippel presents a range of situations in which customers and clients participate in the company's innovation efforts. Mainly key-users assist in generating ideas for new products or enhancements to existing products in various segments such as scientific instruments (RIGGS; VON HIPPEL, 1994), kite-surfing equipment (FRANKE *et al.*, 2006) and banking (OLIVEIRA; VON HIPPEL, 2011). One of the studies, for example, discovered that 67% of significant innovations in equipment for production processes were developed by users of the equipment, not by manufacturers, in two industry segments: semiconductor manufacturing and electronic subassembly (VON HIPPEL, 1977). As seen, the relationship with clients and their networks is considered an important source for R&D.

Table 4 summarizes the concepts discussed in this Chapter, which were identified in the literature as fundamental aspects of inter-organizational cooperation. As shown in Table 4, organizations must have common goals so that cooperation may happen. In addition, another key element of cooperation is the interaction among partners in order to make activities happen. As the activities performed in cooperation have different demands compared to activities internally performed by an organization, the coordination of relationships also demands a different attention.

Table 4 - Key elements for cooperation

Key elements for cooperation	Concept of the element	References
Common goals	The existence of shared interests between partners.	Beckman *et al.* (2004) Brass *et al.* (2004) Castells (1996)
Interaction	Connectivity among the actors. Partners need to interact somehow so that the activities and the purpose of the network are fulfilled.	Axelrod (1984) Castells (1996)
Management	Processes performed to define the direction to be taken by the group of organizations and to coordinate the activities of inter-organizational relationships. It may be formal, as contracts, or informal, as restrictions to behaviour implied to actors.	Bachmann and Zaheer (2008) Brass *et al.* (2004) Caglio and Ditillo (2008) Ebers (1997) Grandori and Cacciatori (2006) Grandori and Soda (1995) Hibbert; Huxham and Ring (2008) Provan and Kenis (2003)

As the main focus of this research is R&D as a result of the strategy of cooperation, the next section of this literature review studies innovation, mainly R&D, performed from inter-organizational relationships.

2.3 COLLABORATIVE R&D

The current state of the economy is characterized by dependence of organizations with regard to information and knowledge, and high levels of expertise. Thus, R&D projects performed in cooperation with other organizations allow companies to have access to knowledge and technology that they would not be able

to produce or use alone. From the sharing of knowledge and other resources, the partners learn from each other. Since the absorptive capacity explored by Cohen and Levinthal (1990) to latest terms as open innovation (CHESBROUGH, 2003), it stands out that companies produce new organizational knowledge when they collaborate with other firms, and when they observe and import their practices (DYER; NOBEOKA, 2000). This learning is focused mainly for the development of new products and processes.

Collaboration not only happens among companies. It also happens among institutions. There are numerous types of partners for innovation, depending on the degree of novelty being searched and on the market segment in which the company operates. Different partners may generate different results of R&D activities.

2.3.1 Benefits of collaborative R&D

Access to knowledge provided by suppliers, inserted into new materials and equipment provided by them, allows companies to generate new products (PAVITT, 1984). Also the Oslo Manual (OECD, 2005) justifies partnerships with suppliers for incremental innovation because these R&D activities are led by the cost of inputs in stable and mature sectors. Tomlinson (2010) identifies positive impacts of cooperation with suppliers for the DNP, in the utility and quality of the key resources for R&D, and in the simultaneous exchange of information and ideas. Complementarily, the development of new processes benefits from upstream co-operation over delivery times, technology, labour training and production organisation (TOMLINSON, 2010, p.769).

Also regarding the impact of R&D cooperation, Belderbos *et al.* (2004) analysed the performance of Dutch companies, differentiating the type of partner among competitors, suppliers, customers and research institutes and universities in relation to the impact on growth of labour productivity (value added per employee) and growth of sales per employee for new products to the market (productivity in the sale of innovative products). According to them,

> competitor and supplier cooperation focus on incremental innovations, improving the productivity performance of firms. University cooperation and again competitor cooperation are instrumental in creating innovations generating sales of products that are novel to the market, improving the growth performance of firms. Furthermore, customers and universities are important sources of knowledge for firms pursuing radical innovations, which facilitate growth in innovative sales in the absence of formal R&D cooperation (BELDERBOS *et al.*, 2004, p.1477).

With opposite result regarding Belderbos *et al*. (2004) on consumers, Tomlinson (2010) states that cooperation with buyers is less important than with suppliers both for the portfolio and for the level of development of new products. The positive side is that this relationship decreases the ex-post doubt about the commercial performance of the new products.

As seen, the company searching for innovation can develop multiple interactions to have access to new information, knowledge, technologies, production practices and human and financial resources (OECD, 2005). Thus inter-organizational relationships for R&D go beyond dyadic partnerships. They may include multiple participants and indirect connections among them, characterized by sparse and weak ties. Noteboom (2008, p.618) notes that “in frequent and intense interaction between many actors, in a dense structure, much of the information circulating in the system is redundant”. Even so, there are advantages in operating in a dense collaborative network. As explains Powell (1998, p.230), “inside a densely connected field, organizations must adjust to a novel perspective in which it is no longer necessary to have exclusive, proprietary ownership of an asset in order to extract value from it”. Brass *et al.* (2004) complement saying that innovation, as other traditional business results vary according to ties maintained over time, thus establishing a relatively stable pattern of network interrelationships.

Todeva (2006) claims different patterns of relationships between organizations. The author identifies twelve types, one of which is networks and alliances for R&D. According to her,

> Managing R&D and innovation by firms is one of the most challenging tasks, and requires a wide intra-firm and inter-firms cooperation. Managing R&D fundamentally depends on the management of diverse formalised and tacit knowledge which is scattered between specialised units and scientific fields, embodied in current products, processes and technologies, and carried out by scientists and researchers, employed in a wide range of business organisations (TODEVA, 2006, p.189).

Besides several possible partners, multiple interactions among organizations performing R&D may be accomplished in many ways. Teece (1996) argues that the proliferation of inter-organizational arrangements is because they unite some benefits of integration avoiding certain costs. Cooperative relationships compared to market contracts,

> involve constant interaction among the parts, more open information channels, greater trust, rely on voice rather than exit, and put less emphasis on price. Compared to hierarchies, such alliances or networks among firms call for negotiation rather than authority and put great emphasis on boundary-spanning roles (TEECE, 1996, p.207).

Also Gassmann and Enkel (2004) present a way of performing collaborative R&D, called by them as *coupled*, that mixes outside-in and inside-out processes. The outside-in process enriches a "company's own knowledge base through the integration of suppliers, customers, and external knowledge sourcing. That would increase the company's innovativeness. The inside-out process exploits ideas in different external markets, selling IP and multiplying technology by channelling ideas to the external environment. Combining them, the coupled process works "in alliances with complementary companies during which give and take are crucial for success" (GASSMANN; ENKEL, 2004, p.12).

This description meets the concepts of the Oslo Manual, which defines the process of collaborative R&D as considered in this thesis:

> Innovation co-operation involves active participation in joint innovation projects with other organisations. These may either be other enterprises or non-commercial institutions. The partners need not derive immediate commercial benefit from the venture. Pure contracting out of work, where there is no active collaboration, is not regarded as co-operation. Co-operation is distinct from open information sources and acquisition of knowledge and technology in that all parties take an active part in the work (OECD, 2005, p.79-80).

Therefore a project for collaborative R&D involves the active cooperation of innovative enterprises with external private or public organizations on R&D activities. The next item presents some models of collaborative R&D.

2.3.2 Forms of collaborative R&D

R&D projects involving two or more organizations have grown in various industries with different features. The literature reports some models and forms of structuring collaborative R&D, from types of knowledge sharing to the realization of joint development. According to Todeva (2006, p.193), “R&D networks are usually project based and resemble networks involved in research and business application of scientific knowledge.”.

Regarding network of relationships for R&D in biotechnology, Powell (1998) states that when the uncertainty is large, developing contracts with well-defined functions is not as important as other features. In a context of rapid technological change, organizations interact more with external partners in order to share knowledge and resources in a horizontal manner. Therefore, the focus should not be on the specific details of the transaction, as to ally with whom or under what terms, and for how long. More important than defining those features is to have the necessary skills to negotiate two obstacles: moving from information to knowledge and from learning at an individual level to learning at an organizational level turning it into routines.

Also focusing on knowledge sharing, Dyer and Nobeoka (2000) present a somewhat different view since they reported the importance of established routines and rules for participation, and for the entry of new partners in the network. Analysing the relationship between Toyota and its suppliers, the authors point out that this model is “highly effective to facilitate interfirm knowledge transfer” (DYER; NOBEOKA, 2000, p.347). The characteristic of being a vertical network led Toyota to create a series of conditions to motivate suppliers to participate in order to create a strong identity for the network. It led also to the establishment of rules and standards to prevent the problem of opportunism, that could happen as a partner hiding valuable knowledge or utilizing the expertise of the network for its own benefit. The authors explain that

> Toyota solves these dilemmas by simply eliminating the notion that there is 'proprietary knowledge' within certain knowledge domains (e.g., production-related knowledge). By openly sharing all of its production know-how, Toyota has created a norm (rule) within the network that very little of the knowledge that a firm possesses is proprietary (with the exception of certain product designs/technology). (DYER; NABEOKA, 2000, p.358).

The complete openness of knowledge to partners has the role as a "barrier to entry" for new participants, making dense relations among the participating companies. Also initially formed by strong ties, the structure of IBM's relations for R&D was characterized by a strategy of *exploitation*, oriented to product incremental development and new products development within the existing business model. The change in the network structure for an *exploration* strategy allowed the inclusion of new partners in the network and the formation of weak ties, even with existing partners. According to Dittrich *et al.* (2007), that was how IBM turned from a company producing hardware to become a software company and global service provider.

The authors identify two ways of structuring the network of relationships, as quoted in Table 5.

Table 5 - Network characteristics for exploration and exploitation strategies

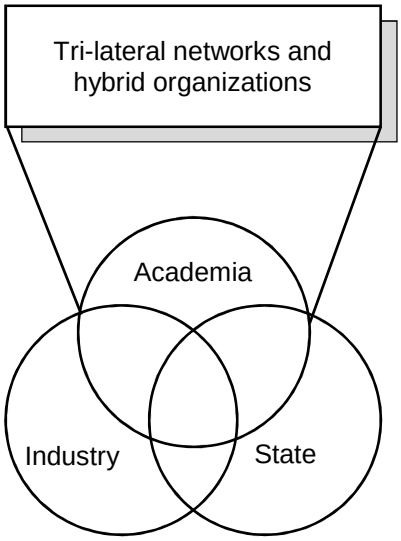
Strategy	Exploration	Exploitation
Alliance type	Non-equity alliances; few equity alliances	Relatively high number of equity alliances
Speed of changes of partners	Higher: many new partners enter the network	Lower: few new partners enter the network
Type of partner capabilities	Partners with different technologies	Partners with similar technologies in same business

Source: Dittrich *et al.* (2007, p.1498)

Depending on the strategy - exploration or exploitation - the company reaches different results from its innovation activities in collaboration with external partners. As seen in Table 5, the change of the strategy of collaborative R&D may be promoted from the search for partners in different areas of expertise compared to the company's, and from the increase in speed of changing partners.

Presenting the thesis of the triple helix, Etzkowitz (2003) claims that the interactions among industry, university and government, as illustrated in Figure 5, are the key to improving the conditions for innovation in a knowledge- or science-based society.

Figure 5 - Triple Helix



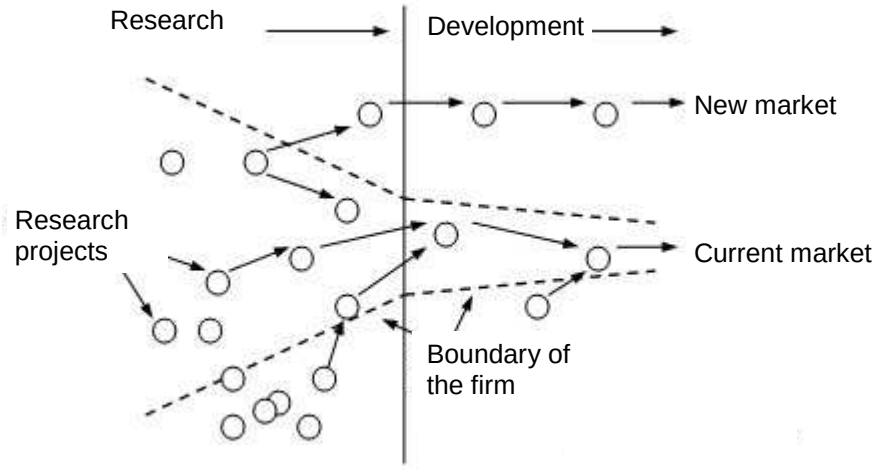
Source: Etzkowitz (2003, p.302)

Industry is the locus of production; the government would be the source of contractual relations that guarantee stable interactions and exchange; and the university would be the source of new knowledge and technology. The equality of the partners leads to new developments of innovation strategies and practices arisen from cooperation, such as incubators, science parks and venture capital firms. According to Etzkowitz (2003), encouraging interactions among the institutional spheres of Figure 5 fosters a self-sustaining innovation dynamic. Etzkowitz (2002) says that this “innovation in innovation” is a global phenomenon involving “learning by borrowing”, importing and adapting organizational models from abroad.

Another format that emphasizes the variety of partners for collaborative R&D is called “open innovation” (CHESBROUGH, 2003). Based on a scenario of abundant knowledge, open innovation (OI) considers that R&D projects can be initiated from internal or external ideas. Likewise, the activities for the DNP can be performed

internally by the company or outsourced to external partners. Furthermore, OI considers the licensing of technology for the innovation process within the organization, as its new technology to be licensed externally in the market. According to Chesbrough (2003, p.xxv), “the knowledge that a company uncovers in its research cannot be restricted to its internal pathways to market. Similarly, its internal pathways to market cannot necessarily be restricted to using the company’s internal knowledge”. Figure 6 illustrates the funnel of open innovation,

Figure 6 - Funnel of open innovation for the management of industrial R&D



Source: Chesbrough (2003, p.xxv)

As illustrated at Figure 6, ideas and technologies go out of the boundaries of the firm to external markets throughout the R&D flow, as well as other ideas and technologies are included in the funnel not only at its beginning, generating new products for existing markets and new markets.

The map of an organization’s relationships with different partners in different projects indicates to the market and to other potential partners about the quality of the activities and products of the organization (POWELL, 1998). According to Pittaway *et al.* (2004, p.147), there is no consensus as to the optimal networking configuration. The ideal design for a network is contingent on the actions that the structure seeks to facilitate at the same time that it depends on its industrial context.

Apart from searching for partners in order to form an alliance, Grandori and Soda (1995) add that the network form has to be devised and agreed upon.

Some companies have already established partnerships that generate effective results to reach the goal of innovating. However, by always collaborating with the same partners may limit the possibilities of new ideas and knowledge (NOTEBOOM, 2008). It is not guaranteed that the existing partners will have the best ideas or knowledge in all situations. Previous research has demonstrated that network closure established by strong ties between actors is less effective for R&D activities (BURT, 1992; GRANOVETTER, 1973; RUEF, 2002). Therefore a broader search could generate more valuable knowledge that would be not available in an existing set of strong ties. This negative effect of the networking practice is caused by the redundancy of information as a consequence of the actors' isolation from the external environment to the network. To overpass this situation, a possible solution is the third party that acts as an intermediary, which will be discussed throughout the next sub-chapter.

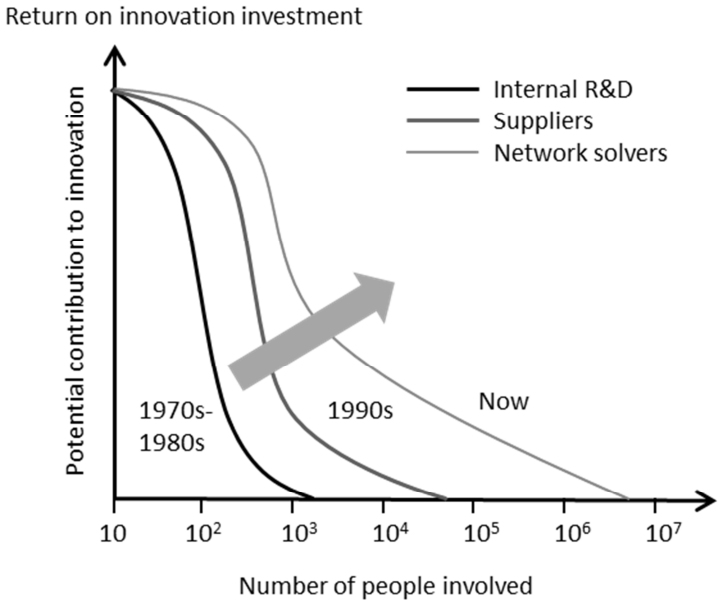
2.4 INNOVATION INTERMEDIARIES

Although collaborative R&D may facilitate the achievement of results, it presents challenges to organizations. Identifying and selecting partners as well as coordinating joint activities take time and resources for a firm. Moreover, companies may be limited in their scope and scale of reaching possible new relationships. Businesses often lack the technical and commercial competences required when trying to attract partners (PITTAWAY *et al.*, 2004, p.146). In order to help the search for new and non-redundant sources of knowledge and therefore help in improving the effectiveness of collaborative R&D, there is a type of organization with the role of intermediating or brokering relationships. The use of innovation intermediaries, according to Tran *et al.* (2011), raises the opportunity for firms to outsource R&D while decreases the associated costs.

In the past, the subject of intermediation was included in the literature of financial transactions, where intermediaries were "middlemen", brokering

transactions between buyer and seller (TRAN *et al.*, 2011). Nevertheless, the innovation intermediary presents itself as providing different services for interorganizational projects. Billington and Davidson (2013) illustrate how the use of intermediaries may extend the boundaries of partners search, as shown at Figure 7. The authors say that larger networks turn into higher returns on innovation investment.

Figure 7 – Reach of possible solvers for R&D needs



Source: Billington and Davidson (2013, p.1468)

As it can be seen at Figure 7, internal R&D involves lesser people than if a firm collaborates with suppliers and much lesser than using an intermediary to create a network of partners to solve needs for innovation activities.

Intermediaries bring a triadic dimension on relationships for R&D, following what Bryant and Reenstra-Bryant (1998) affirm that triads have been growing in importance with technology brokers serving as intermediaries of intellectual property. This recent growth of triads with intermediaries is due to the increasing complexity of technology and consequent need for complementary resources and expertise in R&D activities. According to Pitassi (2012, p. 529), intermediaries play a direct role in the

innovation chain of the firm, performing activities knowingly relevant to R&D, but that were previously performed internally.

Dalziel (2010) argues that firms rely on innovation intermediaries to perform networking activities because the commitment of brokers to their mission creates the trust required for network sustainability. This way, any organization involved in R&D activities can benefit from the services provided by an intermediary with respect to collaborative projects. As Winch and Courtney (2007, p.757) affirm, “the universities use the brokers to seek partners for their externally funded research programmes while the firms use the brokers to shape research programmes to meet the perceived needs of the industry.” Also the findings by Lichtenthaler (2013) show that manufacturing firms may reduce their transaction costs in technology markets by collaborating with intermediaries. Complementarily, Billington and Davidson (2013, p.1468) affirm that using intermediaries is “significantly less expensive than conventional mechanisms for developing and procuring innovative solutions”. They mention empirical evidence from the pharmaceutical industry about a seeker-solver network that can be more than 20 times less expensive than regular R&D paths.

2.4.1 Typologies of intermediaries

At their empirical review, Kirkels and Duysters (2010, p.377) found that the most influential brokers were found in the non-profit and science sector. They say that “regional (semi-) government agencies and non-profit discussion platforms facilitate the acquisition of competitive capabilities by compiling and disseminating knowledge and by reducing search costs”. This way, intermediaries in a R&D environment may play a large institutional role in a strategic level, between the top policy level and the operational level of research performers.

Gianiodis *et al.* (2010, p. 566) classify innovation brokers as generalists and specialists, explaining that “generalists build expertise in multiple industries, offering cradle-to-grave services that facilitate technology exchange. In contrast, specialist firms focus on one particular industry, or a few exclusive technology domains.” According to the authors, the ability to identify breakthrough solutions across varying contexts is most important. Another classification was made by Dell’era and Verganti

(2013), whose typology differentiate brokers and mediators. According to them, brokers provide knowledge by exploiting their position in the network to connect separated worlds; and mediators provide contacts by introducing disconnected organisations. As one may see, several kinds of organizations are identified as intermediaries. Among the different types reported in the literature, different approaches can be identified in relation to their actions in collaborative R&D.

The knowledge broker facilitates the recombination of existing solutions to solve new problems (SIEG *et al.*, 2010). According to this stream, the intermediary is an organization that performs innovation activities and keeps many relationships; but the situation is not a network of firms. Usually, the knowledge broker is a service company which combines knowledge from its clients and partners, with the intention of developing innovation itself (HARGADON; SUTTON, 1997; HARGADON, 2002). Lingo and O'mahony (2010, p.50) explain that “brokers of collective outcomes do not just transfer, share, or broker ideas, they must incorporate them into a creative product, regardless of whether it is a musical, a building, or a recording”.

According to Hargadon and Sutton (1997), the technological intermediary transforms and blends information. It introduces existing solutions in some industries into another segment, when these valuable ideas are unknown to this segment. This way, the knowledge broker creates new products, which are originally combinations of existing knowledge from disconnected industries. These authors empirically focus on the network of contacts that the designers at the company IDEO built along their experiences allowing the use of knowledge from one industry to develop solutions to another segment. IDEO, in their research, is considered an intermediary. According to them, the process model of how innovation happens through technological knowledge intermediaries consists of a) having access to various industries; b) acquiring technological solutions for possible use in later projects; c) storing potential technological solutions; and d) retrieval old technological solutions from IDEO’s memory to fit the new combination (HARGADON; SUTTON 1997, p.725). As seen, the knowledge broker uses the knowledge for its own developments.

This approach to intermediary, although much quoted in the literature on the subject, refers to organizations that are sources of new ideas and create products, not being limited to intermediate relationships among companies. In the case of knowledge brokers,

> the process is more opportunistic depending on the particular networks of the broker and its clients, and the firms that are the source of new ideas need have no knowledge of how those ideas are applied elsewhere. It is also clear that organizations such as IDEO are more conduits than channels because they are closed to external gaze as its clients seek direct competitive advantage from a commission (WINCH; COURTNEY 2007, p.750).

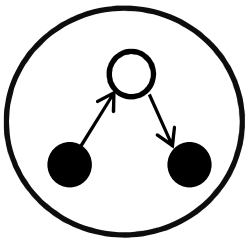
As seen, the knowledge broker may reach the result of innovation by internally performing R&D without partnerships.

The second approach in the literature about intermediaries comes from the social networks' field, where the intermediary is also a company performing activities. The broker is the partner positioned with greater centrality among others in a network of firms, and with the largest quantity of relationships, exploring the structural holes between actors not directly related. Gianiodis *et al.* (2010, p. 566) says that most research on innovation brokers has been conducted at the network level".

Social capital in networks is a competitive advantage, and one of the mechanisms to build and increase it is brokerage across structural holes. These set of studies about the brokerage of relations as a mechanism for social capital arises from Burt (1980, 1992 and 2000), following strength of weak ties by Granovetter (1973) and the betweenness centrality by Freeman (1977), where the intermediary is the company connecting two (or more) other unconnected partners in a network. This intermediary benefits from the flow of information between the other partners, and starts having power due to that. Burt (2000, p.2-3) complements saying that "social capital promises to yield new insights, and more rigorous and stable models, describing why certain people and organizations perform better than others. The social capital metaphor is that the people who do better are somehow better connected." Having a central position among other players yields an early access to information, which can be a competitive advantage.

Kirkels and Duysters (2010) graphically represent this brokerage role as it can be seen at Figure 8. The blank point represents the broker that enhances the interaction between members of the group he belongs to, represented by the black points. The ellipse represents the network. The information flow finds its access between actors enabled by the intermediary.

Figure 8 - Graphic presentation of the broker embedded in a nework



Source: Kirkels and Duysters (2010, p.377)

A third approach of intermediaries comes from the open innovation (OI) concept. Different from the two previous approaches, the intermediary does not participate in R&D activities and does not belong to the network of companies. Its business is to mediate the relationship between the organization which needs a solution for its innovation and an organization which has the solution (Chesbrough *et al.*, 2006). Following this line, Bessant and Rush (1995) identified three roles for the service they call “consultant” on innovation:

> A third role is that of 'marriage broker', providing users with a single point of contact through which to access a wide range of specialist services. These might be available from the consultant in question or they might be provided by other organisations known to the consultant. In this role the consultant is acting as a channel and selection aid to the user (BESSANT; RUSH; 1995, p.101-102).

Gianiodis *et al.* (2010) analysed 43 academic papers about open innovation published since 2003. The typology developed by the authors shows the distinction between four innovation strategies: the company seeking a solution, the company providing the solution, the company working both ways, and the intermediary promoting the relationship between the seeker and the company with the solution to the innovation. They authors affirm that

> the presence of intermediaries helps explain the explosive growth of OI by firms across various industries and economic regions. They act as catalysts for market exchange, and have influenced shifts in many firms away from the traditional closed model of innovation. Although some intermediary firms have gained strong market positions — Innocentive, Yet2.com, Nine Sigma, just to name a few — researchers have yet to fully incorporate the role of

> intermediaries in models of OI, or empirically examine their affect on OI adoption or performance (GIANIODIS *et al.*, 2010, p.561).

According to the OI approach, the benefit of its practice is the diversity of knowledge, which is expanded with the entry of new partners. However, new relationships initiated from intermediaries tend to start as weak ties, and this process can generate transaction costs, increasing the overall cost of innovation, as mentioned by Dodgson *et al*. (2006):

> The costs of managing the new dispersed networks of experts and expertise are uncertain, particularly as the number of interdependencies increases with more sophisticated and often competing demands placed on multiple relationships. It is not yet clear what transaction costs are involved and whether all the benefits expected will be accrued, and by whom, in the open innovation model (DODGSON *et al.*, 2006, p.343).

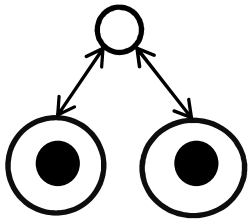
Since one of the benefits of networking with long-term inter-organizational relationships is the reduction of transaction costs, the practice of always seeking new partners through an intermediary may move otherwise. That is what Tran *et al.* (2011) believe when they say that

> In any form of exchange, parties have the option to transact directly with each other, or transact through an intermediary. However, a middleman would want some form of economic compensation for the services provided; hence, the value that the innovation intermediary provides should exceed the cost of using them (TRAN *et al.*, 2011, p.82).

Brokers should promote the negotiation offering an acceptable option to both organizations, within the options available in the market. Benassi and Di Minin (2009) describe the role of intermediaries of patents and licenses. According to these authors, the main object of transactions in technology markets is patents and licenses because they deal with the generation of direct revenues. Complementarily, Verona *et al.* (2006), add that this role can be performed also by *virtual* knowledge brokers (VKBs) that help firms to complement the knowledge they can acquire through traditional physical and virtual channels for customer interaction. According to the authors, VKBs “extend a firm’s scope of interaction to include knowledge that comes from diverse and previously disconnected sources” (VERONA *et al.*, 2006, p.766).

Also Hacievliyagil *et al.* (2007, p.780) say that “the networking possibilities brought about by the internet, in combination with the information storage capabilities of computer databases, lead companies to change the management of R&D”. VKBs, as explained by these authors, carry out market interactions mainly for science-based companies. In addition, Chu (2013) affirms that the implementation of Internet innovation intermediary platforms helps increase the transparency of open innovation (OI), in particular the protection of intellectual property rights. He researched practices in China and Taiwan. The broker according to the OI perspective can be graphically represented as Figure 9.

Figure 9 - Graphic presentation of the broker as an outsider



Source: Kirkels and Duysters (2010, p.377)

At Figure 9, the open point represents the intermediary as an outsider that enhances the interaction between members of different groups, represented by the black points. The ellipses around them represent the networks in which each actor is embedded. This image also fits with the next view of the broker.

The fourth and last approach about intermediaries identified in the literature is the System of Innovation. In this case, the intermediary does not perform innovation activities, but coordinates the functions among partners, acting as a “maestro” of innovation activities (BATTERINK *et al.,* 2010). Intermediaries would be a type of “superstructure” organizations, which according to Howells (2006, p.717) “act to provide collective goods to their members and help to facilitate and coordinate the flow of information to ‘substructure’ firms (those actually producing the ‘innovation’ or its technological complementaries)”. The author says that such organizations may be both public and private in nature. Complementing, Winch and Courtney (2007) affirm

that the intermediary has a status *ranging between* the public and private sectors. They explain that this kind of legal status is vital for the effective execution of their missions.

The focal point between the last two approaches is that the intermediary does not perform R&D. Therefore it is not an active agent of R&D activities. This profile of broker is called by Hacievliyagil *et al.* (2007) as *innomediators*. Table 6 shows the main two characteristics regarding the profile of intermediaries found in the literature, which refer to belonging to the network of firms and performing R&D activities.

Table 6 - Main differences among the four types of intermediaries

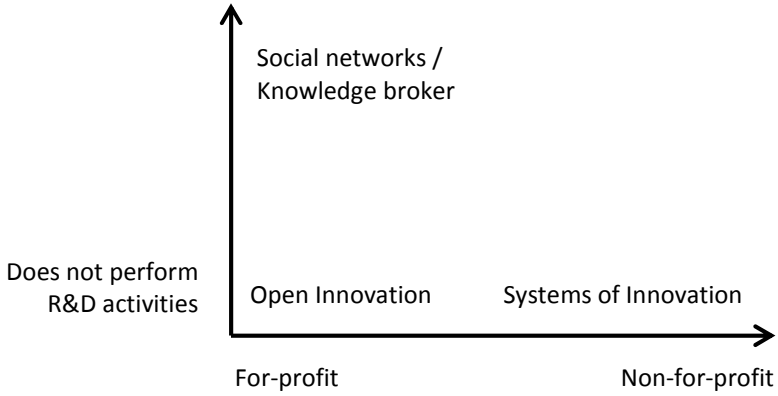
	Belongs to the network of firms	**Performs R&D activities**
Knowledge broker	No	Yes
Social networks	Yes	Yes
Open innovation	No	No
Systems of Innovation	Yes	No

As seen at Table 6, each of the four types is different from the others considering the two characteristics. In sum, the four approaches can be broadly divided into two groups: intermediaries that carry out R&D activities and those that are focused in connecting and helping other organizations to get together to innovate. The intermediary according to the open innovation approach could be included into the broad concept of Systems of Innovation, but if considering the description by Chesbrough (2006) who created the concept, the intermediary in the OI approach is a private company whose business model is to broker relationships. Therefore not all intermediaries in the Systems of Innovation approach belong to the practices according to the OI view.

Considering their ownership structure, Figure 10 shows the differences among the four mentioned approaches compared to the activity of performing R&D.

Given the variation of concepts and hence of practices of intermediaries found in the literature, it was necessary to define the type of intermediary used in the present study to determine its focus. If the concept was broadly used, including all concepts previously mentioned, there would be also large roles played by the intermediary, which would decrease assertiveness on the focus of the research,

Figure 10 - Approaches about intermediaries



whose attention is directed to the role of an intermediary in collaborative R&D projects.

Therefore, the first limitation on the scope of the concept is that the intermediary acts in joint R&D projects, not only on business transactions of technology and intellectual property. In the second hand, the intermediary acts as liaison between the partners involved in innovation activities, not performing them. In the third place, the intermediary must be an active agent and not just a channel or means through which organizations meet (according to Winch and Courtney, 2007, more conduits than channels). To conclude, the research focus on intermediaries within different approaches, including organizations in the National System of Innovation and private ones.

In any of the referred approaches, the intermediary may perform many kinds of functions, depending on the profile of relationship or network to which the broker is related. Each case demands different roles from the intermediary for the activities to result in effective innovation. The next section analyses the main elements of collaborative R&D projects that can be influenced by a third party, thus developing the research framework.

2.4.2 The influence of intermediaries in the main elements of collaborative R&D projects

The literature review allowed the distinction of some elements that affect collaborative R&D projects. The identification and selection of partners with common goals, the establishment of the relationship among them and coordinating the network of relationships, as well as its activities are elements which help the achievement of the desired results. A collaborative project also depends on human and financial resources and is driven by scientific and product development activities carried out jointly by the organizations. Six key elements of joint R&D projects, on which the intermediary may influence, will be analysed.

2.4.2.1 Common goals

For collaborative R&D to happen, firstly there must be shared interests among participants of a relationship. Stuart (1998) studied the formation of alliances in the semiconductor industry, and found that the most valuable partnerships were among companies with similar technological focus or operating in similar markets, while effective cooperation with distant firms in these aspects proved to be difficult. In the same line, Tanriverdi and Venkatraman (2005) argue that a company learns more when an alliance partner has related knowledge and skills. Therefore, Castells (1996) says that consistency is necessary, meaning the existence of shared interests between components of a network.

To identify new partners with common goals, some organizations have established their own structures. The coffee chain Starbucks offers a tool where everyone may offer ideas of innovation, vote and comment on them at an online platform. However, this strategy demands the firm to have a specific structure responsible for classifying, filtering, forwarding and turning ideas into viable and innovative products and services (VASCONCELLOS; MARX, 2011). Procter & Gamble has the platform Connect & Develop, where the company seeks to expand its network of relationships using the resources of the internet. The system shows R&D’s needs, and receives suggestions for solutions and ideas for new products,

both from established partners as from any source interested in starting a relationship with the company (HUSTON; SAKKAB, 2006). While these kind of individual solutions enable the identification of partners with common goals, they can represent a high cost to the company. Alexander and Martin (2012, p.38) mention that “this type of intermediation is resource-intensive and often smaller companies are unable to bear the cost of these dedicated roles”. Moreover, the structure for the search and selection of partnerships has limitations of amplitude, because the scope of a single organization may not be enough to constantly find and identify partners with common goals.

An organization’s strategy for searching external partners was classified by Laursen and Salter (2006) according to its breadth and depth, representing the components of the openness of individual firms. Breadth is defined as the quantity of external sources or search channels. The external search depth is defined in terms of the extent to which firms draw deeply from the different external sources or search channels. The authors found that searching widely and deeply is curvilinearly (taking an inverted U-shape) related to performance. Sofka and Grimpe (2010) explain that “while search efforts initially increase performance, there is a turning point from where firms risk impeding their performance by ‘over-searching’ their environment”.

To face the challenge of finding partners with common goals, authors as Batterink *et al.* (2010) refer to the intermediary’s activity of scanning the environment and selecting the players, establishing the procedures and tasks for a possible partnership as “network orchestration”. The authors emphasize three basic functions of R&D brokers: demand articulation, network composition and innovation process management. Network composition refers to “scanning, scoping, filtering and matchmaking of sources of complementary assets such as knowledge, materials and funding” (BATTERINK *et al*. 2010, p.52).

As seen previously, the existence of shared interests among partners is essential for collaboration. The related studies on this item highlight the role of intermediaries in identifying potential partners with common goals (GASSMANN *et al.*, 2011), leading to the following research proposition:

Proposition 01 (P.1): The intermediary influences the search of possible partners with common goals.

2.4.2.2 Interaction between organizations

As a second stage to collaborative R&D, the relationship between organizations has to be initiated; they must come together to interact. Thus, an important element for joint R&D projects is the interaction or the connectedness (CASTELLS, 1996), because the partnership for DNP goes beyond interactions between actors in a value chain or an established network of companies. Often the relationships for R&D are performed between actors which were not previously connected. Hargadon and Sutton (1997, p.716) state that “ideas from one group might solve the problems of another, but only if connections between existing solutions and problems can be made across the boundaries between them”.

Also Powell (1998, p.231) puts the connectivity of the inter-organizational network as a key elements to the logic of organizing joint R&D activities. That agrees with Batterink *et al.* (2010, p.68) who note that “brokers are very concerned with interaction processes in the R&D networks, and that they take the lead in facilitating interactions between the network members, who often represent different types of actors with different timeframes and cultures”.

Winch and Courtney (2007) analysed 10 cases of innovation intermediaries in the construction industry. As a result of the study, they identified two main functions of the intermediary on collaborative R&D: “the first is the classic network liaison role of acting as an intermediary, while the second provides important insights into the ways that innovation brokers operate within networks by adding value in the innovation process, rather than simply acting as a link” (p.756). According to the authors, the direction of interaction between companies from the intermediary can be started in two ways: a) from the sources of new ideas to potential implementers in top-down R&D and b) from potential implementers to possible sources in bottom-up R&D. The second function identified by these authors will be addressed in the section about the coordination of projects.

Thus, the evidence presented herein, particularly regarding the manner in which innovative companies begin their relationship with partners, leads to the following research proposition:

Proposition 02 (P.2): The intermediary influences the start of the interaction among the organizations.

2.4.2.3 Access to resources

The theory of resource dependence states that organizations are potentially dependent on external sources of resources, including financial and physical resources as well as information (PFEFFER; SALANCIK, 1978). The need for these resources obtained from the environment makes organizations to be embedded in networks of interdependencies and social relationships (GRANOVETTER, 1985). The collaboration therefore offers companies the availability of a wide range of resources almost immediately, without sacrificing flexibility, while limiting uncertainty (ARIAS, 1995). Besides knowledge as a resource (which will be addressed later), R&D projects needs human, financial and material resources to be effective. And that is not limited to R&D activities. Adams *et al.* (2006) stress that resources must be considered as a broad definition, because small and medium enterprises as well as the service industry do not always perform formal R&D activities.

In Japan, Okamuro (2007) indicates that 26% of small and medium companies obtain public subsidies for cooperative R&D. Funding is also an input addressed on the Survey of Technological Innovation (IBGE 2010) in Brazil, which analyses the costs and the lack of sources of funding among the factors of economic nature that could have harmed innovative activities in organisations. There are three economic problems identified as major obstacles to innovation - high costs of innovation, economic risks and scarcity of funding sources - and one internal problem in the company - the lack of qualified personnel. According to the Survey,

> in the industry, the first place is high innovation costs (73.2%), followed by excessive economic risks (65.9%), lack of qualified personnel (57.8%) and lack of funding sources (51.6%). If these data are compared to the results of PINTEC 2005, there is a change due to an increase on the lack of qualified personnel in contrast to the decline of the scarcity of funding sources as obstacles to innovation (IBGE 2010).

Also in the United Kingdom, the lack of some resources - as qualified personnel, information on markets and on technology and the availability of finance -

were identified by companies as high barriers to innovation. The UK Innovation Survey 2011, that sampled over 28,000 UK enterprises, revealed that

> cost factors (the availability and cost of finance in particular) were the most frequently 'highly' rated. SMEs perceive all barriers to be greater than large firms. Again, relatively few enterprises felt constrained by a lack of knowledge. (…) Enterprises engaged in innovation activity were almost 4 times as likely to perceive cost factors as barriers than businesses who did not attempt to innovate (BIS 2012, p.14-15).

The considerations above indicate that joint R&D projects depend on resources as human, financial and facilities to be performed, taking to the following research proposition:

Proposition 03 (P.3): The intermediary influences the access to necessary resources for collaborative R&D projects.

2.4.2.4 Management of the project

Besides the existence of common goals, the interaction between companies, and resources for the effectiveness of collaborative R&D projects, the management of relationships and activities is also essential.

According to Provan and Kenis (2008, p.231), "network effectiveness is defined as the attainment of positive network-level outcomes that could not normally be achieved by individual organizational participants acting independently". R&D here is an outcome, and the governance of a network of relationships may be critical to successful network-level results as the development of new products. The governance may ensure, according to these authors, that actors engage in collective and mutually supportive action, that conflict is addressed, and that network resources are acquired and utilized efficiently and effectively. Pittaway *et al.* (2004) add that the rules of engagement constrain the partners' behaviours.

Especially when collaborative R&D has the participation of major public bodies, the intermediary becomes important in helping the establishments of the terms of the contract. Batterink *et al.* (2010) found that the role of intermediaries in networks of small and medium enterprises (SMEs) in the food agriculture industry included the management of R&D projects. Regarding the coordination mechanisms,

the authors argue that SMEs do not have the experience and knowledge to encompass all the necessary details for the preparation of contracts. They explain that “in contrast to the SMEs, innovation brokers have ample experience with earlier innovation projects and often have explicit ideas and even templates for setting up appropriate coordination mechanisms, such as contracts” (BATTERINK *et al.*, 2010, p.60).

Compared to the governance of R&D activities within a single company, the management of inter-organizational arrangements for R&D faces different situations. Teece (1996) explains that

> some of these arrangements constitute extremely complex open systems, and some may be unstable. The managerial functions in these interorganizational networks are quite different from the authority relationship which commonly exists in hierarchies. Managers have to perform boundary-spanning roles, and learn to manage in circumstances that involve mutual dependency (TEECE, 1996, p.207).

As such, the intermediary may be responsible for typical issues of R&D management in an inter-organizational context, such as conflict management and prevention of opportunistic behaviour. As R&D brokers are typically outsiders to the network of companies performing R&D, in the case of conflicts between the other parties, the intermediaries may be considered as a stabilizing factor in the cooperation process (BATTERINK *et al.*, 2010). Hacievliyagil *et al.* (2007) cite as examples of opportunism in joint R&D the situation of a company seeking solutions for R&D when it uses information provided by another organization, obtained through an intermediary, without paying for it. Another opportunistic situation would be when organizations get to know about each other and meet through the intermediary, but they start the partnership without paying for the broker’s service.

Pittaway *et al.* (2004) state that R&D networks fail due to inter-firm conflict, displacement, lack of scale, external disruption and lack of infrastructure. They report that “networks can endure and evolve over many years. As a consequence, they go through periods of conflict between partners, and such conflicts can and do lead to the failure of the network” (PITTAWAY *et al.*, 2004, p.158). Some of these reasons may be minimized or even eliminated from the governance of the network and its activities. In case of conflicts between the participants of joint R&D projects, the intermediary may be a third party, with a neutral position from the network. It is

therefore an important factor for stabilizing the situation. To accomplish the role of conflict pacifier, the intermediary may use its previous experience and “lessons learned” in other projects (BATTERINK *et al*. 2010).

Adding value to the R&D process, beyond simply acting as a connector, was identified by Winch and Courtney (2007, p.756) as a major function performed by brokers. In this line, the authors found in the case of construction that an important role of the intermediary is the establishment and validation of process standards performed by all companies.

As seen, the literature on the management of relations between organizations includes a wide variety of functions, such as the use of institutions and authority structures, contracts elaboration, the management and control of joint actions and the prevention of participants’ opportunistic behaviour. Consequently the following research proposition arises:

Proposition 04a (P.4a): The intermediary influences the management of activities among partners in collaborative R&D projects.

As the literature above indicates, there are several activities on the management of collaborative projects which the intermediary may influence. One specific issue of R&D projects is the distribution of results arisen from the relationship. The intermediary may influence the definition in relation to intellectual property and technology transfer as results of R&D activities. This role is particularly important because most R&D results may never reach the market (STEVENS; BURLEY, 1997).

Howells (2006) states that the issue of protecting the results of R&D is growing for intermediaries. They can provide independent advice and mentoring on protecting intellectual property and evaluation on the outcomes of R&D collaboration. At the same time, Dodgson *et al.* (2006) argue that the issue of intellectual property is not well resolved in collaborative R&D projects. According to them, it is not entirely clear how it will be managed, although the use of virtual intermediaries helps in this matter. Benassi and Di Minin (2009) argue that the main objects of transactions in technology markets are patents and licenses, as they generate direct revenue. These authors describe the role of the patent brokers, which promote the negotiation offering an acceptable option to both organizations. Then Billington and Davidson

(2013, p.1467) post that one of the key roles of intermediaries, apart from the linking seekers to solvers, is related to the distribution of finances involved in the transfer of technology. They exemplify that “this involves making sure that solvers are rewarded rather than exploited and in providing processes and routines that protect the IP of the solvers”.

Even being among the various management activities influenced by an intermediary, the involvement on the results of collaborative R&D projects originates a specific research proposition given the rising importance of this issue:

Proposition 04b (P.4b): The intermediary influences the definition and commercialization of the results of the project.

2.4.2.5 Research and knowledge production activities

Knowledge is the raw material for R&D, and its creation may be fostered by collective action (BALESTRIN *et al.*, 2008). Moreover, discoveries arising from scientific research can be a source for further development of technology. Cohen *et al.* (2002, p.18) found that collaborative R&D projects with the contribution of public research (universities and government R&D labs) and informal information exchange with the same sources have much stronger correlations to project completion than to the suggestion of new projects. This result shows that research, even basic, serves to the DNP at the industry.

Sofka and Grimpe (2010) studied the impulses from external knowledge for the DNP driven by the market (customers and competitors) or driven by technology (universities and public research institutes), reminding the aforementioned discussion of *market pull* or *technology push* flow of R&D activities. The quantitative analysis performed by the authors with more than 45.000 firms from five European countries also showed that in technologically sophisticated environments, it will be most beneficial for firms to reach out to universities and public research centres in order to access highly novel technological knowledge. With quite an opposite result, they found that “internal R&D activities are particularly valuable when combined with a search strategy oriented toward market knowledge, i.e. the knowledge of customers and/or competitors. Neither a science- nor a supply-driven search strategy provides

an extra benefit for innovation performance on top of the additive effects" (SOFKA; GRIMPE, 2010, p.317).

Todeva (2006) identifies different moments of inter-organizational relationships for R&D besides the direct activities of DNP, as the basic research with no immediate practical application. The author says that "business networks for innovation are a multi-layered system with different innovation processes happening in the laboratory level, in the scientific knowledge level, at the corporate level and at the level of market adoption" (TODEVA, 2006, p.191).

Also about research, Dalziel (2010) affirms that intermediaries are able to enable the innovativeness of one or more firms by conducting and supporting technology development activities in the gap between the business and research communities. These evidences indicate that the generation of knowledge and research can be done through the process of collaboration, and the intermediary influences the relationship between industry and universities or science institutes, commonly regarded as sources of knowledge without immediate application generating basic research. Thus, this evidence leads to the following research proposition:

Proposition 05 (P.5): The intermediary influences research and knowledge production activities in collaborative R&D projects.

Karlsson *et al.* (2004) argue that research and development activities are different resources for innovation, and therefore they should be measured differently. Also Torugsa and Arundel (2013) found that there is no direct association between collaboration with public research organizations (PROs) and the share of new product sales. That would be because the knowledge acquired by firms from collaboration with PROs is not close to commercial application, and further development is needed to achieve commercialisation. So the next item deals with development activities, resulting in prototypes of new products and processes.

2.4.2.6 Development and prototyping activities

The activities for the DNP also can be performed collaboratively. In terms of product development with a high degree of innovativeness, hardly a single innovator will find the needed solution available in the market. Thus, relationships for the development of radical innovation will probably be long-term, not being just punctual relations of R&D.

As an example, between 1985 and 1996, Nokia had been involved in 25 partnerships, 14 for the joint development of new products. Dittrich and Duysters (2007) estimate that the majority of these agreements involved the development of mobile telecommunication technology, for which the existing capabilities of organizations were used for the development or extension of existing technologies to markets already conquered. After that period, the authors show that between 1997 and 2002, Nokia increased to 48 alliances, 25 of which were related to the joint development agreements. From 2003 on, the company intensified its collaboration with competitor manufacturers such as Ericsson and Siemens. The changes in the relations for co-development are explained by different needs of the company in each period.

Either for introducing basic technology or for creating commercial products, the intermediation is important on linkages of university and industry and inter-firm (KODAMA, 2008). Also interactions with a firm's main customers and obtaining customers through the main customers' networks have a positive association with new product development (BRASS *et al.*, 2004). In the fashion market, Tran *et al.* (2011) identified several value-added dimensions in the client's product development process from their relations to intermediaries, such as decreasing costs of product development; reducing risks; increasing development speed; and enhancing product attributes.

The presented literature indicates that a collaborative R&D project to be successful depends on joint activities for product and process developments. Thus the following research proposition arises:

Proposition 06 (P.6): The intermediary influences development and prototyping activities in collaborative R&D projects.

This section showed the elements of collaborative R&D and the influence of intermediaries on them. The theoretical framework developed so far was based on the concepts of innovation and cooperation, with the focus on collaborative R&D projects and especially on its constituent elements. The role of intermediaries in identifying partners for R&D was addressed, as well as the way they put organizations in contact, their contributions to the governance of joint activities, and their help in obtaining the necessary resources for the R&D project.

The next chapter presents the research framework built from the theoretical and conceptual references about collaborative R&D projects as well as methodological procedures.

3. RESEARCH DESIGN AND METHOD

The purpose of this chapter is twofold. First, it presents the organization of the research, including the variables to be empirically studied and the deriving theoretical propositions about the role of intermediaries in collaborative R&D projects. A framework pictures the operationalization of the constructs in a processual logic. Afterwards, the methodological procedures of the study are discussed, mainly how data were collected and analysed.

3.1 CONCEPTUAL FRAMEWORK

This section presents the conceptual framework that helps to structure the study giving relevance to the research question and objectives. The theoretical issues addressed in the previous chapter allowed a better understanding about the role of intermediaries in the dynamics of collaborative R&D. During the literature review, some evidences concerning critical elements to collaborative R&D projects stood up; they are therefore considered the research variables. Table 7 summarizes the variables that form the group of key roles of intermediaries in collaborative R&D, showing also the authors who postulate about them and the research propositions arising from the variables.

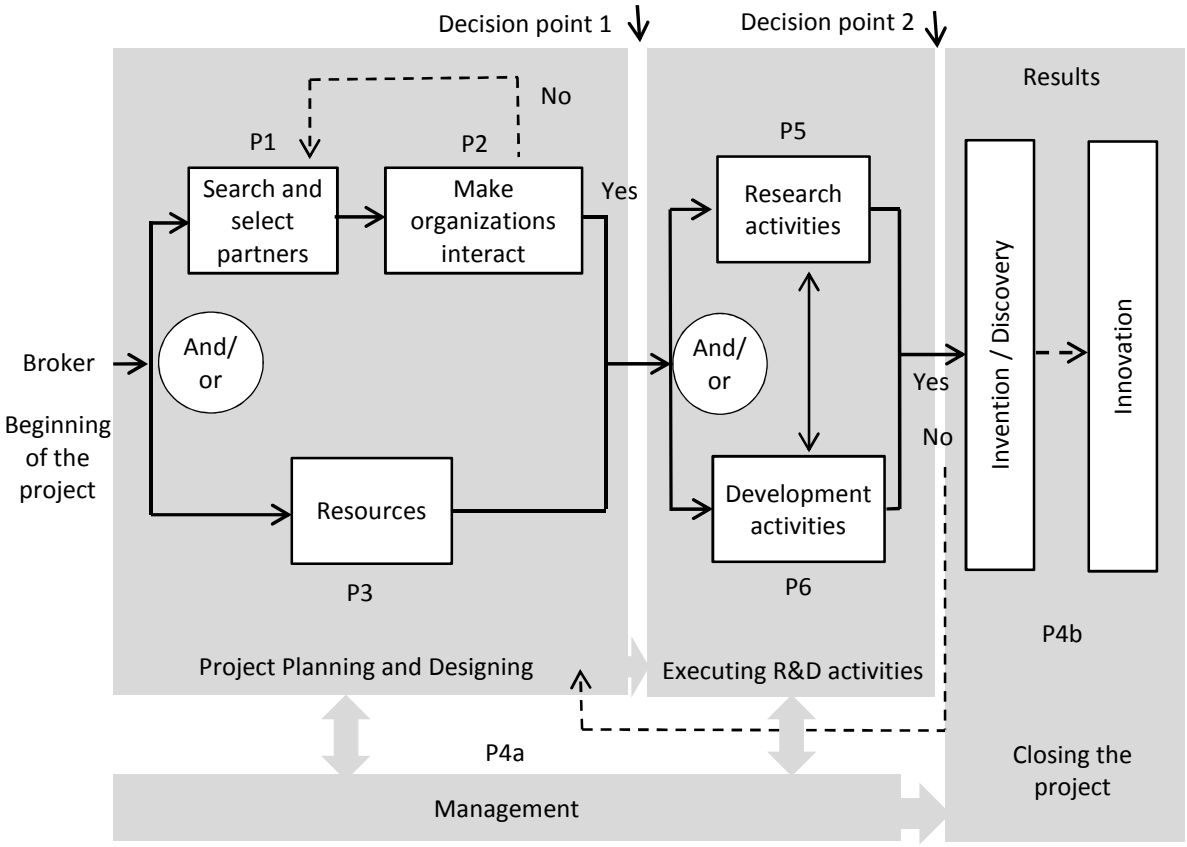
As seen at Table 7, the literature review showed that there are some elements that can influence how collaborative R&D happens, and that intermediaries may enable the dynamics of collaborative R&D in different ways. The research propositions may be illustrated according to their connections. Figure 11 shows the flow of activities of a R&D project that may be influenced by intermediaries.

Table 7 – Organization of research propositions

Critical roles of the intermediary	Variables	References	Research propositions
1. Influencing the search for partners with common goals	- Structure and channels; - Search strategies; - New partners; - Existing partners; - Knowledge and skills of partners.	Batterink *et al.* (2010) Castells (1996) Huston and Sakkab (2006) Laursen and Salter (2006) Sofka and Grimpe (2010) Stuart (1998) Tanriverdi and Venkatraman (2005)	**P.1:** The intermediary influences the identification of possible partners with common goals.
2. Influencing the beginning of interaction	- Structure; - Direction of the flow; - Previous relationship with the intermediary.	Batterink *et al.* (2010) Castells (1996) Hargadon and Sutton (1997) Powell (1998) Winch and Courtney (2007)	**P.2:** The intermediary influences the start of the interaction among the organizations.
3. Influencing the access to resources	- Human resources; - Financial resources; - Equipment and material; - Infrastructure.	Adams *et al.* (2006) Arias (1995) Bis (2012) Granovetter (1985) IBGE (2010) Okamuro (2007) Pfeffer and Salancik (1978)	**P.3:** The intermediary influences the access to necessary resources for collaborative R&D projects.
4a. Influencing the management of the project	- Drafting contracts; - Coordination mechanisms; - Establishing each partner's tasks; - Conflict resolution; - Prevention of opportunism.	Batterink *et al.* (2010) Hacievliyagil *et al.* (2007) Pittaway *et al.* (2004) Provan and Kenis (2007) Teece (1996) Winch and Courtney (2007)	**P.4a:** The intermediary influences the management of activities among partners in collaborative R&D projects.
4b. Influencing about the results of the project	- Protection of the invention; - Evaluation of invention's value; - Negotiation of invention's licensing; - Distribution of financial results.	Benassi and Di Minin (2009) Dodgson *et al.* (2006) Howells (2006)	**P4b:** The intermediary influences the definition and commercialization of the results of the project.
5. Influencing research and knowledge production activities	- Basic research; - Knowledge generation; - External knowledge for R&D.	Balestrin *et al.* (2008) Cohen *et al.* (2002) Dalziel (2010) Sofka and Grimpe (2010) Todeva (2006)	**P.5**: The intermediary influences research and knowledge production activities in collaborative R&D projects.
6. Influencing development and prototyping activities	- Technology development; - Prototype building; - New product development.	Brass *et al.* (2004) Dittrich and Duysters (2007) Kodama (2008) Tran *et al.* (2011)	**P.6**: The intermediary influences development and prototyping activities in collaborative R&D projects.

As stated by Natalicchio *et al.* (2014), the use of intermediaries is consistent with the increasing tendency to decompose the whole innovation process into distinct phases. The framework on Figure 11 therefore presents four different stages of R&D projects (represented by the grey boxes): a) planning and designing the project before the R&D activities are performed; b) executing R&D activities; c) closing the project after it has reached a result; and d) the management of the project involving all the activities in the collaborative project. As we can see, the Management stage includes the other three stages comprehensively.

Figure 11 - Research framework



At Figure 11, the grey arrows connect the different stages of R&D project. The straight thick lines stand for the normal flow of activities. The dotted lines symbolize possible feedbacks in the process, when the output of the activity is not the expected

flow as it was intended to be. Therefore, the flow according to dotted lines may not happen if the generating activity ends up as it should.

Firstly, there are two groups of critical elements to a R&D project influenced by an intermediary which have to be obtained in order to perform research and/or development activities: the establishment of partnerships, beginning with the search for partners with common goals, and the acquisition or resources. The intermediary may influence one of these two critical elements of collaborative R&D projects or both. After the project is planned and designed, the next step is executing R&D activities.

So the second set of elements of the collaborative project is purely R&D activities. According to the innovation being sought, some projects may include only research and knowledge production activities, if they are about science discoveries, for instance. Some other projects may include only development and prototyping activities. The intermediary may influence one of these two elements of joint projects or both. This stage finishes when it reaches a result. It may be considered an invention or an innovation, according to its adoption in the market. The intermediary may influence the definition about the results, either being the protection of an invention, or negotiations for commercializing an innovation.

Along with the previous mentioned elements for collaborative R&D projects to reach a result is the management of everything. The activities of monitoring and controlling go through all activities since the beginning of the project to its completion. According to the project, intermediaries may start providing services in different stages, not necessarily in the beginning of the process. Additionally, there may be more than one intermediary in each project. Different agents can influence companies at different stages throughout the project.

Importantly, the elements presented in the framework of Figure 11 are theoretical evidences and need an empirical validation in the context of collaborative R&D projects. Although the identification of constructs and connections among them is useful, one should recognize it is just an attempt to define what is found in field research on each critical element of collaborative R&D influenced by intermediaries. As Eisenhardt (1989) stated, the specification *a priori* of a construct does not guarantee a place in the resulting theory. The preliminary framework had the role of

guiding the researcher on the field study, searching for empirical evidences to validate it.

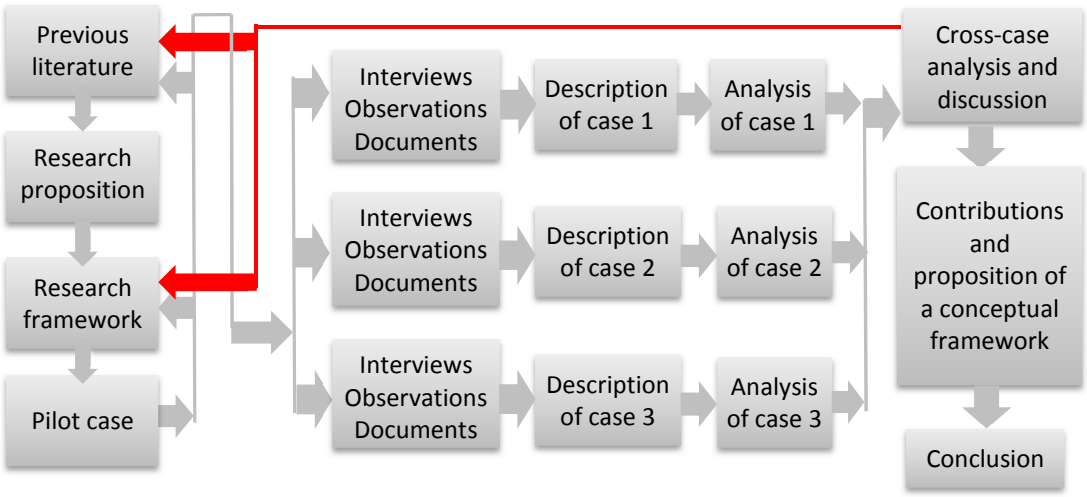
After presenting the conceptual foundation of this study, the next section shows the methodological procedures used in the empirical field as basis for reliability in achieving the objectives of the research.

3.2 METHODOLOGICAL PROCEDURES

The purpose of this chapter is to provide details of the data collection and analysis procedures employed in this qualitative research. Miles and Huberman (1994) suggest that qualitative research designs should be used when there is a clear need for in-depth understanding, local contextualization, causal inference and exposing the points of view of the people under study. So the method strategy that best suited the objectives proposed in this thesis according to the nature of the problem is the research case study because it allows the answer to “how” and “why” questions. Moreover, it is the adequate strategy when the researcher has little control over events, when the focus of investigation is “a contemporary phenomenon within its real-life context especially when the boundaries between the phenomenon and context are not clearly evident” (YIN, 2009, p.13).

The research was initiated by analysing previous literature and secondary data to identify gaps in the existing theory that needed to be addressed. The derived research propositions were organized in a process framework indicating the path for the empirical study to be performed later on, as it can be seen at Figure 12. After having deepened the analysis of previous literature on the field of research, and having identified the propositions, R&D projects to be studied were searched.

Figure 12 - Research phases

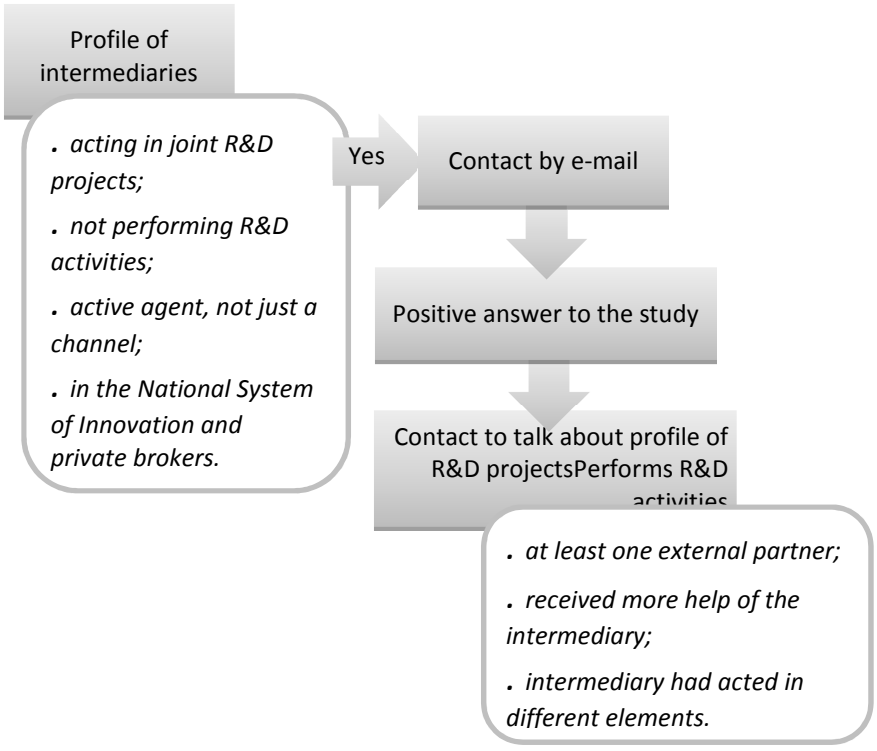


The collection of primary and secondary data was performed in steps. Firstly, some intermediaries were identified according to the profile established in this research, as previously mentioned: *the intermediary acting in joint R&D projects, not only on technology and intellectual property negotiations; the intermediary acting as a connection between the partners involved in R&D activities, not performing them; the intermediary being an active agent and not just a channel or means through which organizations meet; and intermediaries within different approaches, including organs in the National System of Innovation and private brokers.* The flow to choose the units of analyses is illustrated in Figure 13.

As it may be seen, firstly, we performed an Internet search with the aim of identifying intermediaries in the United Kingdom. Also, the academic community of the University of Southampton was questioned about knowing private intermediaries. Having identified some intermediaries, a first interview was performed with one representative of the broker to check if the organization was really the profile of this research. After that, the project to be studied was agreed with the representative according to some criteria to meet the research objectives. It was essential that *the R&D project had had at least one external partner*. From the range of projects in each intermediary's portfolio, the preference was given to the *projects that received more help of the intermediary*. It was not necessary that the intermediary had helped

all the elements of the collaborative R&D project, but that the intermediary had acted in different elements.

Figure 13 – Flow to choose R&D projects as case studies



The pilot case study was performed with the intermediary 100%Open. Firstly, the co-founder of the company was interviewed. From this conversation, one collaborative R&D project (called OSCR) was chosen to be used as a case study. Secondly, the main manager of this project was interviewed. The purpose of the pilot case study was not to build conclusions on empirical evidences. It helped to refine the propositions and the research framework as well as conceptual and methodological issues. The pilot case study also assisted the researcher to get to know the field, making it easier to perform the in-depth case studies later on.

As a result, the issues brought up by the pilot case study were added to the items analysed at the case studies and therefore added to the research protocol with the questions for interviewees. The mains points illustrated by the pilot case study

were: a) the fact that the whole collaborative project may be initiated by the intermediary, not necessarily by one of the organizations performing R&D; b) the limitations of the intermediary's service on searching for partners with common goals when the intermediary is a third party, since it may not know enough about its client; and c) that a collaborative R&D project may have more than one intermediary at the same time playing the same role.

After refining the research protocol including new sub-items to be analysed, the OSCR case was examined more deeply; and two other in-depth case studies were performed. The next section presents the three units of analysis followed by the procedures for data collection and analysis.

3.2.1 Units of analysis

This research describes and analyses intermediaries working with a group of organizations involved in R&D projects. It is assumed that the intermediary enables different elements of relationships and helps these participating organizations to achieve R&D results. The unit of analysis therefore is the collaborative R&D project that received help from intermediaries.

The choice of studying multiple cases is justified by the pursuit of analysing cooperation influenced by the intermediary valuing the deepening of the subject through theoretic and conceptual generalizations, not aiming to make statistical generalizations. This research, therefore, is subject to generalization limitations implied by the sample size natural to the case study method, as stated by Eisenhardt (1989). Thus, the criteria for selecting the units of analysis were the correspondence of the case to the research's objective and the availability of relevant information for the researcher to answer the research question, focusing on theoretical and conceptual breadth (VERGARA, 1998). As already mentioned, the intermediaries were chosen for presenting different practices and for representing different backgrounds and policies for actions. Within the range of projects from each intermediary, the research looked for different sectors which would tend to lead to complementary findings.

The empirical research collected data from intermediaries in two countries: the United Kingdom and Brazil. Countries with good results in the generation of science and technology were able to implement, throughout history, practices for the exploitation of knowledge as a result of the adequate construction of their innovation systems. It explains the fact that science and technology policies from developed countries tend to be adopted by developing countries (BELL; PAVITT, 1997). That is why this research analysed two countries at different stages in relation to the establishment of institutions that foster innovation and, consequently, different practices of collaborative R&D.

Some innovation intermediaries that were approached declined participation because of company policy. This reveals one difficulty about researching innovation-related subjects which is the need to keep secrecy of R&D projects. Five private organizations acting as intermediaries of relationships among innovative companies declined participation in the United Kingdom. Even the intermediaries which agreed to be studied had some restrictions about projects to be analysed. Even though, the cases were agreed by the researchers for suiting the proposed framework, and for presenting the practices and requirements necessary to answer the research question. In each of the cases, all possible stakeholders were identified in order to develop a deeper and more comprehensive understanding of the R&D project.

In the United Kingdom, two R&D projects were studies: a) Orange Service Call and Reward (OSCR), promoted with the intermediation of Corporate Connect Programme by the the National Endowment for Science, Technology and the Arts (NESTA) an independent non-for-profit public organisation in the United Kingdom. Nowadays, the Programme is performed by the private company 100% Open that spun-out of NESTA, and b) StarStream project, intermediated by the department Research and Innovation Services (R&IS) at the University of Southampton.

At 100%Open, there were more than 20 cases of collaborative R&D projects that could be used as case studies. The chosen one was OSCR project, run by NESTA to the client Orange, a telecom operator from France Telecom group. This project was chosen after the first interview with the co-founder of 100%Open, for having reached a commercial result; for presenting different roles of the intermediary; for involving more than one intermediary; for dealing with different types of innovation

at the same time (service, process and organizational innovation); and for the availability of interviewees and secondary data.

Equally, the University of Southampton had many R&D projects in partnership with external companies that had the influence of the intermediary, in this case, R&IS department. Some projects though would present limitations of analysis due to the quick and small role played by the department. After a few meetings with the staff from R&IS, the StarStream case was chosen because it involves many partners in different situations, therefore presenting challenges to the roles played by the intermediary. The external partners in this R&D project are varied: a small technology company own by its founder; a large multinational company producing consumer goods and a large government nuclear company, to give some examples.

In Brazil, one R&D project was studied: Force for Elastomers, performed at the Chemistry School of the Federal University of Rio Grande do Sul (UFRGS) with the intermediation of the Secretary for Technological Development (Sedetec), responsible for the liaison between academia and industry. The project is being performed in cooperation with the firm Frenzel. As the other two cases, UFRGS had several R&D projects in partnership with external companies that received the help of the intermediary, in this case, the Sedetec. In a conversation with two employees from the department, we realised that some projects would present limitations of analysis because the partners were big-size public organizations in Brazil, located in States far from the University; therefore the access to contacts could be weak, and observations would not be possible as a data collection technique in many projects.

Theodorakopoulos *et al.* (2012) post that national systems of innovation in Latin American countries evolved into weak entities, and that science and technology institutions do not fully perform an enabling role. The Sedetec was chosen as the intermediary for research because it is the oldest TTO in the State of Rio Grande do Sul, and it is known for having helped several R&D projects in collaboration between industry and academia. In Brazil, collaborative R&D projects tend to increase in number due to the growing investment on technology transfer offices within universities.

Data from the three units of analysis were collected using similar techniques, presented at the next sub-chapter.

3.2.2 Data collection

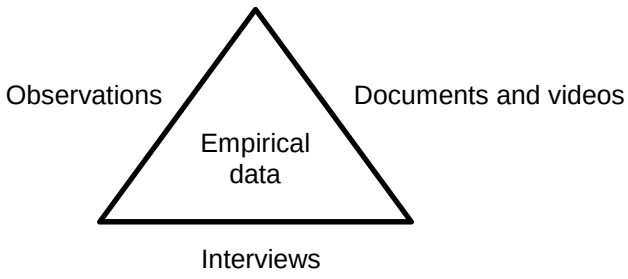
The procedure for data collection was based on a data triangulation approach, which is a technique of cross-checking data from multiple sources to search for regularities. The use of methodological triangulation enhances the validation of the research outcomes by establishing converging lines of evidence. As it can be seen at Figure 14, the triangulation of data collection comprised the following sources of evidence:

a) Semi-structured in-depth interviews;

b) Observations; and

c) Secondary data as documents and videos.

Figure 14 - Data collection triangulation



All the cases were investigated using the same types of sources. Variables of each critical role of the intermediary in collaborative R&D, as summarized at 7 (in Chapter 3.1), gave rise to the research protocol for the interviews. Figure 8 presents the questions derived from those variables (which also may be seen at Appendix 1). For triangulation reasons and for the complete understanding of the subject, different questions were used for intermediaries and for organizations in R&D projects.

The main purpose of the protocol of interview was to increase reliability of the case study. The protocol was applied to three cases selected for this research to ensure that the data collection procedures were implemented in exactly the same manner for all cases. The protocol also served as a guide during the process of data collection so that all criteria and procedures were adhered to.

Table 8 – Protocol for semi-structured in-depth interviews

Critical roles of the intermediary	Questions for intermediaries	Questions for companies in R&D projects
1. Influencing the search for partners with common goals	How do you search for new partners? Do you use the internet to do so? Do you go to trade fairs, etc? Do you search partners for R&D projects among suppliers and clients of the company? How do you evaluate if the company is suitable to be a partner? What characteristics do you consider? Is the search different if the possible partner should be from the academia or the industry? If an organization has a technology (i.e. university) and wants a commercial partner, what do you do? On the other hand, if an industrial organization needs a technology for its new product in development, how do you search for partners who can build the solution?	How did you identify skills and knowledge you did not have for innovation which could be complemented by a partner? Did the intermediary help you to identify these lacks of skills and knowledge? Did you know exactly what kind of partner you needed? Did you help the intermediary to narrow your search for a possible partner? How? How did the intermediary help you evaluate if the company is suitable to be a partner? Did you search for a partner because you had a technology and wanted a commercial partner? Or you needed a technology for your project of new product and a partner which could develop the solution?
2. Influencing the beginning of interaction	If the possible partner does not belong to the net of relationships of the company, how do you make them meet? Do you organize events where companies can meet?	How did the intermediary make you meet with your partner when the two organizations didn't know each other? Have you ever been to an event organized by the intermediary for organizations to meet possible new partners? How did you hear about possible partners that the intermediary had identified? Have you ever met a new partner through the internet?
3. Influencing the access to resources	If a joint project needs people for R&D, what do you do to help them? Do you recruit people for R&D? How? Do you help joint projects get funding from third bodies? How? Do you provide facilities for the joint R&D activities? Or help companies to establish them?	Did the intermediary help you hire people to work at the R&D project? How? If you hired people with the intermediary's help, what would you have done without it? If not, did you try the intermediary's help in this matter before hiring through different channels? Did the intermediary help the project get funds? If so, how would you have applied for funds without the help from the intermediary? If not, did you try its help and the intermediary couldn't help? Did the intermediary help the project with facilities and infrastructure for innovation activities? What did the intermediary do?
4a. Influencing	Do you write contracts or help companies to elaborate them?	Did the intermediary help you and your partner to write the contract for the relationship?

Critical roles of the intermediary	Questions for intermediaries	Questions for companies in R&D projects
the management of the project	Do you establish the rules for partners to belong to the relationship? How do you make organizations to agree with them? Or do you help partners to establish them? Do you define or help organizations to define each partner's tasks in the project? Do you suggest or validate technical standards to be used among the partners? If there is a conflict between partners, do you get involved? What do you do then? How do you help projects to prevent opportunist behaviour from partners?	When the organizations in the project got to know each other, did everyone know the rules of engagement and each one's tasks? Was this kind of information previously explained by the intermediary? If the rules of engagement and each one's tasks weren't previously defined, did the intermediary help the organizations to establish them? Have you ever had a problem/ conflict with partners and solve it with the help from the intermediary? Have you ever had to negotiate with partners about technical standards to be used among all the organizations involved in the project? Did you have the intermediary's help for that?
4b. Influencing about the results of the project	Do you help partners to define about the results of the project, as IP ownership? Do you help partners to define about sharing the commercial (financial) results of the project? Are you responsible for distributing the commercial result among the partners?	Did the intermediary help the organizations in the project define about the results of the project? How? Did the intermediary help the definition of IP ownership (if there was an IP resulting from the project)? Did the intermediary help the organizations define about the commercial (financial) results of the project? Does the intermediary manage the distribution of commercial results?
5. Influencing research and knowledge production activities	Do you help partners' activities during research? How?	On research activities, did the project have the intermediary's help? How?
6. Influencing development and prototyping activities	Do you help partners' activities during technology or product development? How?	On product development activities, did the project have the intermediary's help? How?

Most interviews were audio-recorded to allow more than one listening and consultation. Figure 9 presents the interviewees from the case studies, their positions in the organization and data about the meetings.

Table 9 - Interviewees from case studies

Interviewee code	Position in the company and in the case	Means of communication and dates of interviews
OSCR project		
Respondent A	Former Director of Open Innovation at NESTA. Co-founder of 100%Open.	Via Skype on 03/12/2013. Meeting at The Union on 07/03/2013. E-mails.
Respondent B	Ex-Head of Open Innovation at Orange. Networks Manager of 100%Open.	Via Skype on 04/03/2013. Meeting on 07/03/2013. E-mails.
Respondent C	Former executive of Wireless Innovation. Project Director of Interactive Scotland.	By telephone on 02/05/2013.
Respondent D	Founder of Last Second Ticket, the winning proposal.	Meeting on 08/05/2013. E-mail.
Star Stream project		
Respondent E	Collaboration Manager for the Faculties of Humanities; Business and Law; and Social and Human Sciences.	Meeting on 17/01/2013. E-mails.
Respondent F	Research Support Officer for the Faculty of Business & Law.	Meeting on 17/01/2013.
Respondent G	SETsquared Centre Director.	Meeting on 09/01/2013.
Respondent H	Collaboration Manager for the Faculty of Physical and Applied Sciences.	Meeting on 15/05/2013. E-mail.
Respondent I	Collaboration Manager for the Southampton Marine and Maritime Institute.	Meeting on 15/05/2013.
Respondent J	Collaboration Manager for the Faculty of Natural and Environmental Sciences & Institute for Life Sciences.	Meeting on 01/05/2013, 17/05/2013 and 30/07/2013. E-mails.
Respondent K	Academic Doctor from the research group that launched StarStream technology.	Meeting on 10/07/2013.
Respondent L	Technical Specialist from the Decontamination Centre of Expertise at Sellafield Ltd.	By telephone on 17/07/2013.
Respondent M	Senior Business Development Manager at Philips.	Via skype on 06/08/2013.
Respondent N	Former Project Leader at Philips.	Via skype on 16/08/2013.
Respondent O	Founder and current director of Ultrawave.	Meeting on 10/09/2013 E-mail.
Force for Elastomers project		
Respondent P	Technological Development Assessor of the Sedetec.	Via skype on 09/09/2013. E-mails.
Respondent Q	Legal Assessor of the Sedetec.	Meeting on 21/10/2013 and 04/12/2013. E-mails.
Respondent R	Professor and researcher at Ufrgs.	Meeting on 01/11/2013. E-mails.
Respondent S	Founder and current director of the company Frenzel.	Meeting on 21/11/2013.
Respondent T	Industrial Manager of the company Frenzel.	Meeting on 21/11/2013. E-mails.
Respondent U	Intellectual Property Coordinator at the Sedetec.	Meeting on 04/12/2013.

Added to the mentioned sources of primary data, there was some informal information gathering. About the OSCR case, there was an informal conversation with a NESTA actual employee and with the other co-founder of 100%Open at The Union, a meeting of companies interested in collaborating for innovation. About R&IS department, there were informal conversations and e-mails exchanged with the Head of Faculty Support, who holds the second highest position in the department. These chats were useful for the researcher to get familiar with the cases and to better understand how organizations work.

The amount of interviews was not pre-determined when defining the cases to be studied. The research considered it to be enough when there was no new information coming from the sources about the collaborative project and about the intermediaries' activities. The limitation on sources of information for the findings of the OSCR case would be the absence of interviews a)) with a current Orange employee related to the company Last Second Ticket to check his/her view of the relationship, and b) with other applicants (the ones who did not win the competition) to check their views of the intermediaries' roles and activities during OSCR project. Orange was not available to give the interview for this research; and information about other applicants was not possible to be obtainable due to confidentiality agreement of OSCR project. Regarding StarStream case, further information could have been added if there had been interviews with other external partners. Nevertheless, the comprehensive profile of the interviewed companies allowed a large-scope understanding of the case. About Force for Elastomers case, further data could have been collected from the company interested in the new technology. However, the partners of the collaborative R&D project who own the patent requested confidentiality about that company.

Another source for collecting data was through direct observations. According to Yin (2009) direct observations are useful in providing additional information and understanding of the case. There is an implicit limitation though, because the presence of the observer may affect the behaviours of observed interviewees. Such limitation for the result of the research is minimized here by the use of other sources of data collection. At the OSCR case, the observations took place at 100%Open headquarters concerning relationships among members of the staff. Also observations were made at the Union, an event organized by 100%Open with the

presence of companies from diverse sectors of the industry wanting to meet possible partners to innovate.

At StarStream case, at the University of Southampton, the observations took place at R&IS department concerning relationships among members of the staff, i.e. between faculty-focused teams with thematic-focused teams; and between the Director and the Head of Faculty Support with collaboration managers from different faculties. Also, direct communication among external partners and faculties' researchers were observed. For Force for Elastomers case, at the Federal University of Rio Grande do Sul, observations were made at the department regarding the relationship between interviewed members of the staff, and direct communication among external partners and the University's research group were observed.

The documentation analysis was used to corroborate and augment evidences from other sources of information, as suggested by Yin (2009). Moreover, the documents allowed some inferences about the cases. For the OSCR case, the secondary data used were: the brief of the competition developed by the company Orange; the video from the launch event; two videos of speeches about the OSCR case by Jogesh Limbani from Orange; the report from Nesta about its Corporate Connect programme; news from Orange's website; the case study from 100% Open website.

From the Research and Innovation Services of the University of Southampton, the documents used for the analysis of StarStream case were: the organization chart; the Strategic Plan of two consecutive years; the handbook explaining modes of collaboration handed for external organizations; the document called Principal Services provide by Research and Innovation Services specifying the department's responsibilities; news about innovation partnerships at the University's website, the partners' websites and other websites; the Invention Information Form, where professor and research groups report a potential idea for commercialization; and the Confidentiality agreement for partnerships.

For the Force for Elastomers case, some of the documents used as sources of data were: the handbook explaining modes of partnerships and the departments of the Federal University of Rio Grande do Sul that need to be involved for the approval; the Request for the Search on Patent Databases form, where the professor or research groups describe the invention and suggest key-words related to the it

before beginning the filing process; the Invention Report used to begin the patent process, where professors or research groups fill information about the activities that led to the discovery; a video from a research competition presented by the undergraduate student involved in the second phase of the collaborative project where the research is explained; the Sedetec's organization chart; the cover of the collaborative contract's addendum where there was the list of departments within the University through which the addendum had passed for signatures; and three documents from the University's Council – CONSUN[2].

The limitation on using external documents as evidence for the case study is that they are written for a specific audience and purpose. That is why they are triangulated with the other two sources of data.

For the complete understanding of the subject, the profiles of the companies as well as of the intermediaries were also observed. Characteristics as the size of the organization, number of people, location, age and segment in the market provided additional details on the cases. About the R&D projects, data as the number of people involved, duration, activities performed, type of innovation being searched, funds, institutional context, roles and responsibilities in the project, previous relationships among the companies involved and results obtained from the project were also investigated as fundamental data for understanding the empirical findings.

Each case study is presented individually to allow exploring details obtained from the sources. After that, the analysis of data will explore convergences, as explained in the next sub-chapter.

3.2.3 Data analysis

The analysis of data is divided into two parts: individual case study analysis and cross-case analysis. Firstly, after the data collection, a detailed within-case description was developed about each R&D project chosen as a case study, drawing from the interviews and collected documents. The material was organized to present the temporal linkage of events of each R&D project. Some interviewees' speeches were reproduced to illustrate their opinions on the situations. The focus of the

[2] In Portuguese, the documents are: Decisão número 193/11, Portaria número 2679/11 and Portaria número 3064/98.

description is not on the technology being developed, but on the activities of the intermediaries and organizations involved at those projects.

After the description of each case, an analysis of the case aimed at identifying the role of intermediaries in each of the critical elements of the collaborative R&D project; at pointing out significant issues within each critical element; and at exploring reasons underlying intermediaries' activities and roles in that particular case. In order to do so, the variables of each element of collaborative R&D (presented at Table 7 in Chapter 3.1) were reviewed to identify whether the intermediary had that role in each one of them. All three cases were analysed using the same variables in order to keep the consistency of interpretation.

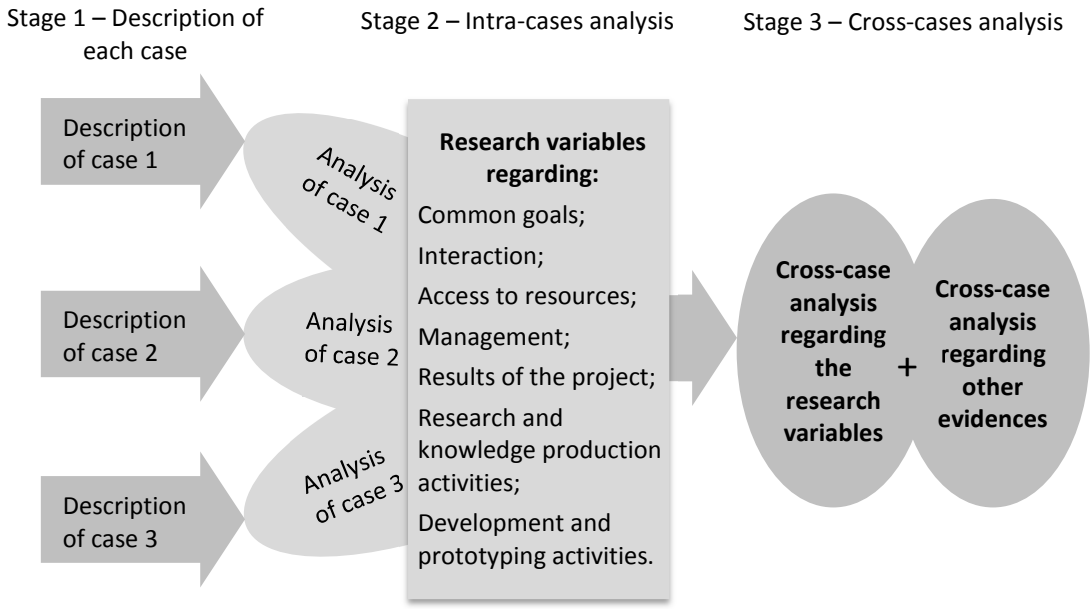
After the individual case analysis, a cross-case analysis was developed for a comprehensive understanding about intermediaries. It aimed at synthesising the research findings of the three individual analyses and identifying patterns of practices to answer the main research objectives. As a qualitative research, the cross-case analysis tries to reach a more in-depth understanding of the phenomenon. In order to do it, the previous individual analyses were matched and related to the literature used to give rise to the research propositions. Following the content analysis technique (BARDIN, 1986), the variables of each element of collaborative R&D project that could be influenced by intermediaries (Table 7 in Chapter 3.1) were reviewed according to the cases. Empirical evidences were matched with theoretical evidences; and each research propositions was addressed. Figure 15 illustrates the flow of activities for the data analysis.

After the cross-case analysis, it was possible to offer some contributions regarding the theory and practice of R&D collaboration with the influence of intermediaries and to propose a conceptual framework explaining how intermediaries actually influence collaborative R&D projects.

3.2.4 Reliability and validity assessment

According to Yin (2009), four tests have been commonly used to determine the quality of empirical social research, including case studies: construct validity, internal validity, external validity and reliability.

Figure 15 - Activities for the data analysis



Construct validity deals with the establishment of correct operational measures for the concepts being studied. There are three tactics suggested by Yin (2009, p.34) to increase construct validity: using multiple sources of evidence; establishing a chain of evidence; and having the draft reviewed by key informants. All of them were followed in the present study. As already described at item 3.2.2 (Data Collection), information was gathered from interviews, observations and documents to allow the triangulation of data and cross checks. Thus, the descriptions produced from data were organized in order to be presented according to the links among evidences, producing timelines of events in the end. Also, the narrative of the cases produced by the researcher was checked by some participants. In some situations, the interviewee added further information after reviewing the description of the case. Such validation of the researcher's understanding was useful mainly in the StarStream case, where the extent of the collaboration over time and amount of organizations involved at different times made it particularly difficult to reconstruct the whole story sufficiently accurately.

The *internal validity,* as explained by Yin (2009) should be a concern for explanatory or causal studies. It is also a concern extended from the broader

problem of making inferences. Regarding that, Yin (2009) and Riege (2003) suggests within-case analysis, then cross-pattern matching, explanation-building and time-series analysis as techniques in case studies to achieve internal validity. The explanation-building in explanatory case studies is the parallel procedure to the generations of hypothesis in exploratory case studies. However, the goal here is not to conclude a study but to develop ideas for further studies. According to Yin (2009, p.141) “the better case studies are the ones in which the explanations have reflected some theoretically significant propositions” and “the social science propositions, if correct, can lead to major contributions to theory building”. So at the present research, the internal validity was handled by developing within-case analysis of each collaborative R&D project considering the timeline of events, before the multi-case analysis that searched for patterns of practices. When analysing the multiple-case studies, the goal was to build an overall explanation that suits each individual case, even though the cases vary in their details.

The *external validity* deals with the degree to which a study’s findings may be generalized across social settings. Here, the external validity was increased by studying multiple R&D projects influenced by intermediaries and by analysing the practices of intermediaries from different countries. Moreover, evidences were compared with extant literature.

The fourth test is *reliability*. According to Bryman (2001, p.390) there is an external and an internal reliability. External reliability is the degree to which a study can be replicated. He explains that this is a difficult criterion to meet in qualitative research since it would be impossible to “freeze” a social setting and the circumstances of the initial study. The *internal reliability* is the consistency of data collection, analysis and interpretation. It is the degree to which different observers would get the same result from the study (YIN 2009, p.36). As suggested by both authors, reliability was addressed in this research by developing the protocol for interviews and refining it after the pilot, and following the same standards for data gathering in all cases.

The research followed the previous orientations in order to guarantee the scientific accuracy. The techniques used in the present study therefore aimed at enhancing the reliability and validity of the research.

The Research Design and Method chapter provided details on the research framework as well as about data collection and analysis procedures employed in this research. Therefore, this Chapter provided the basis for the empirical study performed on the following chapter, in order to address the research question and objectives.

4. EMPIRICAL RESULTS

In the former chapters, the theoretical and methodological bases of this research were presented. The following section presents three parts. Each one of them consists of one case study about intermediaries' roles on inter-organisational R&D projects. These chapters are structured as follows: the first part is dedicated to describing the intermediary and its organizational contexts as the services provided by the broker. After that, the R&D project is presented providing a description of partners involved, actions of the intermediary and other issues relevant to each case.

4.1 CASE 1: ORANGE SERVICE CALL + REWARD (OSCR)

In 2006, the emerging practice of open innovation led the National Endowment for Science, Technology and the Arts (NESTA)[3] to launch the programme called Corporate Connect to investigate how relationships of businesses can be enhanced. It involved different kinds of innovation, as product innovation at fast-moving consumer goods' companies, service providers and process innovation at manufacturing firms. NESTA's stated aim was to play a role "in easing the transition of open innovation from marginal to mainstream, helping to create a more effective market between large enterprises and the wellspring of entrepreneurial talent in the UK" (NESTA, 2010). The result for NESTA, in the words of its former Director of OI (respondent A), was that, from the insights and discoveries resulting from this project and from other practices analysed in the programme Corporate Connect, NESTA created new methods for OI aiming at helping organizations co-create with suppliers, consumers or customers to produce investable propositions and launch them successfully to the marketplace.

[3] The National Endowment for Science, Technology and the Arts (NESTA) is the United Kingdom's foundation for innovation. Its stated mission is to help people and organisations bring ideas to life by providing investments and grants and mobilising research, networks and skills (NESTA, 2012). NESTA was brought into being in 1998. Until April 2012, it was a public body. From then on, NESTA became an independent charitable foundation, getting benefits from the income provided by NESTA's £320 million endowment.

In 2010, when the programme had reached its results, two of NESTA's employees (respondent A and a colleague) spun-out and launched an independent company called 100%Open. One of the co-founders, said that "at NESTA, we had designed and run open innovation competitions and programmes for over four years. We had quite a lot of success and reputation in doing that. So we decided to spin out from NESTA" (respondent A). As a consultant and service provider, 100%Open targets at helping organisations create value by innovating with partners. Most of its services were created inspired on the discoveries from NESTA's Corporate Connect programme. That is why the services described in the following section are nowadays provided by 100%Open; however, the OSCR case was performed when the staff worked at NESTA.

4.1.1 Services provided

This section presents the main services provided by 100%Open following the programme previously performed at NESTA.

4.1.1.1 Search for partners

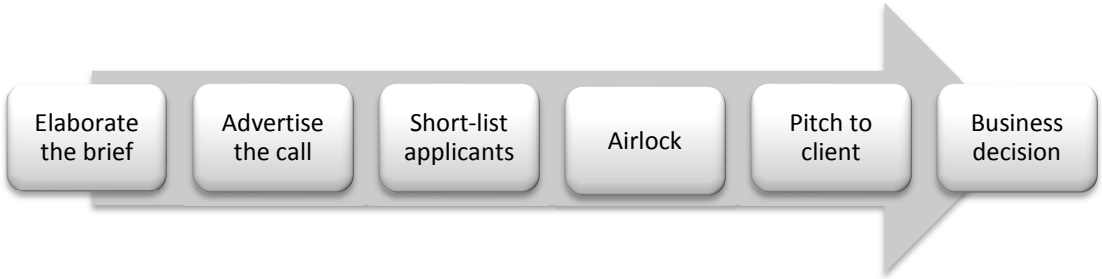
There are two different flows for the intermediary to help clients with the aim of beginning relationships for innovation. The two different starting points are: a) the client wants to work with another organisation or another group of people and b) the client has a specific problem or need that they want to solve. 100%Open calls them, respectively, Jam and Discover. According to the co-founder, "probably on one third of our time we do targeted jobs, what we call Discover. So there is a specific problem that we try to find a solution. On two thirds, we start with a community and try to find productive ways to work with them" (respondent A).

The Jam method was tried and tested with the companies Virgin Atlantic, Oracle, Tesco and McLaren (100%Open, 2010). This method starts focusing on finding a group of people or organisations that could work well together, sharing both their aims and the workload as the relationship develops. Usually three sources of partners make a network or a community: the end consumers of a product or service;

existing suppliers that already have a transactional relationship with their customer; and the company's own staff (NESTA, 2010). As there is not a previous need to be solved, creative freedom generates open briefs. Using brainstorming and other workshop techniques, the intermediary also makes use of insights or horizon-scanning programmes to help the network to author a final brief on an opportunity area. The role of intermediating fosters a collaborative and status-free atmosphere. But its role extends beyond managing creative events because it follows-up with the Jam method keeping business-focused discussions. Next to that, the stage of business planning aims at extracting investable propositions. This culminates in a pitch where teams have the opportunity to make investment or partnership decisions. According to Nesta (April 2010), results tend to be external routes to market, ending in collaborative business models like joint ventures or delivery partnerships.

The Discover method, according to 100%Open (2010), was tried and tested with companies such as Procter & Gamble and Orange, which will be addressed at item 7.2 with the OSCR case study. The process starts with a specific problem of a client. The flow of activities is linear beginning with a focussed innovation brief detailing the unmet need. This brief releases a problem to a competing community. The management of the method is responsibility of a Trusted Agent, as they name the intermediary. The result of the whole process tends to be internal routes to market (e.g. licence deals). Figure 166 presents a summary of the stages at a Discover method, which will be deeper described afterwards.

Figure 16 - Activities at the Discover method



In more details, on the first stage of the Discover model, the client provides a summary brief to the Trusted Agent describing the type of innovation that they would be interested in gaining. This brief is advertised to an innovative audience that may apply potential solutions as candidates for a business deal with the client. The

proposals however are not disclosed immediately to the client. The Trusted Agent chooses the most suitable candidates according to the brief and to the client's needs. The next stage of the competition is called The Airlock. The short-listed proposals get help from the intermediary to improve their technologies, to tailor their offerings according to the needs of the client and to protect it. All technical information provided by the Candidates to the Trusted Agent is held under a confidentiality agreement within the Airlock and is not disclosed to the client. Candidates therefore are free to disclose full details of their innovations. Funding is provided to enable the candidates to file the intellectual property.

After this stage, the Airlock is "broken" in a formal pitch. Both the client and the short-listed candidates are introduced to each other with full technical disclosure. There usually follows a pre-contractual period during which the innovator cannot present to others. At the end of this time, the client has to make a decision either to hire the proposal or to refuse it. If declined, the candidates are free to find alternative investment elsewhere (HART, 2012). In this model, the clients save time as they see only those ideas that best answer the brief.

4.1.1.2 The Union

The Union is an event organized by 100%Open with the presence of companies from diverse sectors of the industry wanting to meet possible partners to innovate. According to 100%Open (2013), there are around 700 members from diverse sectors of industry. The participants are senior innovation and venturing professionals with the purpose of creating value through contacts. This event has been running quarterly for an evening for almost five years. The co-founder of 100%Open (respondent A) says that a lot of relationships come from hosting these events. Until 2013, there was no membership fee.

The Spring meeting in March 2013 had around 100 people. About 15 participants presented their companies and the innovation that they are seeking, or presented what they have to offer for possible partners, in a 10 minutes speech each. Complementary to the presentations, the Union has a moment where the participants

interact informally. There are drinks and snacks in the room, and all the members are standing and chatting around the place to get to know other participants.

The next section presents a R&D project managed by the open innovation group at NESTA within Corporate Connect programme, who spun out afterwards to launch 100%Open.

4.1.2 Collaborative R&D project

Launched in 2009, Orange Service Call and Reward (OSCR) was a competition ran by NESTA for the telecom company Orange UK, that involved also the service design innovation consultancy LiveWork and Wireless Innovation, an incubator of small and medium companies (SME's) from Scotland. The project aimed to create long-term business relationships between small firms and Orange around innovative services and business models. The winner was a service called Last Second Tickets, an online and mobile platform that has been running ever since, specialised in unsold tickets for events as theatre plays and shows.

a) The beginning of the project

It was the first of its kind for Orange and, therefore, it was an internal process innovation, because the company traditionally applied a closed view of corporate innovation. Open innovation (OI) had started at Orange at the lab level one year before, with the creation of a role of Head of OI. As the concept of OI was very new to the company, the first Head said that "the project with NESTA was received as being quite risky because we would source innovation from outside the company, integrate it into the day job of my colleagues in the business unit, and they would have to deploy it the same way as if they would anything on their pipeline" (respondent B). It took the manager six months and various levels of presentation to get his idea through. After getting the company's approval, and before launching the competition, the former Head of OI together with Orange's business units defined and specified what they needed.

Although NESTA was the organisation responsible for coordinating the whole project, the companies LiveWork and Wireless Innovation were also intermediaries (called “trusted agents” in the project). The former executive of Orange explains that the competition required the company’s own intermediaries to be part of the process, because “as well as NESTA was doing a great job, in testing innovation modules in other companies, they didn’t know about us and our business as much as we needed them to” (respondent B). LiveWork had worked with Orange for 10 years and, according to respondent B, it was a key trusted agent because it knew the company, it understood the brand and it had developed services for Orange before. Wireless Innovation had experience of incubating SME’s in Scotland. It has worked with NESTA before as well as with Orange for some years. Orange’s former executive says that “they were brought in on a consultancy basis for their specialist expertise on couching, mentoring and getting a feel of which innovations were going to be successful because they had incubated over 250 companies through their centre” (respondent B). As the former executive of Wireless Innovation complements, “I have worked with Orange before because I had held series of one-to-one brokerage meetings with start-up companies and various departments across Orange (R&D labs and business teams/groups). That gave me an insight into their business model” (respondent C).

The total budget of OSCR, according to Orange’s former executive, was £150,000, of which £100,000 were given for finalists and £50,000 was used for logistics and to pay for Wireless Innovation and LiveWork consultancy services to act as intermediaries. But, in the end, only £100,000 was used as the finalist did not need to share the full fund. The costs of the project were shared between Orange and NESTA. There were no costs for the applicants apart from their time.

b) The launch of the competition

NESTA helped Orange to write the brief according to the needs identified with the company’s business units. After that, it was released for the applicants and for the media. The project targeted small companies that could propose innovative services and business models that would create revenues worth €20 million over

three years, which would grow audience share and increase customer loyalty. So for the SME's, the competition provided a summary brief describing the type of technology innovation that Orange was interested in gaining. According to the company's former Head of OI,

> The two pages brief summarized generally the audience and advertising area. It gave five categories of service innovation and the maturity of innovation. It had to be something that differentiated Orange against its competitors. It had to be a pilot or in testing because we wanted something that we could convert into a market opportunity quite quickly, not a technological innovation that would take years to design, test and integrate in our infrastructure. We wanted something that didn't need deep integration in our network (respondent B).

The brief was sent to over 500 SME's from NESTA's, Orange's, Wireless Innovation's and LiveWork's networks. Also, a launch event was held at NESTA's headquarter when more than a hundred potential applicants attended in person. Companies interested in submitting ideas could meet with representatives from Orange to further understand the company's needs. At the event, the partners presented the competition and introduced the jury who would later choose the winner. The jury was formed by Orange UK's senior representatives, the key decision makers, as the Head of Product Marketing and the Head of Content Operations.

The owner of the winning proposal said that he did not hear about OSCR from the media, so he could not go to the launch event, which had already happened when he got to know about the competition. A friend of his saw the announcement on Twitter.

> I didn't hear about the competition prior to that twit. And I should have heard, because I had my antenna tuned to telecommunication companies (telcos). I was already quite far progressed with another telco and I had already done quite lots of crafting of the proposition for them. But they move so slowly. So OSCR came out from nowhere, but it was a good fit for my business because everything I had been doing for six months was all about trying to present something really interesting to a major telco (respondent D).

Orange's former executive comments on the way that the winner got to know about the competition: "The most amazing thing was that we spent a lot of effort in marketing this in the UK through innovation clusters. But the winner didn't receive the emails and he wasn't at the launch event" (respondent B).

The applicants filled a form which detailed their technology, service or platform. There were not specific items to be completed; the submission allowed up to four pages size A4. In order to properly address Orange's needs, the winner's admits that he watched the videos from the launch event several times.

> What was brilliant was that, when they launched OSCR, they video-recorded it. They had many presenters saying what they were looking for; and it was incredibly useful for me because I was able to watch and listen to it like 40 times. I did 'start, stop, start, stop, start, stop'. I knew exactly what they wanted just by listening to them on the presentation. So when I wrote my proposal, I was able to think 'humm, they wanna talk about this, they wanna talk about that, etc, etc (respondent D).

The competition received 85 proposals of service innovation. According to NESTA's former OI Director, "the biggest challenge to narrow the applicants and choose the ones to go into the Airlock was finding the right attitude, meaning that they had to be open to doing business with Orange and realising the real incentive was the scale that partnering with Orange could bring them" (respondent A). The former executive of Wireless Innovation complements describing the process of short-listing the applicants, when

> each reviewer took notes beforehand and then we got together on a business meeting to discuss as a team about each application on its own matter. That was fortunate because each reviewer had experience of different elements about the same business. Instead of having people that were all technologist, we had one who was specialized in marketing, another one in business and another one of us was good at technology issues (respondent C).

The three intermediaries first narrowed the applications down to around 20 to 30 forms. Then there were face-to-face meetings with the applicants. To be able to better select the proposals according to Orange's needs, the intermediaries analysed the applications regarding to more issues rather than just the submitted forms. As the former executive of Wireless Innovation exemplifies,

> in addition to the brief, there were business criteria that we were able to use from our own perspective: if it was a scalable platform; what the business trading history was; if the company could cope with working with a big corporate; if it was just an idea or it was already prototyped; if it had addressed the brief properly (respondent C).

After the face-to-face interviews with the applicants, the intermediaries selected the most promising six opportunities to pass immediately on to Orange for fast-track development. Seven further proposals were selected by the intermediaries to enter the process called Airlock.

c) The Airlock

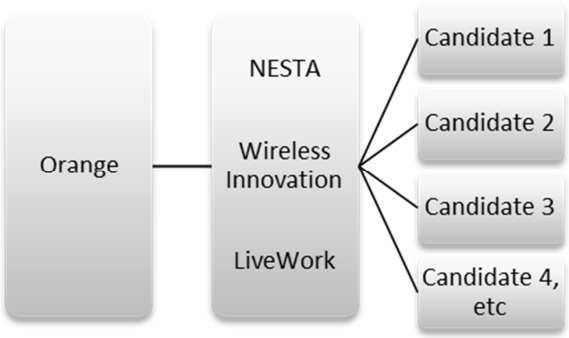
The Airlock was the stage of the project where the selected propositions received funds, support and advice about how to improve, protect and adapt their proposals according to Orange's needs. The intermediaries' role was to help the applicants in the Airlock to build a visual business case that was customized to Orange's target audience. NESTA's former OI Director explains that, in the Airlock:

> we develop the propositions and protect them. We need to make sure that they are addressing the needs of our client before they finally present it to our client. So the client only has to sign one contract with us rather than tens or hundreds of contracts with potential external parties (respondent A).

Within this stage, all technical information provided by the candidates to the intermediaries was held under a confidentiality agreement and was not disclosed to Orange. The applicants therefore were free to reveal full details of their innovation, including yet to be protected IP. According to the winner of the competition, this rule was one of the most important in the competition. He says that "they clearly stated right from the outset that, if you are selected for the Airlock, they would guarantee your IP. They would make sure that we were legally covered. And it proved to be incredibly useful further when negotiating with Orange" (respondent D).

Figure 17 shows how the relationships were held within the stage called the Airlock, where Orange did not know and did not have access to the applicants.

Figure 17 - Communications within the Airlock



As it can be seen at Figure 17, the three intermediaries were involved at this stage of the process. According to the former Director of Open Innovation at NESTA,

> LiveWork represented Orange in the Airlock and Wireless Innovation represented the small companies in the Airlock. The team brought a business consultant in, because one of the criteria of the competition was to demonstrate a 20 million euro service innovation. So the business consultant provided a financial module which projected a 20 million euro revenue market according to the service proposed (respondent A).

Complementing this information, the former executive of Wireless Innovation explains that the intermediaries initially had a teleconference with the selected companies. When it came to one-to-one advice, it was provided by another company, the consultant. However, at the interview with the winner of the competition, when he was questioned about what happened during the Airlock, he did not mention about the consultant. Only after the researcher asked about it, he remembered: “oh yeah, there was a consultant, you are right. I remember now that he showed us very interesting charts” (respondent D).

According to NESTA’s director of OI at that time, there were three or four meetings over eight weeks, either at NESTA’s office or at the applicant’s own locations. However, the winner of the competition said that the communication with the intermediaries was by email and telephone. He complains that he wanted more details about Orange’s business, to adapt his proposal when presenting it to the telecommunication company on jury day. As he comments:

> I was constantly asking the intermediaries 'where can I find this information about Orange, what about that'. I think I asked around 40 questions, and I got nothing. Big mistake. I kept asking detailed information so that when I present it I could have really accurate statistics. I think that was a big disconnect. They didn't give help and advice all the way through in terms of information about Orange (respondent D).

A positive outcome of the Airlock, though, was the funding received by the selected applicants. The money was not given automatically. The former executive of Orange explains that "each finalist had to apply for what amount they needed and say what they were going to spend it on. So some wanted business and financial consultancy whereas others needed branding or prototyping services" (respondent B). According to the winner,

> the money they gave was huge for a start-up company. It was to create the best you could ever do in the end of one month. I think, as a young start-up company, what you can do with £10,000 is so huge. I created a whole video and other things. I went crazy, because it was such a major opportunity. I don't get how the other companies don't see that (respondent D).

After the first round of help and advice, the applicants had an opportunity to test the presentation that they were planning to do for Orange later on. Around ten people from the intermediaries were the audience. The panel made questions, critiques and suggestions for the applicants about their presentations. The owner of the winning proposal points out that this activity was useful. He affirms he got valuable feedback and it helped to improve and change the final presentation for Orange. In contrast, the applicant complains that he was the last one to present, and the activity was delayed from previous exhibitions. He explains that "some of the commentators had to rush to the airport to get a flight. Also one of the electric devices broke and my presentation was crashed in the middle. I had to present a little without the video. That's unacceptable" (respondent D).

The Airlock stage was completed in February 2010, when the ideas were pitched to Orange.

d) Jury day: show time

NESTA planned the presentation day. Five companies from the Airlock presented their proposals for the jury. The intermediaries decided that two

companies from the Airlock were not ready to present on the event. The audience was formed by representatives from the three intermediaries and the judges from Orange. One applicant could not watch the others.

As the initial brief was quite wide, allowing a big variety of proposals, the winner of the competition said that he prepared his presentation matching what the judges had revealed on the launch event. He comments that “the written brief was a bit opaque” (respondent D). His concern about adapting his proposal according to Orange’s needs proved to be positive when the judges saw his presentation on jury day. The former Head of Open Innovation at Orange exclaimed that “when respondent he presented his proposition, it was ‘Wow!’ Something so good that the brief didn’t matter anymore” (respondent B).

e) After the jury day

When the presentations were done, LiveWork and Wireless Innovation ended their participation in the project. NESTA was still involved in introducing the two companies from the Airlock that did not present on jury day. As the former Head of OI at Orange comments,

> When the two were ready, NESTA facilitated a meeting so that they could present but not to the final jury. Just to me. They were good but very early-stage ideas. Also there were other elements, like quality and commitment, because they didn’t finish in time for the pitch (respondent B).

NESTA facilitated follow-up meetings between Orange and the seven companies. After that, it ended its participation in the project. The owner of the winning proposal expresses his opinion that the intermediary should have gotten involved further than that. He says that he was never told he won: “we found out by chance on an email. No congratulations. No fireworks” (respondent D). According to OSCR contract, after the pitch, Orange would have 90 days to decide which ideas to pursue further. The former Head of OI at Orange also finished his involvement with the project, because the negotiations between the telecommunication company and the winner were responsibility of the respective business unit and the commercial department. The owner of the winning proposal comments that “when we started

negotiating, a complete different team took over who knew nothing about the OSCR project. Negotiations took seven months until we signed the contract. Meanwhile I had no money from my company" (respondent D).

Until the publication of this research, the two companies (Orange and Last Second Ticket) keep being business partners. Their service, called FunFinder, is exclusive for Orange's customers in the mobile sector. Apart from that, the company Last Second Ticket has other four clients in different sectors. Their contract established two years of exclusivity in the telecom market, period that ended in October 2013. Also, there were other companies included in their initial contract with which Last Second Ticket could not sign a deal, as Apple, Sky and Google.

The service is seen as a loyalty program by Orange, covering the whole country. From each sale, Orange and Last Second Ticket split 50% of the revenue. The founder of the service explains that, "typically, we receive 10% or 15% of sales commission from the venue or the promoter. We also charge the consumer a booking fee of about 10%. So this is a revenue generating service. We pay to Orange between £15,000 and £20,000 of revenue" (respondent D).

f) Other results from the project

Apart from the launch of the service Fun Finder, there were other results from the project for Orange as well as for the applicants and for NESTA. The applicants, even the ones who did not win, got introduced inside Orange. Also, they had the chance to improve their proposal using the funding and advice provided in the Airlock stage. The intellectual property of those ideas that Orange rejected remained with the applicants, who were then free to negotiate their innovations to other companies. An important note here is that none of the interviewees knew if other applicants pursued their projects after the competition.

For Orange, the former Head of OI comments that, at a macro level, France Telecom Group has realized that the competitive landscape has changed. A position of Head of OI was created in Poland, Egypt and Spain. The director of open innovation of France Telecom Group, based in France, heard about the success of OSCR and asked the British OI department to help him design an equivalent process

to work in France. Orange's former Head of OI compares the French to the British project:

> It was broader, because it was about technology innovation (systems, infrastructure, servers, etc). In France, they were open to having proposals that resulted in changes in the network infrastructure which take longer to roll out because they cost billions of Euros in capital expenditure. It was also a public relations activity. France Telecom is partly state-owned by the French government and they have a not-very-good reputation of working with SME's (respondent B).

The program was called Arc Bretagne Atlantique. And the goal was also to target SME's to fill in the holes of the supplier - Alcatel-Lucent – so that Alcatel-Lucent could be more innovative to France Telecom as a customer. The intermediary was a French body called Oseo[4]. The next section presents the analysis of the project since its start.

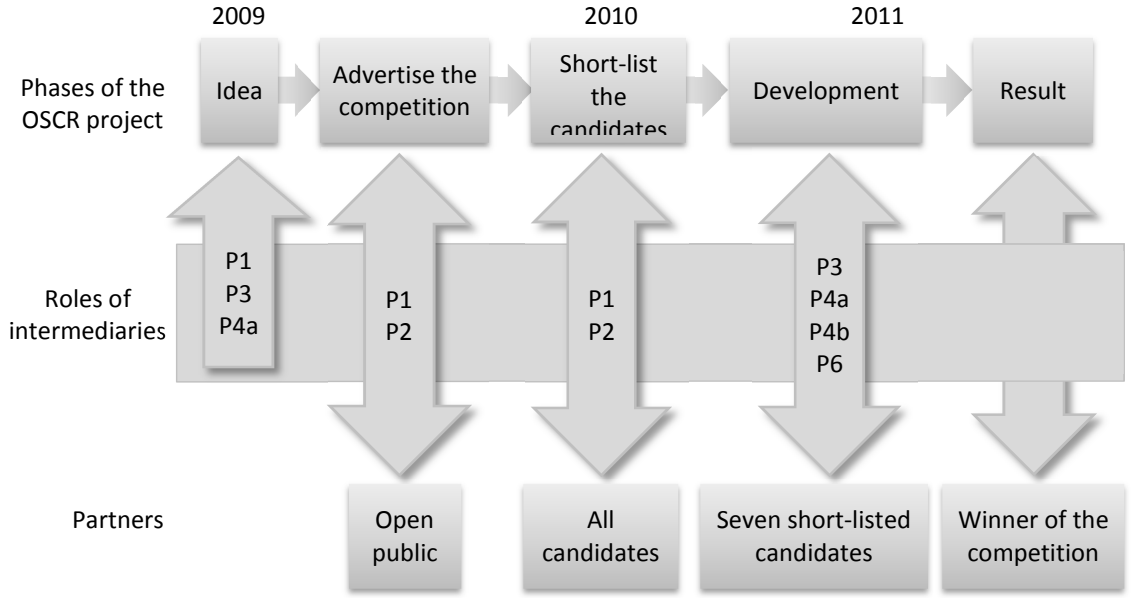
4.1.3 Case analysis

Next, Figure 18 shows OSCR's timeline with the main activities. Each stage is related to the partners, indicating which activities were performed by the intermediaries according to the research propositions. The direct link between OSCR project and the winner of the competition (last stage of the project) means that the organizations were connected but the intermediaries did not perform any role at this stage of the project.

The start of the competition was internal to Orange, with the Head of OI lobbying it to the main decision-makers in the company. After having the approval to move forward with an OI programme, he and the business units decided what they expected from external partners. That is when the process starts having the influence of an intermediary. NESTA helped Orange to write the brief that was further spread and advertised to potential applicants by these two companies and other two intermediaries (LiveWork and Wireless Innovation).

[4] OSEO is a holding with public status. It reports to both the Ministry for Economy, Finance and Industry, and Ministry for Higher Education and Research.

Figure 18 - OSCR's timeline



Critical roles of intermediaries (research propositions):
P1. Influencing the search for partners with common goals;
P2. Influencing the beginning of interaction;
P3. Influencing the access to resources;
P4a. Influencing the management of the project;
P4b. Influencing about the results of the project;
P5. Influencing research and knowledge production activities;
P6. Influencing development and prototyping activities.

Within the advertising stage, there was the launch event with the participation of the four organizations. After that, only the three intermediaries were involved during the stages of short-listing the applications, choosing the ones to go into the Airlock and selecting the ones to present on jury day. At the pitch, the three intermediaries were together with Orange. Later on, NESTA arranged meetings between Orange with two other applicants who did not present on the pitch. The final stages of the process were internal to the telecommunication company, regarding the decision about the winner of the competition and the negotiation of the contract to start with the partnership.

Next, the OSCR case is analysed considering the proposed research framework about intermediaries' roles on R&D projects. The activities and roles of intermediaries were reviewed according to the proposed research framework presented at Chapter 3. To conduct the analysis, the discussion of critical elements of collaborative R&D projects influenced by an intermediary was based on the variables mentioned at the literature about each of the elements. The comparison and convergence with the other studied cases will be presented at Chapter 5.

Table 10 summarizes the activities and roles played by the intermediaries at OSCR case, relating them to the critical elements of collaborative R&D projects influenced by intermediaries.

Table 10 – Intermediaries' roles at OSCR project

Critical roles of the intermediaries	**Intermediaries' activities at OSCR case**
1. Influencing the search for partners with common goals	NESTA had the network of SME's, start-ups and incubated hubs in the UK with 500 possible applicants. The intermediaries were responsible for short-listing the submitted proposals.
2. Influencing the beginning of interaction	There was an event organized by NESTA with the attendance of around 100 potential future partners not previously selected. Most of them were from NESTA's network. Orange's innovation people were introduced to around 10 possible partners chosen by NESTA. Some had a fast track after applying and the others were in the Airlock. The flow of NESTA's activity was initiated by both: the organization that wanted a solution and the intermediary itself that wanted to test open service innovation.
3. Influencing the access to resources	The intermediaries at OSCR hired a market consultancy to help the applicant in the Airlock. NESTA had a role in funding part of the project. Also some meetings happened at NESTA's office in London, according to the organisation.
4a. Influencing the management of the project	The design and coordination of the entire project was done by NESTA. It was responsible for not letting Orange know who the applicants were, keeping the confidentiality as agreed on the contract. NESTA was also responsible for signing contracts with the applicants and separately with Orange, centralizing the control of the project.
4b. Influencing about the results of the project	The business relationship between Orange and the winner did not have the influence of any intermediary. The intermediaries had a minor role regarding intellectual property. As the project was about services innovation, the applicants had a mixture of ways to protect their developments. The intermediaries were responsible for hiring IP advice from an independent advisor (a lawyer).
5. Influencing research and knowledge production activities	Not applicable in this case.
6. Influencing development and prototyping activities	The intermediaries helped the applicants in the Airlock to adapt their business cases and developments according to Orange's needs.

As it can be seen at Table 10, most critical elements of collaborative R&D project had the influence of intermediaries. NESTA helped its client on searching for partners with common goals (proposition 1). However, the importance of the intermediary to this issue may be questioned, considering that the organisation advertised the competition to around 500 SME's and start-ups, but the winner was not from its network. Also, there is not a measure of the effectiveness of the intermediary regarding its network of SME's, because there is not a registration of how many applicants were from NESTA's network and how many applicants did not receive the advertisement from NESTA.

Another point regarding NESTA's role on searching for partners with common goals is the fact that none of the interviewees kept track of other applicants; and nobody knew if they had pursued their projects after OSCR. In addition to not knowing, the Head of OI at Orange and at NESTA did not keep in touch with other applicants, who may have been also possible partners with common goals. The project, and NESTA as an intermediary, did not foster relationships apart from Orange and Last Second Ticket. So the project as a whole was successful in terms of finding a profitable innovation for the client, which was its purpose. But it could have fostered the creation of more ties among all the parties involved, if the intermediaries had had this concern.

Still about proposition 1, another deviating result from the project was that the winner did not fit in any of the categories advertised at the written brief. Maybe other potential winners would have applied if the brief was different or wider. As the intermediaries were responsible for short-listing the applicants to go into the Airlock, it raises some questions. How would have the selection been if the other two intermediaries (LiveWork and Wireless Innovation, that knew Orange better) were not hired for the project? When analysing the identification of common goals shared by the applicants with the client (in this case, Orange), the fact that the intermediary is an external organization not related to the client may reduce the intermediary's role. At OSCR case, Orange solved this gap by bringing other two intermediaries, which were related to the company before.

Regarding the beginning of the interaction between organizations (proposition 2), it was not found in the previous literature and it may be considered as a finding from the OSCR case study the fact that the flow of interaction as the whole R&D

project was initiated not only by the client, but also by the intermediary (NESTA). The interaction in this case was initiated by both: the organization that wanted a solution and the intermediary itself that wanted to test open service innovation different from the findings of Winch and Courtney (2007) who describe two different flows. NESTA organized an open event to present the project, where around 100 potential applicants attended. Most attendants were from contacts who received the advertisement. NESTA chose and introduced around 10 possible partners to Orange staff involved with innovation.

About the acquisition of resources (proposition 3), the intermediaries at OSCR case helped the applicants with financial resources for the developments, human resources in consulting and infrastructure for meetings. Funding was a very important issue for this project to happen because the applicants were SME's that not always can afford formal R&D activities.

The influence of the intermediary on the management of the project (proposition 4a) at OSCR case was clear because NESTA was responsible for designing the whole project and managing the contracts with the applicants. Also the organization made sure that the confidentiality, agreed on the contract, about the proposals was maintained throughout the process, protecting the applicants against any potential opportunism.

Concerning the definition and distribution of the results of the project (proposition 4b) at OSCR case, the intermediaries had a minor role regarding intellectual property. As the project was about services innovation, the applicants had different ways of protecting their developments. The intermediaries were responsible for hiring IP advice from an independent advisor (a patent attorney). However, the business relationship established between Orange and the winner of the competition did not have the influence of any intermediary.

The proposition about research activities (proposition 5) could not be analysed for not being included in this case. The OSCR project showed that the intermediaries had a stronger role in helping the applicants turn their development activities into a commercially appealing service; and a smaller role on helping them to develop or pilot their proposals (proposition 6).

There are unequal speeches about what happened in the Airlock phase of the process. One must consider that the OSCR project took place from 2009 to 2010. So

some of the interviewees may have forgotten how the activities occurred, what may explain some differences in their views. Finally, although the initial objective of this case study was to analyse the role of NESTA at the OSCR project, throughout the research it became evident that the other two intermediaries also played fundamental roles.

The current chapter presented the Orange Service Call + Reward (OSCR) collaborative project. Next chapter presents another collaborative project intermediated through Research and Innovation Services department from the University of Southampton.

4.2 CASE 2: STARSTREAM PROJECT

The University of Southampton, based in the South of England, developed from the Hartley Institution, officially opened in 1862. The University was founded in 1952 when Queen Elizabeth II granted a Royal Charter to the former University College. Nowadays, it has 17,000 undergraduates and 7,000 postgraduate students, divided into more than 20 academic schools on six campuses - four in the city of Southampton, one in the city of Winchester and the Malaysian Campus in the city of Iskandar, opened in 2012.

The University has its strategy towards entrepreneurship, which could be proven by some numbers. Over the last two years, a total of almost £20 million has been awarded to the University by grants from the Department of Trade and Industry (DTI) Technology Programme, now run by the Technology Strategy Board in the UK (University of Southampton, n.d.-a). Moreover, the institution runs a science and technology park. The site provides a base for over 60 high-tech and knowledge-based companies including a business incubator.

The University has had collaborative R&D projects with industrial partners ranging from multinationals such as Rolls-Royce, AirBus, Microsoft, IBM and Nokia, to small and medium sized companies (SMEs). In a study of collaborative diversity in research projects in nanotechnologies, Pandza *et al.* (2011) identify a cluster of research institutes that top the list of partners with the most network partnerships.

The University of Southampton is cited among the first 30 individual institutions in Europe.

Research & Innovation Services (R&IS) is the department of the University of Southampton responsible for supporting the academic body in applying for funding for research as well as collaborations with partners – industrial, academic, public sector and government. Its role is to stimulate and support consultancy, applied research, corporate relations and the generation of externally funded research grants and contracts, including support for cross-University initiatives to increase application numbers and success rates. Moreover, R&IS is responsible for the exploitation of intellectual property (IP) such as licensing and spin outs.

To enable these activities, the department had 53 people at the time of this research. It adopted a structure where a team of Research Support Officers are embedded in faculties. They are the first point of contact for researchers on all R&IS matters. Faculties also have Collaboration Managers (CM's) responsible for brokering partnerships and supporting the commercialization of University's intellectual property. Both groups work closely with several teams of experts who are centrally based covering R&IS' activities including knowledge transfer support, IP management, bid management and multidisciplinary research through the University Strategic Research Groups. Thematic-focused teams at R&IS hub and faculty-focused teams are connected and communicate frequently.

About their role, the collaboration manager for the Faculty of Natural and Environmental Sciences & Institute for Life Sciences says that the biggest challenge is brokering the difference in culture. He explains that "the difficulties are not born of the fact that academics behave in a particular way or equally that their industry contacts behaves in a particular way. It is the fact that we are trying to get two different cultures to interact and understand each other's motivations" (respondent J).

4.2.1 Services provided by R&IS

This section presents more specifically the main services provided by the department concerning internal research activities and collaboration with external partners.

4.2.1.1 Search for partners

When the academics or R&IS staff identify that a commercial opportunity might exist (i.e. that a new invention has some application), R&IS works in order to attract potential partners. This may involve approaching companies directly or commissioning market assessments.

There are two different approaches for the beginning of the search by R&IS staff. The collaboration manager for the Faculties of Humanities, Business and Law, and Social and Human Sciences, explains that when a funding call is announced that requires the involvement of a company, R&IS staff seek to identify researchers who could be both eligible and interested in the call by looking at the background of researchers in that area and then identifying companies that would be suitable partners. After that, they seek to broker and support in the building of a relationship. She comments that “this is not ideal, because usually the timeframe is short, normally the deadline is three months from the call publication” (respondent E). Another path is when the academic comes to R&IS saying that he has done some research and he thinks that could be applied in the industry. So the collaboration manager responsible for that area of science works with the academic to protect the technology and to find partners that would be willing to invest in its development or support grant funding applications.

4.2.1.2 Knowledge Transfer Partnerships

R&IS is also responsible for administering the program called Knowledge Transfer Partnerships (KTP), which is a business support scheme managed by the Technology Strategy Board, a non-departmental public body, and supported by 18 government funding organizations. The program involves a partnership between an organization (i.e. a firm, local authority, National Health System, charity) and the university, enabling the external partner to access and embed skills and expertise. On a KTP project, a graduate or postgraduate is appointed to work at the business location, supported by the academic.

4.2.1.3 Business Incubation

The SETsquared Business Acceleration Programme is a collaboration between the universities of Bath, Bristol, Exeter, Southampton and Surrey to support new business creation. Although the Programme may give an impression of relationships existing between the companies and the University, the director in Southampton declared that this is not a common practice (respondent G). The partnership with the other four universities is mostly about best practices of supporting start-ups.

4.2.1.4 Invention protection

The University seeks to assist a researcher (or research group) in the process of developing novel ideas towards market adoption, some of which may have commercial value. When a discovery is considered to have reasonable prospects of acceptance, R&IS staff will firstly assess if the ideas can be protected and whether adoption is likely/commercially viable. In the case of intellectual property that may have some commercial value and where patent protection is a key requirement for exploitation, R&IS supports the patenting process. Before hiring attorneys to write the patent, the collaboration manager (CM) responsible for that School meets the academics who developed the invention, as explained by one CM:

> It is very important, at the initial stage of assessing an invention, to meet the academics and get a thorough understanding of the technology and its applications but most importantly what alternative technologies/approaches already exist or are in development. This information as well as details of who contributed to the invention and the funding that underpinned the original work is captured in a document to determine access rights and rights to future financial returns. Patent attorneys are then engaged and are provided with this document and any draft publication. The attorneys meet with the academics to review the invention and this is a vital step in the process as the attorneys must convert the information into a set of claims. (respondent J).

He explains that a well written patent is more likely to receive fewer comments back from the examiner from the patent office requesting clarification and thus cost the University less money in fees. The University does not incentivise the academic

for filing a patent. But it gives a reward if there is a commercial income from the patent, i.e through licensing (decreasing percentage as the amount of money goes up). The academic unit and R&IS get money as well.

Besides setting out the patenting process, the department may meet a proportion of costs. Usually the originating School covers 50% of the external patent costs and the University pays the remaining 50% up to and including the Patent Cooperation Treaty filing stage. “Experience has shown that under this shared model the School gives diligent consideration to whether the opportunity is inventive and merits the investment of monies and time (from the inventor) in the commercialization process.” (University of Southampton, n.d.-b). Even if R&IS considers that the discovery’s commercial value does not justify patenting, but the School wishes to proceed, R&IS still supports the administration of the patenting process without paying for the external patent costs.

4.2.1.5 Drafting and negotiating contracts

Concerning research collaboration with external organizations, R&IS puts in place the necessary agreements to enable it. There are different types of contracts to ensure each party's respective rights and obligations are set out. According to the University of Southampton (2013), some examples are:

> a) Memorandum of understanding: used when parties are grouping together to apply for funding. They are usually a forerunner to the Collaboration Agreement because they are relatively quick and easy to put in place.
>
> b) Collaboration agreements: used to govern a relationship when there are two or more parties working together on a research project. Some of the items included on the contract are each party’s roles, funding, the structure for decision making and conflict resolution.
>
> c) Material transfer agreements: used when some material is transferred from the owner to the researcher who wants it for research purposes.
>
> d) Studentship agreements: used when a student is funded by industrial partners for some or all of their research.

There is another kind of contract not so focused on collaborative R&D projects, but also within R&IS’ responsibilities, which is the Consultancy/Supply of

Service Agreements used when the academic is providing advisory or consultancy services to another party.

Next section will present a R&D project performed by the University of Southampton and external partners which had the influence of R&IS acting as an intermediary.

4.2.2 Collaborative R&D project

In 2006, Professor Timothy Leighton, from the Institute of Sound and Vibration Research, and Doctor Peter Birkin, from Chemistry launched a research project of an ultrasonic cleaning technology. Named StarStream, it enhances the ability of water to clean and is thought that it has the potential to generate savings in water and power use in a range of cleaning applications. The technology adds ultrasound and bubbles to a low volume stream of water. The development is currently in progress in a number of areas related to surface cleaning including nuclear decontamination.

So far, a range of companies have paid more than £150,000 for testing and prototyping the technology, apart from funding received from awards and from the university (ASTLEY, 2013). Three collaboration managers (CM's) from the R&IS department have worked on this case: the first one was involved for more than two years; the second CM helped the academics for around six months; and the third and current CM has been working on the project since 2011. As it is a breakthrough innovation, the complexity in terms of the uncertainties implicit to the technology and the amount of companies that have been involved in the project increases the influence and the work of intermediaries.

The first collaboration manager who worked for the project commented that this is the most complex project he has worked on. He declared: "I have never come across another project that has been potentially so diverse in applications and in scope, nor complicated in terms of how to move from R&D into product development" (respondent H). The current CM complements that the variety of potential applications is such that a huge range of companies with very distinct and diverse cleaning problems had an interest in the technology. The academic researcher confirmed the importance of R&IS on the project, saying that the CM's gave a lot of

support in terms of their time and expertise to interact with companies. According to him,

> The best advice is dealing with the companies, managing their expectations and making sure that we understand the companies' motivations, processes and needs. Managing companies is quite difficult because we would like to talk about the science. But at most of the companies' meetings, there is a focus on getting results rather than understanding which can then enable results. This is a subtle but important difference. We also don't know how much things are really worth. So having someone to help us in that way is very good (respondent K).

According to the academic, R&IS' staff identify which areas the companies are best placed to act as development partners. Many companies will list a range of areas of interest but they realistically will only have the resources and capability to commercialise it in specific areas. As the CM comments,

> Our biggest role is to facilitate the interaction between two cultures that have very different drivers. Academics are incentivized by publications and research; and industry is incentivized by delivering shareholder value. Then you have to try and interpret all of the human factors and behaviours that surround these drivers, and try to interpret if a company is going to be a good partner in taking a technology to market and whether the academics can work well with them. For example, some companies will spend a lot of time evaluating a project and even funding it just because someone has a target to meet of assessing external technologies and not necessarily the funding or appetite to take it to market (respondent J).

At its start, the research received university's support from the Engineering and Physical Sciences Research Council (EPSRC) from 1999 until 2006. It was from 2006 on that external partners began to be involved.

a) The beginning of collaborations

For about two years, the research had funding from a sponsor, as a post-doctoral support. The group got this contract directly through contacts or "word-of-mouth", as referred by the researcher (respondent K). It was a short term contract, according to which the sponsor could fund three or six months of work, and then it would roll over if it was happy with the progress. The researcher explains that "the progress was good so they rolled it over. And the sponsor was very pleased with the initial phase of the project, because it went much further than what it had first

thought. But in a weird way, because we were successful, they cut ourselves off from the funding" (respondent K). That happened because the funding was for academic research; and the group had improved the technology on to a stage where the sponsor could not fund anymore, because it was turning into a prototype development. The results of this research was utilised in a project sponsored by the UK Defence Science and Technology Laboratory (DSTL), from the Ministry of Defence, which developed a prototype cleaning device (LEIGHTON, 2011).

The collaboration manager (CM) at that time said that, when the academics contacted R&IS, they had already achieved significant results from the research.

> For a period of time, they managed to have some control over the phenomenon that they were investigating which was using ultrasonic cavitation cleaning into a certain environment, which was a flowing system rather than just a bath which you would insert an object in. Tim5 believed that it was a significant science breakthrough and thought it was patentable. That's why he went to RIS (respondent H).

This happened in the first half of 2008, when R&IS started providing services and guidance for the research project.

b) The involvement of R&IS

When the researchers went to R&IS informing that they had an invention, the department hired an external patent attorney to deal with the requirements for the application. The University's staff are not trained to write patents. The CM currently working with the project comments that it is very important for the attorneys to spend time with the academics, to hear first-hand about the technology and receive demonstrations. Such is the nature of many academic inventions, the academics may have other ideas already as to how to improve or change the technology and this can often be missed from an initial filing (respondent J).

The patent application was filed in September 2009. After having the decision to patent the invention, R&IS staff turned their minds to what could be done with it concerning to spin-out a company or licensing the technology. At this period of time, the University supported the research in terms of funding.

[5] Professor Doctor Timothy Leighton is the other main researcher involved at the project.

c) The beginning of external relationships through R&IS

The first organization to which the technology was disclosed was IP Group. It is a venture capital company that commercialises intellectual property primarily from its research partner universities. IP Group signed its long-term partnership with Southampton in 2002. The current CM says that “in general, we discuss early stage technology opportunities with them that may form the basis of a spin-out. However, we’d yet to identify a product and business model that would warrant the technology to be exploited through a venture-backed start-up company as opposed to pursing licensing opportunities” (respondent J). That was the reason why the organisation decided not to invest in a spin-out company at that moment.

After that, from late 2009 into spring 2010, the CM at that time was actively looking at market sectors and opportunities to license the technology. He had discussions and visits from an international company that produces medical devices (COMPANY A). It was interested in cleaning contaminated appliances, but they did not establish a partnership.

At the same time, he got in contract with a UK technology company specialised in consumer electronics (COMPANY B) that invested financial resources in the development. The CM at that time had a personal contact working there. The firm was interested in commercial exploration in the domestic market. Through a EPSRC funded, a knowledge transfer secondment, a PhD student interacted with the company in terms of testing the technology at the university’s laboratory, and going to the firm’s facilities to test it with different materials. The academic (respondent A) affirmed it was a strong interaction. And the CM adds that the firm was very keen on the technology for about 18 months.

> We got to board level, when the founder of the company was briefed on it. We had a junior researcher working full time at the project for months. But in the end, the partner withdrew. It was a rational decision, because they couldn’t see a product coming out of that (respondent H).

At that time, it was difficult to turn the technology into a prototype for a product as the company wanted. So the CM started searching for other partnerships. In his words, “I wanted to get feedback from the technology by demonstrating it. Every different way we tried to demonstrate to a new potential user, we actually had to go

back to the laboratory and conduct further tests and subsequent development. The technology is a very sensitive phenomenon. But when the researchers got the right conditions to try it, it was very effective at cleaning certain items" (respondent H).

While the research was moving on, and more tests were being held, Professors Leighton and Birkin applied for and were successful in an application to the Royal Society Brian Mercer Award for Innovation 2011.

d) Award as a significant step

The Award paid £250,000 over two years to help the researchers develop the technology towards a product. This funding ended in October 2013. One of the CM's involved at that time said that "as a result of the video from the Brian Mercer Award going on YouTube, a lot of other companies started contacting the university. All of a sudden, we had like 12 different companies that were interested in the technology" (respondent I). The academic confirmed that the publicity that came after the Brian Mercer Award brought interest from external firms. He complements: "some of them have been useful, others were not related to our technology. R&IS staff is very helpful in identifying the difference" (respondent K).

StarStream was submitted for the Award in three tracks: industrial, medical and consumer. The project is also associated with interacting with firms. One of the partners from the industrial side was the company Ultrawave Ltd, from the city of Cardiff, specialist supplier of ultrasonic cleaning equipment. This contact started through the academic (respondent K) who contacted the firm for something different. He was writing a paper and was interested in some numbers about the market in this particular area. According to the researcher,

> they brought some of their expertise to the table. We are trying to develop and solve some of the hardware issues. And they have some of our technology there. They are interested in producing a robust prototype for industry. We could build it in the lab but 1) it would be very expensive and 2) it would not be as robust as industrial standards would need it to be (respondent K).

The former CM of the project explains that, because of its size, the firm is not big enough to have a research budget to fund the entire project. The University

therefore has applied for a number of European collaborative research projects with Ultrawave. He adds that “the company has given us a lot of technical support and guidance on what we need to do to turn this technology into a product” (respondent H). At the same time, the current CM mentions that Ultrawave is disappointed for not seeing an actual product coming out of development activities. He adds that “they funded for a bid process to go for results around £1million; and it failed. Although, they are the most eligible of the technical area” (respondent J).

The owner of the company explained that when he got involved, he believed that the technology was further forward than it was. In his words, “we were led to believe it has been more development done than it was. When we got involved we realised there was a lot more to be done. So I think the university should have waited a little longer before commercializing the technology” (respondent O). However, he complements saying that if he had accepted the university’s terms for the contract, they would be a lot further: “there were issues with the legal department that got involved with licensing arrangements; and I didn’t like some of the terms in the agreement they were trying to sign” (respondent O).

At the time of the interview (beginning of 2013), the University and the company still did not have a licensing agreement. The partners were collaborating on trust. The owner of Ultrawave thinks that the legal department had fixed ideas about the IP done through the university. According to him, “they are intransigent. Other universities seem to be more flexible. We work with other universities, but not to the same extent of time and money that we spend in Southampton” (respondent O). At that time, the human resources involved in the development at the company consisted in three people: the owner of the company who is responsible for finances and resource allocation, a technical director who understands more about the technology, and one engineer who works part of his time on the project.

Another partnership that started around the same time is with Philips, regarding consumer applications. The company, headquartered in Holland, has a department that looks at new ideas coming out of universities, situated in the city of Cambridge. This relationship started on another School, within the University of Southampton, with a professor from the Mechanical Engineering department who had been collaborating with Philips for many years. On a R&IS meeting, the CM’s had the idea of offering StarStream technology to the company. The CM at that time

went to visit Philips on the 1st of August 2011. Besides, he says he had tele-conferences with staff from the main headquarters.

The Senior Business Development Manager at Philips, involved in the negotiation, said that R&IS staff helped in defining the rules of the contract, as the area in which the company would get exclusivity, what payment they would do and who would own the patent rights. From a different point of contact, the Project Leader affirmed that R&IS' collaboration manager played a major role in bridging the relationship between the academics and the company. He explains that

> professors at universities and companies have very different view of what the technology is. While the professors tend to think that their technology is basically done and can be brought to market soon, the companies see most of the technologies as not practical to become a product that anybody would buy. We saw potential at the technology from Southampton, and we were trying to answer questions inside Philips to the business units, which are often related to safety, environmental issues, costs and practicality. We were asking that to the professors. So it was quite useful to have the CM at the meetings, helping us. He tried to *translate*[6] our communications (respondent N).

The company has funded the development of a prototype. It did not do R&D, but it spent a lot of time on testing it. In a three months project, the academics built the prototype, which was an attachment screwed to a tap on a mobile sink unit. Philips wanted it to showcase it for different business units at their internal innovation day. The current CM involved on the project affirms that the partnership was positive. "Philips had a list with pragmatic criteria as 10 centimetres distance, reduced damaging effect and temperature range. From my perspective, it gave a focus to the researchers" (respondent J).

While some partnerships are successful, some external companies interested in the technology present challenges for R&IS staff and do not turn into an actual partnership. After being granted the Royal Society Brian Mercer Award for Innovation, one of the professors was at the Award's dinner where he met a director of a British Foundation[7]. The CM at that time (respondent I) went with the professor to their office in London for a meeting. The Foundation's proposal was to set up a new company. After that conversation, the Foundation's representatives went to the University of Southampton to meet the scientists and to negotiate with R&IS. The

[6] Italics added.
[7] The name of the Foundation is not disclosed at the thesis.

other CM, who was at this meeting (respondent H), said that the terms were not interesting to the University. “I was sceptical because they were not normal venture capitalists”, he added.

The current CM comments that the Foundation demanded a meeting with the vice-chancellor of the University, because they had wasted time in previous experiences that were not successful. But the vice-chancellor left the meeting for R&IS staff, because he is not involved in details of R&D projects. The meeting happened when the CM’s were changing. So the Director of R&IS participated and did most of the negotiation. Respondent I declares that he did not understand and did not agree with the decision of the Director of not setting the deal with the Foundation. He explains that

> the Director of R&IS said that he did not believe the technology was ready. But I think we have a different role than trying to present a negative picture to the company and say ‘it is going to require years of investment’. My role at the university is to present the technology to companies and say ‘that is what we have’. If the company is keen on taking a license or investing in the technology, we sign the deal. And it is their risk (respondent I).

With a different opinion, the academic agreed with R&IS’ decision of not signing the deal with the Foundation. He sustains that “until the technology has proven itself, nothing will be decided about to spin-out. Without any tangible result to spin-out on, it would be difficult” (respondent K). Now the research group continues on the licensing route.

One of the current partners investing on the technology and that may license it when the prototype works perfectly is the British company Sellafield Ltd, who has funded the development of prototypes (University of Southampton, 2013). The research group is actively collaborating with the firm in building prototypes for different cleanings. The current CM said that the original patented technology may not be employed considering that the projects have been changing since the beginning of the relationship. The company’s Technical Specialist from the Decontamination Centre of Expertise (respondent L) has been going to the University of Southampton twice a year for meetings with the academics and with the CM.

The first contact between the company and the University came from an approach of the collaboration manager. The information was sent for the commercial group at Sellafield Ltd. After that, the company’s Technical Specialist visited the

university in October 2011, when he met the former CM (respondent H) and the research group. By the end of 2012, legal issues had been sorted out and they signed the contract. The chemist says that R&IS helped defining the commercial value of the technology to the firm and helped establishing conditions for licensing the use of the technology in the future. He adds that “they have only an appreciation of technical issues but they are keen of sorting out legal assessment. And they are flexible with arrangements” (respondent L).

Another negotiation began in the middle of 2012 with a glass manufacturer (company C). They funded to build a prototype, and the academics sent some samples for testing. However, the cleaning was not doing as expected, and the organizations (university and company) stop being related. The last collaboration manager (respondent J) said that Ultrawave was intending on contacting company C.

There was still another interaction with a European cleaning firm (company D). The initial introduction was in the middle of 2012. The CM in 2013 (respondent J) points out that the firm saw a demonstration of the technology; and the university did some testing. After that, company D asked for an evaluation license, therefore the CM drafted a contract to the firm’s legal department. Until the end of this thesis, the activities had not been started.

The CM in 2013 stated that the case of this technology is fairly unique because the University has currently filed for patent protection in Europe, the United States of America, Brazil, Russia, China, Japan and India. He explains that “this is incredibly rare. Now we have to revisit the countries we are filing, because it costs much money. Some countries were selected driven by one partner’s interests. Death of technology is time, because if you don’t get money in a time period, it is dead. Patent clock ticks” (respondent J).

Nowadays, the academics are working on bespoke industrial projects. The massive domestic market has been put to a second level of importance, and the technology is been worked more on an industrial-base. The researcher comments about the whole project.

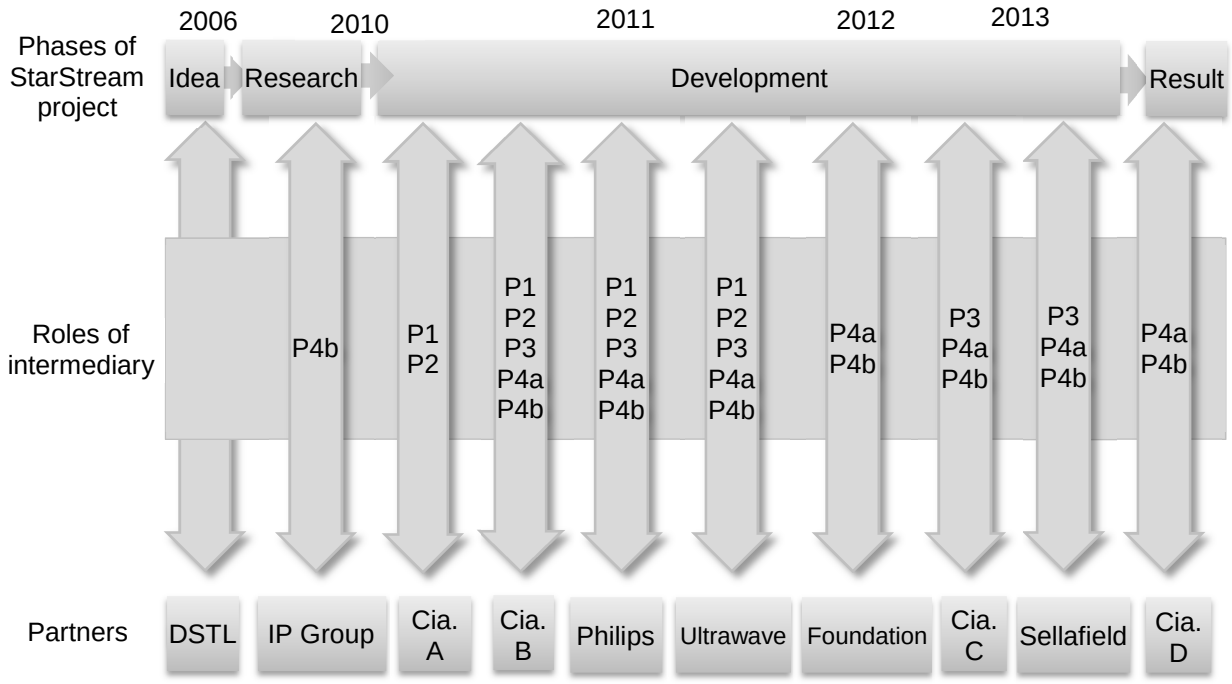
> It has been a very interesting experience. I come from a scientific background rather than a business exploitation or license patent. Having somebody from R&IS is very good in terms of smoothing these issues and handling things that we don’t have expertise in (respondent K).

As it may be seen from the information above, collaborations with different companies have taken place since the beginning of the research on the new technology. Some periods had more than one partner on unrelated industries. That goes along with Pandza *et al.* (2011) when they say that collaborative diversity is an intrinsic characteristic of research networks built on the emergence of technologies that would serve as basis for different purposes. The next section presents the analysis of the project since its start.

4.2.3 Case analysis

Next, Figure 19 shows StarStream's timeline with the main activities.

Figure 19 - StarStream's timeline



Critical roles of intermediaries (research propositions):
P1. Influencing the search for partners with common goals;
P2. Influencing the beginning of interaction;
P3. Influencing the access to resources;
P4a. Influencing the management of the project;
P4b. Influencing about the results of the project;
P5. Influencing research and knowledge production activities;
P6. Influencing development and prototyping activities.

At Figure 19, each phase presents the external partners that have been in collaboration with the academics. The direct link between StarStream project and the partner DSTL (the first stage of the project) means that the organizations were connected but the intermediary did not perform any role at this stage of the project.

The early start of the technology was through basic research since 1999. Collaborations with external organisations began in 2006 when the academics identified there could be a practical exploitation of the discoveries and, therefore, applied for funding from a governmental body. After two years of partnership, the research had improved to a period where funding for research could not be further applied, due to the stage where the academics could build a prototype.

In 2008, the research group entered in contact with R&IS to file a patent application of the invention. Following to that, the collaboration manager started looking at market sectors to which the technology could be licensed or at partners that would invest in a spin-out company. One of the organisations was IP Group, that has been a partner of the University of Southampton for many years. Together with R&IS, the organisation judged that the technology was not ready to become a spin-out. Two other companies were approached by the collaboration manager. Company A did not sign a contract, however company B did.

Bigger partnerships were set for the Royal Society Brian Mercer Award for Innovation in 2011, with Philips and Ultrawave. After the Award, many companies contacted the university. Some interests were not exactly related to what the technology actually did. So R&IS staff did not commit much time with them. A wealthy British Foundation wanted to launch a spin-out company, but the deal was not set because the technology was still working under laboratory control. Throughout 2012 and 2013, the collaboration manager has been dealing with a few partnerships with different interests: Companies C, D and Sellafield Ltd.

Next, the StarStream case is analysed considering the proposed research framework about intermediaries' roles on collaborative R&D projects. The activities and roles of the intermediary were reviewed according to the proposed research framework presented at Chapter 3.1. To conduct the analysis, the discussion of critical elements of collaborative R&D projects influenced by an intermediary was based on the variables mentioned at the literature about each of the elements. The

comparison and convergence with the other studied cases will be presented at Chapter 5 where their analyses will be related to the literature previously analysed.

Table 11 summarizes the activities and roles played by the intermediary at StarStream project, relating them to the critical elements of collaborative R&D projects influenced by intermediaries.

Table 11 – Intermediary's roles at StarStream project

Critical roles of the intermediary	Intermediary's activities at StarStream case
1. Influencing the search for partners with common goals	The frequent meetings among collaboration managers from different areas allowed the identification of a partner (Philips) with common goals that was related to another School within the University of Southampton. R&IS keeps a network of companies and a list of firms where there are graduate students from the University. The collaboration managers usually attend to conferences and fairs from the areas they are responsible to meet new companies. These facts helped them to identify partners as IP Group, Company A and Sellafield.
2. Influencing the beginning of interaction	R&IS staff arranged meetings between external organisations and the academics when they had identified common goals between the parties. The flow of interaction was initiated by the academics, by the external company or by R&IS, depending on the partner in this case.
3. Influencing the access to resources	R&IS did not provide human resources, equipment or infrastructure for the StarStream project. However, the department had a major role in arranging financial resources either from the University or from external partners.
4a. Influencing the management of the project	R&IS staff was responsible for writing the contracts of all partners at StarStream case, except the first one, which the academics got themselves. When negotiating with possible external partners, the department helped in the establishment of rules for the engagement in the project and in the definition of each partner's task, although this last one is usually not a rigid principle. In case of conflict between the academics and the companies, the collaboration managers played a role as pacifiers.
4b. Influencing about the results of the project	The department hired an external attorney to help in the patenting process. Also, R&IS provided the academics and external partners with advice about the value of the technology when it reaches the marketplace. The department's staff is responsible for helping the parties in the definition of licensing therefore about the financial results of the project.
5. Influencing research and knowledge production activities	R&IS's staff did not directly help on the activities.
6. Influencing development and prototyping activities	R&IS's staff did not directly help on the activities.

As it can be seen at Table 11, most critical elements of the collaborative R&D project had the influence of R&IS as an intermediary. R&IS' role on searching for partners with common goals (proposition 1) happened through different means. The collaboration managers usually attend to conferences and trade fairs from the areas related to the Schools that they work for. Also, they keep track of the organizations where alumni are working so that the University has an easier way to get in contact. Apart from that, R&IS has the registration of previous and current partnerships that the department has helped in any situation, either searching for partners or looking for funding. These practices help to build a list of companies in different areas.

At StarStream case, it was from these knowledge that R&IS could identify the potential interest of IP Group, Companies A and B, Philips and Sellafield. Other external partners came from the academics' contacts: DSTL, Ultrawave and the British Foundation. As one may note, the academics were involved in the search for external firms to be partners of the technology development, not letting this entire responsibility to the intermediary.

The frequent face-to-face meetings and the registration of everything that happens with the projects, regarding interested parties, actual partners and academics, help the department to overcome the changes of collaboration managers along the project. There were three CMs involved, and the third one left the job at the University of Southampton in the end of 2013. The external partners that were related to the research for long time faced the change of the staff, which could mean a loss of trust. The only interviewee who mentioned about that was the owner of Ultrawave, who said that in the beginning of the project with the University, "the relationship 'kind of' got stooled because there were a few changes in personnel at that time. From the first CM who I had contact with, to the current one, the relation sort of died. I thought the project had finished. Now the contact is fine" (respondent O).

Regarding the beginning of the interaction between organizations (proposition 2), R&IS staff arranged meetings between external organisations and the academics when they had identified common goals between the parties. The collaboration manager was present at most meetings. Considering the flow of interaction, the relationships, at StarStream case, were initiated sometimes by the academics, other

times by the external organization that got in contact with the University, and other times it was started by R&IS, that put together the academics and a potential partner.

About the access to resources (proposition 3), R&IS did not provide not helped with human resources, equipment or infrastructure for the research and development. However, the department had a major role in arranging financial resources either from the University or from external partners. Among all the partners along the project's lifetime, the partnerships with Company B, Company C, Philips, Ultrawave and Sellafield had the financial negotiation intermediated through R&IS. These companies had financially invested in the technology.

Regarding the influence of the intermediary on the management of the project (proposition 4a) at StarStream case, R&IS staff was responsible for writing the contracts of all the relationships with external partners, except the first one, which the academics got themselves. When negotiating with possible partners, the department helped in the establishment of rules for the engagement in the project and in the definition of each partner's tasks, although this last one is usually not a rigid principle. These establishments hinder opportunistic behaviour from a partner of the relationship. In case of conflict between the academics and the companies, the collaboration managers played a role of pacifiers.

Concerning the definition and distribution of the results of the project (proposition 4b), R&IS had an important role concerning this stage of StarStream project. The department hired an attorney to write the patent to file. Also, the department's staff provided the academics and external partners with assessment about the value of the technology when it reaches the marketplace. This helps the parties in the definition of licensing the technology, because nor the academics had experience in monetizing new technologies neither the partners had an exact understanding of the market to be reached once the invention turned to be an available product or process.

The analysis of the influence of the intermediary on research and knowledge production activities (proposition 5) showed that R&IS's staff was not involved nor helped this stage of the project. Also the department's staff did not influence or helped development or prototyping activities (proposition 6). So from the six research propositions, the stage of executing the project was the only one where the department did not have a role to play.

The current chapter presented the collaborative project StarStream from the University of Southampton, in the United Kingdom. Next chapter presents the collaborative project Force for Elastomers, developed by the University of Rio Grande do Sul in partnership with the firm Frenzel in Brazil.

4.3 CASE 3: FORCE FOR ELASTOMERS

The Federal University of Rio Grande do Sul (UFRGS) has 2,540 lecturers and professors (85% of which are PhDs), 1,100 laboratories, 724 research groups, 89 undergraduate courses and 140 post-graduate programs spread in six campuses (UFRGS, 2013a). According to the University's website, there are "approximately 14 thousand people involved in scientific and technologic research activities, including undergraduate and graduate students, laboratory technicians, professors and visitors" (UFRGS, 2013c).

The Secretary for Technological Development (Sedetec) is the department of the University responsible for interactions of all university research with the industry. Sedetec was created in October 2000, encompassing the Technology Transfer and Interaction Office (EITT), created in March 1997, and the incubator. As Castro and Souza (2012) point out, UFRGS had the concern with the management of inventions and intellectual property even before the Innovation Law in Brazil, in 2004, that established the creation of TTOs.

The aim of the department is supplying the necessary conditions to value and transfer scientific and technologic knowledge generated at UFRGS to society. The importance of the department is growing at the University since the number of research and patents is rising. UFRGS has filed 257 patent applications until August 2013; 21 of which were filed abroad and 11 were filed according to the Patent Cooperation Treaty (PCT). Table 12 shows the growing quantity of applications.

Table 12 - Quantity of patents filed per year at UFRGS since 2009

Year	Quantity of filed patents
2009	28
2010	29
2011	39
2012	45
2013	26 until August

Source: Ufrgs (2013b)

As one may see from Table 12, the number of annual applications has almost doubled since 2009. But this fact does not mean that all patents are reaching the industry and being incorporated into new products, processes or services.

In order to interact with private or public organizations, UFRGS needs to act according to several laws and statutes due to its public status. Therefore Sedetec makes the legal analysis and follows the regulations to allow partnerships. To enable these activities, the department had around 20 people at the time of this research.

4.3.1 Main services provided by the Sedetec

Sedetec's actions encompasses the legal analysis of instruments to provide services and agreements (as foreseen at Decisão number 193/11 and at Portaria 2679/11 from the University's Council); the management of intellectual property and technology transfer (according to Portaria number 3064/98); the management of technologic incubators; and the stimuli for entrepreneurship (MATEI *et al.*, 2012). From these actions, Sedetec is responsible for diverse activities regarding the interaction of research groups with the industry. As the Professor commented, " the Sedetec is our advisor and helps us to find solutions" (respondent R).

Following, the main services provided by the department concerning collaboration with external partners for research activities will be further explained.

4.3.1.1 Search for partners

The beginning of the search for a partner by Sedetec staff is usually stimulated by external firms. The Legal Assessor explains that when a funding call is announced or when the firm has a specific research line with its own funding, the Sedetec seeks to identify researchers who could be both eligible and interested in the project. The department communicates the opportunity to the Directors of research areas, and they reproduce this information among the groups in their units. He says that “it is easier this way compared to a flow where we would begin with an academic research towards the industry, because there is a proposal and we offer Sedetec’s help to that explicit need” (respondent Q). The Intellectual Property Coordinator complements that, in 2013, there were more than ten cases like this, and that this path suits well the small structure of the department. As he has a lot of data and contact with the researchers because he works closely with them to protect the inventions, the Intellectual Property Coordinator acts as a data provider about research groups inside the University.

According to the two respondents, the firms have started identifying the Sedetec as the fastest and best way to search for information inside the university, and also to spread information about projects among researchers.

When a research group has an invention and no external partner, the Sedetec does not have a structure to commercialize the technology. It is not among the department’s duties to search for market opportunities. The Legal Assessor says that they have done this search before, but it is not simple. He explains that “many times, the invention is not exactly like firms want, because the technology is in a laboratory level and they would need to be adapted to suit practical applications” (respondent Q).

4.3.1.2 Drawing up legal contracts

Concerning research collaboration with external organizations, the Sedetec is responsible for writing the agreement according to the relationship. There are different types of documents to formalize each party's respective rights and

obligations. According to the Partnership Department Handbook (UFRGS, 2012), the contracts about partnerships for research and development may be:

a) Contracts for technology transfer;
b) Co-ownership contracts;
c) Contracts for patent exploitation;
d) Contract for services;
e) Confidentiality contract;
f) Contract for the license of technology and/or know how.

There are other types of contracts not directly related to R&D whose channels also pass by the Sedetec. For example, the Cooperation Intention Minute is a document that foresees future activities to be formalized by an Agreement or Contract.

4.3.1.4 Invention protection

The University, through the Sedetec, assists the researcher (or a research group) with the patenting process. Firstly, the Sedetec makes a search on existing intellectual property registrations in order to identify possible technologies that are similar to the one that the professor and/or researcher want to file. There is a form called Request for the Search on Patent Databases where the professor suggests key-words related to the invention in Portuguese and in English; gives a brief description of the invention; compares the invention to current technologies; and comments on the potential of the invention. The Sedetec's staff uses these information to search Brazilian and international patent databases.

To begin the patent process, there is a form called Invention Report, filled by the researcher to the Sedetec with varied information about the activities that led to the discovery. If there was any partnership, data about it is included in the Report, such as: which the connection of UFRGS to the external inventor is; since when the connection exists; if the external inventor was ever directly attached to UFRGS and which position. The Report also includes explanations about the commercial potential of the invention and which markets or companies would be interested in the technology.

The Sedetec, a priori, files all possible patents. The Intellectual Property Coordinator says that the University does not patent the invention if there is anything that hinders it, such as a paper published longer than a year before. He mentions that the less than 5% of the inventions analysed by the Sedetec are not filed. The Legal Assessor complements that the patenting process in Brazil is not expensive; so the department protect everything. However, there are no funds for international patenting. According to him,

> filing patents works to open markets because there are many firms that get in contact with the University because they identify a patent with our name or papers about the technology. Apart from being an assurance of monopoly, the patent acts as an 'entrance door' for external partners (respondent Q).

In the case of simple patents, it is internally written. After that, it passes through an external reviser. When the technology is fragile or has limitations, and the contract needs a hard writing, then the Sedetec hires an external office to do it.

4.3.1.5 Business Incubation

By the end of this research, the Technologic incubators network (REINTEC), was part of the Sedetec. However the structure was changing, and the incubators would start being responsibility of the Technologic Park. At the time of this research, the administration of the Park was located inside Sedetec's building because the space for the Park was being built at another campus. The Legal Assessor comments that the physical proximity influences them to work closely, especially because both organs deal with innovation.

Next section will present a R&D project performed by UFRGS and an external partner which had received Sedetec's services acting as an intermediary.

4.3.2 Collaborative R&D project

In 2010, an undergraduate student of Industrial Chemistry had an idea for her final paper during classes with Professor Michèle Oberson de Souza. So in the first

term of 2011, the Professor supervised the student's research that led to a discovery. The invention was patented as the introduction of a new inorganic force in the formulation of elastomeric compound used in the manufacture of rubber sealing devices. In summary, it is a force added to the rubber that changes the property of the material. As the founder and Director of the company explains, the material is a technologic platform, what allow a wide range of applications (respondent S).

a) Beginning of the project

The Professor (respondent R) received the invitation of a student (respondent T) to be her supervisor on the research that would be used as a final paper before graduation. The student is the Industrial Manager at the company founded by her mother in 1994 with an innovative product. As the founder and Director of the firm comments,

> I used to work at another company. And I wanted to open a business to attend technological niches with fewer volumes, but it did not work out. After six months trying, the company where I used to work 'gave up' on a client because they did not know how to produce what the client wanted; and he brought his problem to me. (respondent S)

In partnership with the Polymers Technology Center SENAI-CETEPO, the Director managed to develop the product and get it legally approved. Nowadays, the firm manufactures rubber pieces for automotive, energy, machines and other industries. There are around 100 people working at the firm. However, sales are done only by the founder and her daughter with a representative in the city of São Paulo. Even being involved in the commercialization, the two entrepreneurs also take care of problems at the production site.

About the initial idea for the R&D project in partnership with UFRGS, the Director of the firm says that her daughter and she usually share a lot of information about technologies. She explains that "I had discovered a similar product. So we used it as we could; we benefited from this product; and we assumed that it would be possible to extract another product from it, which is this new product developed in cooperation with UFRGS" (respondent S).

The Director's daughter, an undergraduate student at that time, developed her research during one term at the University's laboratory and at the company. The study would be used as the necessary final paper to graduate. As it was turning into a successful research, she managed to finish her final paper and, at the same time, to start the process to file the patent in co-ownership with the University. She had the final examination of the paper for graduation in July 2011. The supervisor of the research (respondent R) complements saying that the final paper is not available at the library, as usually most papers are, because of the secrecy of the technology process.

The Professor believes that there is a "luck" factor in this R&D project. According to her,

> it was a matter of luck that we got to know each other in class. Also there is the availability of both: I could have told her 'no', because the suggested research was not entirely related to what I was doing. We cannot deny that there is a distance from professors to undergraduate students when they are not within our focus. (respondent R)

So apart from the idea and successful research activities, the innovation, in the Professor's perspective, depends on peoples' willingness to happen in cooperation.

b) The stage of filing the patent

After having researched the new technology and reached a positive result of tests, the Professor admits that it was not easy to file the patent.

> In this project, we were dealing with a small company that does not have the expertise of registering intellectual property. In previous projects, we had the support of big companies with history in patenting. But now it was different. So I got involved in finding the ways and understanding the steps to file the patent. But I am an academic without experience in this matter. So soon I reached the limitations of my competences. (respondent R)

From this moment on, the Secretary for Technological Development (Sedetec) got involved in the collaborative project. Firstly, the Intellectual Property Coordinator (respondent U) helped with the search of existing patents on international databases to check if the technology or something similar was already registered. The Professor

says that the research group knew that nothing had been published in scientific journals, but they were not sure about patents because this is something they do not deal with on a regular basis.

According to the Professor, the Sedetec had an important role in this moment because she, as an academic, did not have knowledge about the patenting process; and the company, for being small, also had limited resources to help in this situation. The second activity performed by the Sedetec was the writing of the patent application form. The Secretary helped with the attendance to regulations for the Patent Office, for example deadlines and details on the co-ownership inserted in the form. The Intellectual Property Coordinator said that they had had experience in the same area before, related to the School of Chemistry, because the Professor had already filed another patent. The Sedetec also helped financially to file the patent.

The Professor comments that the staff at Sedetec, used to the legal terms, started filling in the patent form. Even though, the department hired an external attorney to write it. The Professor points out that the style of writing a patent is distinguished and unique, because it is a mix of scientific data with legal terms; and therefore academics lack the skills to compose it properly. The director of the company agrees that the Sedetec helped in this stage. She comments that the company and the research group provided the technical content; and the Sedetec helped them to write the patent according to the predetermined structure by the patenting agent.

Until the end of this research, the firm was deciding if it would invest in the international patent, as affirmed by the Director (respondent S). The Legal Assessor of the Sedetec comments that the University does not have funds for international patents. He complements that “we file the patent abroad only in extremely exceptional cases, if there is a negotiation in place, but that is very rare” (respondent Q).

c) The use of the technology

After having patented the invention, the technology was licensed. According to the Professor, the contract for licensing the technology to a firm was different from

the patenting. She believes that the engagement of the Sedetec in the negotiation of licensing is fundamental for many reasons. One is that the academics do not know the value of the technology and the protocols for the business. The second benefit of the involvement of the Sedetec is that academics do not know how to negotiate; they do not possess commercial skills. And in the third place, the Professor observes that it keeps a healthy research environment between the research group and the external partner. She finishes admitting that “I did not even know that there were different modes of licensing. I just knew there were royalties, but I had never heard that the royalties were paid in a different way depending if the new technology is a product, a service or a trademark” (respondent R).

The firm produced it during around a year and a half. Its client was from the automotive industry, but it was not a new client to the firm. The negotiation with the client for the use of the new technology was carried out by the firm without the involvement of the Sedetec. The Director of the firm says that it was difficult to start working with this client, and easy to be left by it. She explains that “this is the problem about not being in the market all the time; you have to be there to identify the symptoms and tendencies” (respondent S).

d) Current research project

After the patenting process and use of the technology, the firm and the University formalized another collaborative project, to keep researching the same subject. Nowadays there is an undergraduate student as an intern and a post-doctoral researcher dedicated to the project apart from the involvement of the Professors and of the firm.

The Professor explains that they are deepening the results from the previous research. She explains that

> we want to check other applications and to better understand why the phenomenon happens. So far, we know that the technology is better but we do not fully understand the reason why. In order to innovate again in the future, we need to master the parameters. Of course we imagine the explanations but they are not scientifically proven. (respondent R)

So the group is performing basic research now, instead of an applied research as in the beginning. Some tests and analysis are carried out in the company, and others are performed at the university's laboratories. This is because there is different equipment in the plants. Some other tests are done in both locations.

The Sedetec helped in identifying which interaction model would be applied to the case before developing the partnership contract. As there is an interaction with a firm, there are many rules that must be satisfied. Each project starts being developed by the research group within its School at the University. Afterwards the Sedetec acts as a filter to check if all details are correct to allow the partnership for the research.

Also the Sedetec approved the internship grant so that the research group could hire an undergraduate student, because all the technologic scholarships pass through the Secretary. The Professor (respondent R) says that the student and the post-doctoral researcher have visited the company to see the production site. However most of the contacts are done by email and telephone, because the firm is located around 100 kilometres from the University. About the interactions, the Director of the company (respondent S) believes that the relationship for R&D needs a person acting in both sides to be a connecting link. That is why there is an employee of the firm who is doing his PhD at UFRGS and researching the same subject.

e) Commercialization after invention

The founder and director of the company said that they did not try hard to negotiate the technology because the firm does not have the structure for it. Even though, there is another company in Brazil interested in the application of the new technology. However, the Industrial Manager of the firm asked to keep the secrecy about details. She just mentioned that the Sedetec does not help in the commercialization of the new technology, although the University is the co-owner of the patent. She complains that "there is no structure to negotiate the technology. We have to do it ourselves" (respondent T).

In an analysis of the way that the University handles the commercialization of an invention, the Director of the company says that, in Brazil, universities in general

are slow. She complains that “the profit, or any other result, is still seen as a sin. Even just producing the invention, commercializing the new technology is seen as a sin. Universities have to grow in this matter. They have to learn that the world has to move forward” (respondent S)

The Sedetec does not perform market search, as previously explained at item 4.3.1.1. The next section presents an analysis of the project since its beginning.

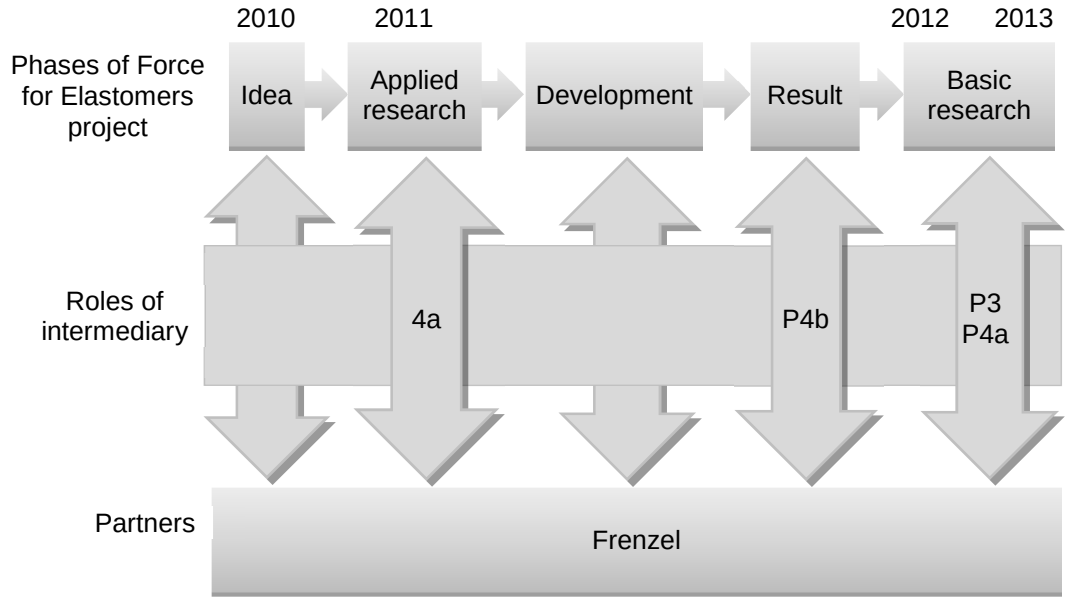
4.3.3 Case analysis

Next, Figure 20 shows the timeline of Force for Elastomers project with its main stages. As the company Frenzel was the only partner of the University in this project, it is cited in all phases of the R&D project. However, not all stages had the involvement of the Sedetec. The activities performed by the intermediary according to the research propositions are indicated. The direct links between Force for Elastomers project and Frenzel (the stages of Idea and Development) mean that the organizations were connected but the intermediary did not perform any role at these stages of the project.

The idea for the collaborative project entitled Force for Elastomers happened in 2010 during classes in the Industrial Chemistry course at UFRGS. The student who worked at the company Frenzel and the Professor began working together in 2011 to add a different force to the rubber produced at the firm. This applied research was carried out as the compulsory final paper for the graduation at the University.

The activities had the successful result of an invention. In 2011, the research group entered in contact with the Sedetec to file the patent of the invention. Following to that, the company licensed the technology to produce the new material to a client. The Sedetec got involved in the licensing contract with the company Frenzel. Around the same time, the student graduated; and the firm started the second collaborative project with the research group at the University with the involvement of more people. This time, the Sedetec helped in the development of the contract and with the scholarship for an intern who started working with the research group, therefore contributing with resources.

Figure 20 - Force for Elastomers' timeline



Critical roles of intermediaries (research propositions):
P1. Influencing the search for partners with common goals;
P2. Influencing the beginning of interaction;
P3. Influencing the access to resources;
P4a. Influencing the management of the project;
P4b. Influencing about the results of the project;
P5. Influencing research and knowledge production activities;
P6. Influencing development and prototyping activities.

Next, the case of Force for Elastomers is analysed considering the proposed research framework about intermediaries' roles on collaborative R&D projects. The activities and roles of the intermediary at the project were reviewed according to the proposed research framework presented at Chapter 3.1. To conduct the analysis, the discussion of critical elements of collaborative R&D projects influenced by an intermediary was based on the variables mentioned at the literature about each of the elements. The comparison and convergence with the other studied cases will be presented at Chapter 5.

Table 13 summarizes the activities and roles played by the intermediary at Force for Elastomers project, relating them to the critical elements of collaborative R&D projects influenced by intermediaries.

Table 13 – Intermediary's roles at Force for Elastomers project

Critical roles of the intermediary	Intermediary's activities at the project Force for Elastomers
1. Influencing the search for partners with common goals	The Sedetec does not have a team to search for partners. However, it looks for an internal research group to be partner of external companies when there is an external demand. The Sedetec does not have an always updated list of researches in operation at the University. At Force for Elastomers case, the Sedetec did not have to search for partners with common goals.
2. Influencing the beginning of interaction	The flow of interaction, at Force for Elastomers case, was initiated by the external company towards the academic. The Sedetec was not involved in putting the partners together.
3. Influencing the access to resources	The Sedetec did not provide equipment or infrastructure for the Force for Elastomers project. However, the department approved a scholarship for an undergraduate student who is working in the second phase of the research project therefore helping with finance for human resources.
4a. Influencing the management of the project	The Sedetec helps the writing of contracts when the academics are engaged in a collaborative project with external partners. The University presents different modes of partnership, with different rules, and the Sedetec helps the academics to identify which mode is applied to their case.
4b. Influencing about the results of the project	The Sedetec hired an external attorney to help in the patenting process of Force for Elastomers, and paid for the procedures. Also, the department was responsible for helping the parties in writing the contract for licensing. However, the Sedetec does not get involved in the commercialization of the technology to other parties.
5. Influencing research and knowledge production activities	It was not identified the direct help of the Sedetec in these activities.
6. Influencing development and prototyping activities	It was not identified the direct help of the Sedetec in these activities.

As it can be seen at Table 13, most critical elements of the collaborative R&D project had the influence of the Sedetec as an intermediary.

The role of searching for partners with common goals (proposition 1) was not the strongest help of Sedetec regarding Force for Elastomers. That is because the Sedetec did not have to; the researcher and the Industrial Manager were Professor and student at an undergraduate class. However, the three interviewed employees of the Sedetec (respondents P, Q and U) commented that the department seeks for internal research groups when there is an external demand from a firm, although it was not the case of Force for Elastomers project.

The nonappearance of the Sedetec's help in seeking for partners in the case of Force for Elastomers leads to the absence of the intermediary's influence also in the beginning of the interaction between the partners (proposition 2).

Concerning resources for R&D (proposition 3), the Sedetec approved a scholarship for an undergraduate student who is working in the second phase of the research project therefore helping with finance for human resources. The department did not get involved with providing equipment, funds or infrastructure for the Force for Elastomers project.

Regarding the proposition 4a, about the intermediary's influence in the management of the project, the case of Force for Elastomers showed that the Sedetec helps the negotiation of contracts when the academics are engaged in a collaborative project with external partners. However, the department does not deal with financial follow-up after the partnership contract is approved.

The University presents different modes of partnership with different rules; and the Sedetec helps the academics to identify which mode is applied to their case. The modes are detailed in the Partnership Department Handbook (UFRGS, 2012). To formalize the interaction, the University uses its own legal instruments, following some interaction criteria.

Regarding the intermediary's influence in the definition and distribution of the results of R&D activities (proposition 4b), the Sedetec is the main responsible for filing the patent at the University. The research group only provides the technical information about the new technology. At Force for Elastomer's case, the department hired an external attorney to help in the patenting process. Also, the department was responsible for paying the patenting procedures. After having protected the invention with the patent in a national level, the Sedetec helped the parties when it came to writing the contract for licensing the use of the new technology. However, the Sedetec did not get involved in the exploration of the technology to other parties through negotiation and commercialization. Those roles are responsibility of the external partner.

The analysis of the intermediary's influence directly on research and knowledge production activities (proposition 5) showed that the Sedetec was not involved nor helped this stage of the project. Also the department's staff did not influence or helped development or prototyping activities (proposition 6) which

happened before basic research at the case of Force for Elastomers. So considering all research propositions that appear in the framework of R&D projects, the stages of executing the project was the only one where the department did not have a role to play.

The current chapter presented three collaborative R&D projects that received influence from the services of intermediaries – OSCR project, StarStream project and Force for Elastomers project. Next chapter presents the cross-case analysis relating the three projects and the discussion of it.

5. CROSS-CASE ANALYSIS AND DISCUSSION

In the previous chapter, the results of individual cases were presented. This chapter now analyses jointly the three R&D projects. Although there may be some limitations due to the heterogeneity of the cases, the purpose of this chapter is to identify convergent aspects and highlight findings that may help the further development of theories on the subject and managerial implications. The purpose is not therefore to make a comparative analysis, but to identify evidences for the development of a conceptual framework about intermediaries' roles and practices later on. The research propositions are revisited in order to facilitate the analytical work.

The Table 14 presents a summary of meaningful points in each of the critical roles of intermediaries found in the three analysed cases.

Table 14 – Critical roles of intermediaries in the cases

Case / Critical roles of intermediaries	1. OSCR	2. StarStream	3. Force for Elastomers
1. Influencing the search for partners with common goals	NESTA had the network of SME's, start-ups and incubated hubs in the UK with 500 possible applicants. The intermediaries were responsible for short-listing the submitted proposals choosing the few possible partners with common goals to offer to Orange.	R&IS identified the possible interest of IP Group, Company A and Sellafield. Moreover, R&IS identified a partner (Philips) that was related to another School within the University. The department has a list of companies and possible external partners.	The Sedetec did not directly help on this matter, at the studied case. The department does not have a team to search for partners. However, it looks for an internal research group to be partner of external companies when there is an external demand.
2. Influencing the beginning of interaction	NESTA organized an event with the attendance of around 100 potential partners not previously selected to meet Orange's staff. Moreover, NESTA chose around 10 possible partners and introduced them to Orange. The flow of	R&IS staff arranged meetings between external organisations and the academics when they had identified common goals between the parties. The flow of interaction was initiated by the academics, by the	The Sedetec was not involved in putting the partners together. The flow of interaction, at Force for Elastomers case, was initiated by the external company towards the academic.

	NESTA's activity was initiated by both: the organization that wanted a solution and the intermediary.	external company or by R&IS, depending on the partner in this case.	
3. Influencing the access to resources	The intermediaries at OSCR hired a market consultancy to help the applicant in the Airlock. NESTA had a role in funding part of the project. Also some meetings happened at NESTA's office in London, according to the organisation.	R&IS had a major role in arranging financial resources for the project, either from the University or from external partners. The department did not help with human resources, equipment or infrastructure for the project.	The Sedetec did not provide equipment or infrastructure for the project. However, the department approved a scholarship for an undergraduate student who is working in the second phase of the project, therefore helping with finance for human resources.
4a. Influencing the management of the project	The design and coordination of the entire project was done by NESTA. It was responsible for not letting Orange know who the applicants were, keeping the confidentiality as agreed on the contract. NESTA was also responsible for signing contracts with the applicants and separately with Orange, centralizing the control of the project.	R&IS staff was responsible for negotiating the establishment of rules for the engagement of parties in the project; and for writing the contracts of all partners at StarStream case, except the first one, which the academics got themselves. In case of conflict between the academics and the companies, R&IS staff played a role as pacifiers.	The Sedetec helps the academics to identify the right mode of partnership among the different pre-established contracts. Moreover, the Sedetec helps writing contracts when the academics are engaged in a collaborative project with external partners.
4b. Influencing about the results of the project	The intermediaries hired advice for intellectual property protection from a lawyer. The business relationship between Orange and the winner of the competition did not have the influence of the intermediaries.	The department hired an external attorney to help in the patenting process, and paid for the procedures. Moreover, R&IS staff is responsible for the negotiation and commercialization of the technology to other parties.	The Sedetec hired an external attorney to help in the patenting process, and paid for the procedures. Also, the department was responsible for helping the parties in writing the contract for licensing.
5. Influencing research and knowledge production activities	The case did not have a research stage.	R&IS did not directly influence these activities.	The Sedetec did not directly influence these activities.
6. Influencing development and prototyping activities	The intermediaries helped the applicants in the Airlock stage to adapt their business propositions according to Orange's needs.	R&IS's staff did not directly influence these activities.	It was not identified the direct influence of the Sedetec in these activities.

As one may see at Table 14, most of the critical roles of intermediaries in collaborative R&D projects had the influence of intermediaries in the three cases. The multi-case analysis now takes a deeper look into each of the critical roles.

Proposition 1: The intermediary influences the search of possible partners with common goals.

The three cases showed different results in this matter. In the OSCR case, NESTA helped its client to get to know different partners through the competition, having selected seven possible partners among a hundred possibilities. However, the chosen partner was not from the intermediaries' network; so the intermediaries did not *find* the partner with common goals, but they were able to *identify* it among a lot of other candidates. A different situation arose from StarStream project, where the intermediary (R&IS department) searched for some external partners that its "client" (the academic group who had developed the invention) did not have contact with. Some other partners came from the academic's own initiative to contact. And at Force for Elastomers case, the intermediary (Sedetec) did not need to search for a partner with common goals, because the partners knew one another and identified the possibility to work together.

The first two cases follow what Batterink *et al.* (2010) name as "network composition", which would be the function of an intermediary when it scans and selects strategic and complementary partners. However, the third case refutes the focus of several authors about intermediaries' activities, such as Winch and Courtney (2007, p.757) when they say that "universities use brokers to seek partners for their externally funded research programmes while the firms use the brokers to shape research programmes to meet the perceived needs of the industry". Even stronger is the affirmation of Alexander and Martin (2012, p.38) who state that "for academics and companies to engage directly without using their respective transfer offices is now the exception, not the norm".

Regarding the possibility of a second work with the same external partner, which would characterize strong ties between the organizations and the maintenance of the relationship between them, at OSCR case, the intermediaries did not show this concern. Showing a different result, at the University of Southampton, R&IS department kept close contact with former partners and with a list of other possible partners, including companies where alumni are working. At UFRGS, the staff from

the Sedetec affirmed they keep in touch with several companies that could be interested in the University's research, although the role of the intermediary at the case Force for Elastomers was null. One may not that both the universities showed the concern with maintaining relationships. That may be a difference between intermediaries who are private third parties and intermediaries who belong to an organization interested in its own R&D projects.

At OSCR case, it was difficult to measure the effectiveness of the intermediary regarding its search for partners with common goals, because there was not a registration of how many applicants were from the intermediary's network and how many applicants did not receive the advertisement directly from NESTA. This does not apply to the other two cases where it is easy to identify when a relationship is initiated through the departments at universities; specially at StarStream project, it was easy to measure the quantity of relationships intermediated by R&IS and how many came from the academic's contacts. With this record, it is also possible to quantify the financial results from the project that came from the intermediary's search and from the academic's search.

Another analysis that emerges from the studied projects is that the intermediary has to know the invention and its client to be able to search for external partners and to identify common goals. StarStream project had different representatives from the R&IS department in different times. Although new people may bring new knowledge and contacts, there may be a loss of trust in relationships previously established. This situation may be related to the external intermediary at OSCR case that does not know entirely the client's business. In both projects (StarStream and OSCR), this problem was addressed. There were different ways to solve this situation: R&IS carries out frequent meetings among the collaboration managers, and the department keep an online registration of everything that happens with the projects, companies and academics. At OSCR case, two extra intermediaries were included because they were related to the client so they knew the company's needs better. These initiatives confirm the findings by Agrawal (2006) who says that focusing on the role of specialized innovation intermediaries is not enough to enhance technology transfer, mainly academic. He affirms that it is better to engage the inventor in an active collaboration with technology transfer experts.

Proposition 2: The intermediary influences the start of the interaction among the organizations.

If proposition 1 happens, then proposition 2 shows the involvement of the intermediary as well. In the cases when the intermediary was not present on searching for partners, and the organizations found external R&D partners by themselves, then the interaction was not influenced by the intermediary as well. This was the case of Force for Elastomers, where the partners got to know themselves without the involvement of the Sedetec.

At OSCR and StarStream cases, the intermediaries helped the flow of interaction to be started between the partners. That role of introducing and starting contacts between companies that did not know each other converges with what Castells (1996) names connectedness, a key element of collaboration. As Batterink *et al.* (2010, p.68) also note that “brokers are very concerned with interaction processes in the innovation networks, and that they take the lead in facilitating interactions between the network members, who often represent different types of actors with different timeframes and cultures”. These authors mention interactions for the beginning of the relationship as well as during the whole R&D project. According to them, interactions among network partners enhance trust; and that is why the innovation broker organizes face-to-face meetings in the inter-organizational network.

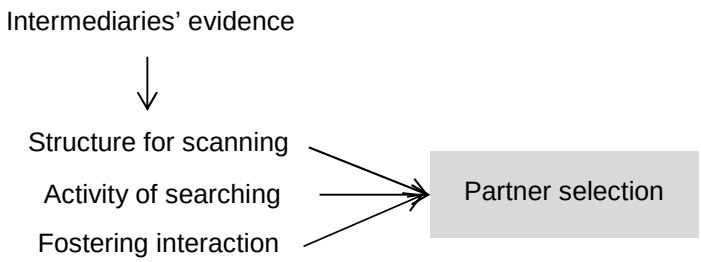
Regarding the flow of first contact, at OSCR case, the interaction was initiated by both: the organization that wanted a solution and the intermediary itself that wanted to test open service innovation. At StarStream case, the flow of interaction began sometimes by the academics towards external firms, other times by external firms towards the University (especially after the publicity gotten by the project due to the Royal Society Brian Mercer Award) and some other times the interaction was started by the intermediary who put possible external partners in contact with the academics. The two cases show a different finding compared to Winch and Courtney (2007) who describe flows starting from the source of technology or from the company that needs the solution for its innovation. The authors did not mention about the interaction beginning by the intermediary.

Also Hacievliyagil *et al.* (2007, p.49) mentions the outside-in process where a company absorbs knowledge and technology from an external party in order to enrich its own knowledge base and enhance its capabilities to innovate. The inside-

out process occurs when a research-driven company get revenue by selling or licensing knowledge or intellectual property to another company, which is better suited to bring the innovation to the marketplace. The coupled process would be when the partners cooperate through joint-ventures and alliances. In none of the situations, the authors mention that the intermediary could be responsible for starting the flow of interactions.

The main variables found in the empirical studies concerning the search for external partners with common goals and the connected activity of fostering interaction between those partners are summarized at Figure 21. The three variables can be related in a broad element called Partner Selection as one of the main activities of intermediaries.

Figure 21 - Variables of the element Partner Selection



Proposition 3: The intermediary influences the access to necessary resources for collaborative R&D projects.

The three cases showed the involvement of the intermediaries in the access to some kind of resource. At OSCR case, the intermediaries helped with financial resources for the developments, human resources in consulting about protecting the inventions, and infrastructure for meetings. At StarStream case, the intermediary was directly responsible for the financial resources either from the University or from external partners. At Force for Elastomers, the Sedetec helped with financial

resources to allow human resources for the research, although the intermediary did not get involved in hiring staff.

Funding is a fundamental resource for R&D as mentioned by Adams *et al.* (2006) and Okamuro (2007); and one may see that the help of intermediaries for financial resources was a very important issue for the existence of OSCR and StarStream projects. However, other sources (BIS, 2012; IBGE, 2010) rank human resources as fundamental for R&D; and the findings here were that intermediaries did not get involved with this issue. The third case, Force for Elastomers, shows the confluence with the findings by Alexander and Martin (2012), who assume that intermediaries in the interface of universities and firms should establish knowledge-based boundary-spanning activities through the effective mobilisation of people (human resources). And the help of Sedetec in approving a scholarship for an undergraduate student fits in this situation.

Proposition 4a: The intermediary influences the management of activities among partners in collaborative R&D projects.

The three cases showed the help of intermediaries on the management of the project in different tasks. OSCR case was different from the other two studied cases because NESTA designed the whole collaborative project, and was responsible for managing the contracts with *all* possible external partners (the candidates). At StarStream and Force for Elastomers cases, the intermediaries had a strong role in helping the management of projects, but they were not responsible for every partnership with external parties.

Helping to write contracts for the collaborations appeared in the three cases. The previous experience of the intermediaries added to some pre-established contracts and modes of partnerships was seen at the three cases. At OSCR project, NESTA had already performed the competition for product innovation; it was the first time that the agency carried out the project for a service client (Orange). Even though, the format of the whole project was already set beforehand. Although the intermediaries R&IS and the Sedetec were not responsible for writing all the contracts by themselves - because there usually was the involvement of academics - the establishments within contracts hinder opportunistic behaviour from a partner of the relationship. That agrees with the statements by Provan and Kenis (2008) that

governance may ensure that actors engage in collective and mutually supportive action, and that conflict is addressed. Also, the previous experience of intermediaries with other R&D projects and even templates for establishing appropriate coordination mechanisms, such as contracts, matches what Batterink *et al.* (2010) had already stated. The intermediary uses “lessons learned” from past projects.

Formal contracts are used as governance mechanisms, but Grandori and Cacciatori (2006) add trust, reciprocity and fairness of the relationship as informal methods of coordinating collaborative initiative. Trust issues were different considering the three studied cases. At OSCR case, the development of innovation propositions by the candidates was kept secret from Orange. The confidentiality, in this case, was intended to protect the applicants against a potential opportunism. At StarStream case, the technology developed by the academics was revealed to partners sometimes even without a signed contract. For example, the company Ultrawave was testing the technology at its plant, and presenting it to its clients for two years before signing a formal contract with the University of Southampton. The relationship was based on trust. The only official partnership was the support for the Royal Society Brian Mercer Award. This situation was the same in the beginning of Force for Elastomers, when the student was developing her research for the final paper for graduation. The contract was signed between the parties (company and University) after the research had already started. One could relate the practices based on trust with the Toyota case, described by Dyer and Nobeoka (2000), where certain knowledge is shared with partners as if there was no owner.

The management of the collaborative project *throughout* its activities was seen only at StarStream case, where the collaboration managers from R&IS department were in constant contact with the academics and their external partners. As mentioned by Batterink *et al.* (2010), the stimulation of network interactions would be typical in the inter-organizational context. Klerkx and Leeuwis (2008) also say that a broker may have a role in intermediating between the two worlds of industry and research, because they have different mindsets, expectations and time frames. In this regard, innovation brokers may act as a translator by facilitating a situation that enhances knowledge transfer during the project.

In contrast, at OSCR case, the intermediaries stopped being involved after Orange chose the winner of the innovation competition who would turn to be the

future business partner. And at UFRGS, partnership contracts with external organizations always include a Foundation from the University to manage finances and other bureaucratic situations of R&D projects; therefore the Sedetec does not keep being involved throughout the project.

Proposition 4b: The intermediary influences the definition and commercialization of the results of the project.

The three cases showed the help of intermediaries on the definition and distribution of the results of the project, mainly in the protection of the novelty and a small role in the commercialization.

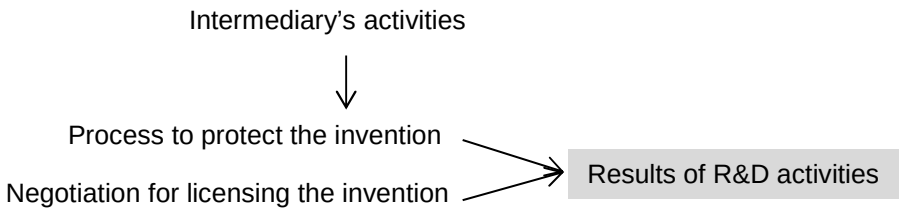
At OSCR case, the intermediaries provided access to information about protecting the candidates' developments but did not get involved in the negotiation of the sharing of results between the companies Orange and Last Second Ticket. At UFRGS, the Sedetec is responsible for filing the patents and helping with the costs of the procedures; but the department does not commercialize the technologies created at the University. The department does not have a commercial strategy. Even though, the academic commented that the engagement of the Sedetec in the negotiation of licensing is fundamental, when there is a firm interested in a business deal with the University. Not all collaborative R&D projects end up in licensing the technology for the external partner. This situation follows what Dodgson *et al.* (2006) relate about the issue of intellectual property not being well resolved in collaborative R&D projects. Also Deschamps *et al.* (2013, p.33) state that "even the intermediaries, whose role is to guide SMEs in university-enterprise collaborations, suffer themselves from the lack of appropriate IP transfer and sharing tools, and do not perceive the need to offer better support in this regard".

At the University of Southampton, the situation was very different from the other two cases, because R&IS was responsible for negotiating financial investments from external partners in the University's research. The department performs market researches and is aware of the value of the inventions at an international level. This way, the staff is able to offer the technologies to external organizations identified as possible partners. The department is responsible as well for filing patents and other types of protecting the inventions. This role agrees with what was previously stated

by Benassi and Di Minin (2009), that under specific circumstances the transaction would not occur or would be much more difficult if a broker were not present. Also Mello and Etzkowitz (2008, p.194) have affirmed that universities are increasingly expected “not only to produce but also to commercialize knowledge, that is, to use research results to create intellectual property and contribute to new process and product tradable in the market”. However, different from the results here, these authors emphasise the role of universities in Latin America that, according to them, have taken up the new challenge of transforming incentive structures and patenting research results.

The main variables found in the empirical studies concerning the roles of intermediaries in the results of the collaborative R&D project are summarized at Figure 22.

Figure 22 - Variables of the element Results of R&D



As illustrated at Figure 22, the two variables are part of the broad element called *Results of R&D activities* as one of the main roles of intermediaries. This situation considers that R&D activities have reached the expected results from partners’ performance.

Proposition 5: The intermediary influences research and knowledge production activities in collaborative R&D projects.

One of the studied cases did not include research activities in the project; therefore the proposition could not be analysed. At both Universities, where research activities were a major part of the collaborative project, the analysis showed no direct help from intermediaries. This result was already expected due to the profile of

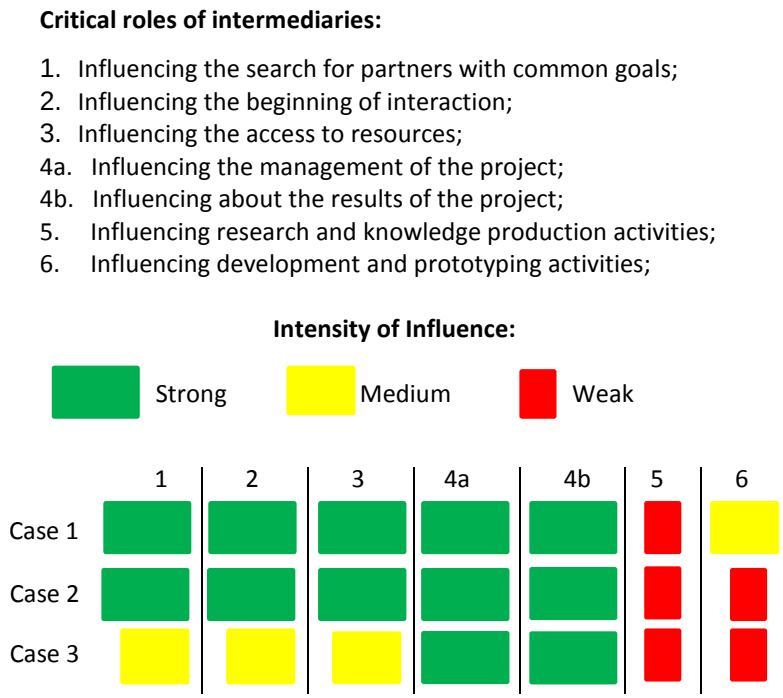
intermediaries studied at this research (who do not perform R&D activities). The proposition was included because research activities are part of R&D projects, therefore being part of the framework developed about R&D projects influenced by intermediaries.

Proposition 6: The intermediary influences development and prototyping activities in collaborative R&D projects.

As well as Proposition 5, it was not expected that the research would find the help of intermediaries on development and prototyping activities. This was confirmed at StarStream and Force for Elastomers case. However, at OSCR case, one may see the involvement of the intermediaries at these activities. The stage of the project called Airlock was intended to help the candidates adapt their ideas and systems into a commercially appealing service to Orange. This evidence matches the benefit of enhancing product attributes that Tran *et al.* (2011) identified in a client's product development from its relation to intermediaries. Even though, one must consider that the help of the intermediaries found in this case was not directly on development activities, but especially on knowledge about the client's innovation needs.

Figure 23 summarizes the intensity of influence of intermediaries in each of the case studies according to the intermediaries' roles. The focus of visualisation at Figure 23 is on the intensity of influence of each intermediary in each of the elements of collaborative R&D projects. The intensities "weak, medium and strong" are based on the evidences shown especially by the cases, but we also considered the generic activities of the intermediaries. As one may note, the intermediaries had a strong influence in most of the issues of collaborative R&D project. Only the direct activities of research and knowledge production (number 5) and the activities of development and prototyping (number 6) received a weak influence from the intermediaries or did not receive an influence at all in all three cases.

Figure 23 – Intensity of influence of intermediaries



Apart from the research propositions arising from the literature, other evidences stood up from the empirical study.

a) One point about the intermediary's roles concerning R&D projects was that it may influence the beginning of the whole project. NESTA was directly responsible for the beginning of the OSCR project. R&IS and the Sedetec also may influence some partners to start collaborative R&D projects in situations when, for example, there is an open call or bid for funding in a specific field of knowledge. In cases like this, the intermediaries suggest starting a project to some academics based on their past experiences. It is more than the intermediary being responsible for the beginning of the *interaction* between partners, as proposition 2 already discussed. This finding shows that the intermediary may be responsible for beginning the whole R&D project.

b) Another finding arising from the empirical evidence is the importance of the intermediary for small and medium-sized enterprises (SMEs). One may note that all three cases had SMEs as external partners, what increased the role of the intermediary. Some of the interviewed SMEs admitted that they would not be able to

pursue R&D activities by themselves without being involved in a partnership with a bigger partner. At OSCR case, the winner of the competition said he would not have had access to Orange's innovation staff in the first place, let alone be able to adapt his system to Orange's need without the intermediary's help. Moreover, the funding received by the applicant to develop his presentation to Orange was, as he said, "huge" (respondent D). If one considers this amount of funding for a big company as Orange or the intermediary NESTA, it is just a small portion among all investments in R&D.

At StarStream case, the owner of the company Ultrawave said he would not have resources to keep a R&D facility by himself. The partnership with the University of Southampton allows the company to explore new technologic possibilities at the University's laboratories and with the academics' knowledge. These were the same benefits affirmed by the owner of the company Frenzel about the partnership with the UFRGS at Force for Elastomers case.

Batterink *et al.* (2010) had already acknowledged that innovation brokers can assist SMEs to profit from the knowledge and capabilities of other organizations. Additionally, the authors say that intermediaries may help SMEs to get access to large capital funding by making the strict administrative procedures imposed by large subsidy providers more comprehensive for the SMEs. This declaration may also relate the procedures of large companies and Universities investing in R&D. In sum, Batterink *et al.* (2010, p.70) affirm that brokers help to initiate collaborative R&D "by helping SMEs to articulate their knowledge demand, by searching for, delineating, filtering and matching cooperation partners, and by guiding the actual cooperation during the innovation process".

Complementarily, Ramos *et al.* (2012, p.09) warns that innovation brokering for SMEs require considerably more support than for larger organizations due to the fact that "SMEs have fewer resources, a more limited knowledge and skill base, and immature management practices". Therefore, SMEs may be considered a moderator variable that changes the influence of intermediaries in collaborative R&D projects. Baron and Kenny (1986, p. 1174) explain that the "moderator variable" influences the strength of a relationship between two other variables - in this case, the independent variable of the involvement of an intermediary and the dependent variable of collaborative R&D project.

c) A third point worth mentioning is related to personal contacts among the people involved in collaborative R&D. The evidence in all three cases show that there is a social relationship involved somehow, besides business relationship and interest in innovation. This may be related to what Granovetter (1973) argued that every economic relation between firms occur within an environment of pre-existing social relationships. Also Powell (1990, p.300) stated that certain economic "exchanges are more social – that is, more dependent on relationships, mutual interests, and reputation – as well as less guided by a formal structure of authority".

At OSCR competition, the former Director of Open Innovation at NESTA (respondent A) and the former Head of Open Innovation at Orange (respondent B) knew one another; and that was how the project started. NESTA wanted to test the model with a service company, because the organization had already tested it with product innovation. As both business men were in contact, then the project was performed by NESTA to Orange, and not to another service company. At StarStream case, bigger firms were involved, so less social contact influenced the results of the intermediary's job. Even though, there was one partner who invested in the University's technology that came from a family relation of the collaboration manager (respondent H): one of his in-laws used to work at company B and helped the beginning of the relationship between the University of Southampton and the company B for StarStream development. At Force for Elastomers, the main people involved already knew one another before establishing the project for R&D. The student-professor relationship was previous to the formal contract for the research. The intermediary was not involved. Fleming and Waguespack (2007) say that the physical interaction may solve an inherent lack of trust associated with brokerage positions.

The first two situations show that the intermediary may grant trust to the relationship not only for its brokerage position, but sometimes because of its personal relationships with people from external firms. This reality follows the findings by Long *et al.* (2013, p.1), when they say that "bridges, brokers and boundary spanners facilitate transactions and the flow of information between people or groups who either have no physical or *cognitive access* to one another, or alternatively, who have

no basis on which to trust each other[8]". Also Chu (2013) found social influence as a driving force of behaviour intention to use the services of Internet innovation intermediary platforms. Nevertheless, he adds that "the role of social influence in technology acceptance and use intention is subject to a lot of erroneous influences and moderations such as gender, age and experience" (CHU, 2013, p.951). Probably there are moderators for social influence on the use of intermediaries also in a not-online environment. It should therefore be further examined.

This chapter performed a joint analysis of the three R&D projects considering the research propositions. Moreover, some other findings that outstood during the case studies were also presented. The objective of the discussions was not to compare the cases, but to highlight evidences about intermediaries' roles and practices. Therefore it was possible to unite and synthetize the main findings and results that may generate contributions. Next chapter develops a conceptual framework about the findings, and elaborates some contributions of the research for theory and practice.

[8] Italics added to emphasize important parts in the citation of the authors.

6. CONCLUSIONS

The purpose of this chapter is to present a summary of the research in terms of outcomes and overall contributions. These include implications for researchers and for practitioners. Also, it outlines the limitations of this study and makes suggestions for future research.

This study was motivated in part by the relatively limited emphasis placed upon the role of intermediaries of collaboration in the literature of innovation. In particular, to the best of our knowledge, there has been little discussion of collaboration for research and development using theoretic approaches which consider both the mediation (or brokerage) and the provision of services, rather than only the performance of activities by the third party. We believe that reality is better reflected in a process which incorporates the influence of the intermediary on interorganizational projects, and not in a frozen moment regarding only the intermediary itself.

In addition, there has been little discussion in the literature of the different profiles of this subject and how they may vary at organizational level - being the intermediary an organization itself - and in R&D projects. These evidences from the literature review jointly led us to consider: what is the influence of intermediaries on collaborative R&D projects? And as the specific goals of the research propose to study: what is role of intermediaries in identifying potential partners with common goals and complementary knowledge or skills? How do they influence the interaction among organizations? What is their role in the access of resources needed for R&D as well as their role directly towards R&D activities performed jointly by organizations? How do they influence the coordination of collaborative R&D projects? And what is their influence in the decisions regarding the results of the project, either being an invention or turning it into an innovation? These issues led to the development of six research propositions which were empirically studied afterwards.

To fulfil the research purpose, in Chapter 3, a conceptual framework of R&D project was developed taking critical elements of collaborative R&D into account and considering the activities influenced by the intermediary. For the sake of the in-depth

understanding, we first investigated the profile of the intermediary and the services provided by it. Then, the attention of the empirical analysis was driven to the roles and activities of the brokers in R&D projects, regarding their influences in the four main parts of the framework: planning and designing the project; executing R&D activities; managing the project; and closing it. In each independent studied case, by looking at the various influences of intermediaries, we generated a table and a timeline that summarised the different roles and activities. The second moment of data analysis explored patterns and differences of influences performed by intermediaries among the cases.

We investigated different profiles of intermediaries and from two different countries. Although the findings of the research may be context specific and vary according to different regions and different institutional settings, the results show commonalities in the way intermediaries influence collaborative R&D projects.

The first specific goal of this research was to understand characteristics of innovation intermediaries. It was found that there are four main approaches to the subject leading to a typology of four profiles of intermediaries: the knowledge broker (HARGADON; SUTTON, 1997; LINGO; O'MAHONY, 2010; SIEG *et al.*, 2010), the social networks' broker (BURT, 2000; DELL'ERA; VERGANTI, 2013), the open innovation broker (AGOGUE *et al.*, 2013; BESSANT; RUSH, 1995; BILLINGTON; DAVIDSON, 2013; CHESBROUGH *et al.*, 2006) and of the systems of innovation broker (BATTERINK *et al.*, 2010; KIRKELS; DUYSTERS, 2010; KLERKX *et al.*, 2009; LUNDVALL, 1992). They vary according to two categories:

a) the activities performed: two types (the knowledge broker and the broker according to social networks) carry out R&D activities while the other two types (the broker of open innovation and of systems of innovation) do not perform R&D activities; and

b) if they belong to the network of firms involved in the R&D project: the knowledge broker and the broker according to the open innovation approach do not belong to the network. On the other hand, the broker according to the theories of social networks and systems of innovation are part of the network of firms involved in the activities.

The second specific goal of this thesis proposed to analyse the role of intermediaries in identifying potential partners and in promoting the interaction among

organizations. The research discovered that these two activities are connected: when the intermediary influences the search for potential partners, it influences the beginning of the interaction between these organizations. Moreover, the study found that the intermediary is not always the most important actor to find a possible partner. Sometimes, one of the organizations involved in the R&D project searches and gets into contact with external organizations that may provide complementary knowledge or other resources. Some other times, the intermediary may not *search* for partners, but may be responsible for *selecting* the most suitable ones for the partnerships according to the organizations' or the project's needs. Still in other situations, the organizations previously know each other and, then, start a R&D project without the influence of the intermediary in this matter.

The third specific goal of this thesis suggested analysing the role of intermediaries in the access to financial and human resources for R&D as well as their role directly in collaborative R&D activities. The research found that the access to funding for collaborative projects receives a great contribution from the services of the intermediary. The access to personnel and other kinds of resources as infra-structure appeared to have a slight influence from brokers. At the same time, the activities of knowledge production and research as well as of prototyping and development revealed to be internal to the group of organizations performing these activities; the intermediary does not directly influence R&D activities.

The fourth specific goal of this research proposed to analyse the role of intermediaries in coordinating collaborative R&D projects as well as in helping the decisions about the results of the project. Within coordination, several activities may be influenced by the intermediary. The biggest help found from the evidences was the drafting of contracts with the establishment of each partner's tasks. This mechanism for coordinating collaborative projects yields the prevention of opportunism. Also, the intermediary acts as the bridge of concepts to build mutual understanding when dealing with different partners, i.e. university and industry or SMEs and big enterprises. Regarding the results of the project, the intermediary influences the evaluation of the novelty's value for licensing, the protection of the invention and the decision about the sharing of financial results.

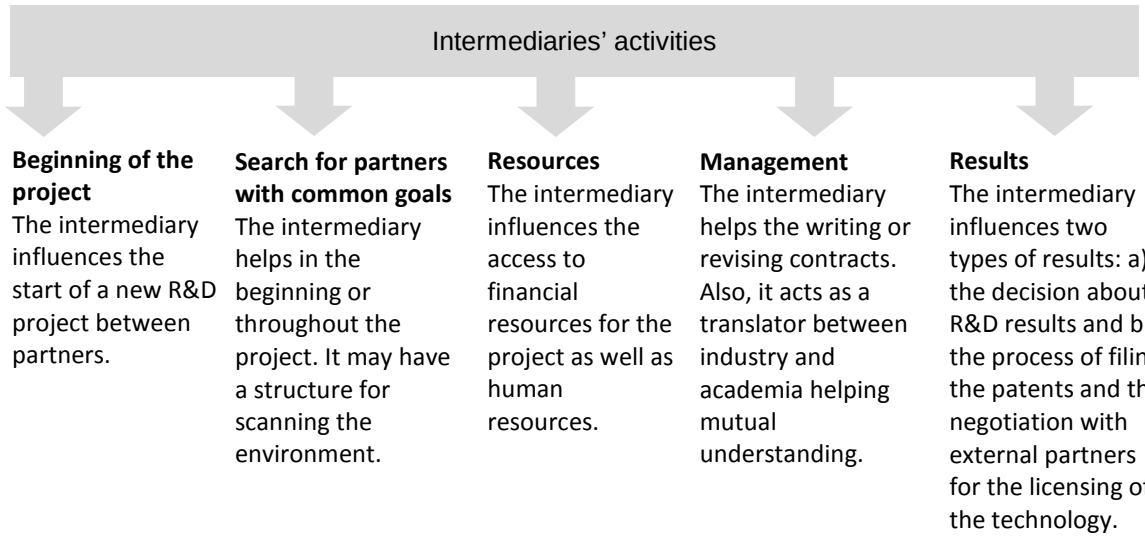
The fulfilment of the research goals led also to discoveries not previously mentioned at the literature. In spite of the fact that the three R&D projects happen in

different contexts and present dissimilar organizational settings, the results of the research allow theoretic inferences regarding the shared features about intermediaries' influences.

6.1 THEORETIC IMPLICATIONS OF THE THESIS

Considering empirical findings and theoretical background as basis, Figure 24 summarizes the main elements of collaborative R&D projects influenced by intermediaries.

Figure 24 - Main activities of intermediaries



As it can be seen in Figure 24, the main roles of intermediaries are five:

a) influencing a new R&D project to be started especially when there is an open external call for funds. This action of intermediaries has not been addressed by the previous literature on the subject. Howells (2006) says that the intermediary would do market research and business planning, by identifying market opportunities and developing business plans; however, he refers to the commercialization stage of the innovation, when the partners plan to exploit the outcomes of the project. Hossain

(2012) is the author who gets closer to this affirmation, by generally saying that “intermediaries provide all necessary services to launch a successful open innovation *program* or to find technology”. Even though, the intermediary is not responsible for a new project; it is limited to providing services.

b) finding partners who share R&D goals and subsequently putting them together. Although these two actions have been previously mentioned in the literature (ALEXANDER; MARTIN, 2012; BATTERINK *et al.*, 2010; HARGADON; SUTTON, 1997; HOWELLS, 2006; WINCH; COURTNEY, 2007), the cited authors did not connect the two actions as only one role; the intermediary either does both or does not perform both.

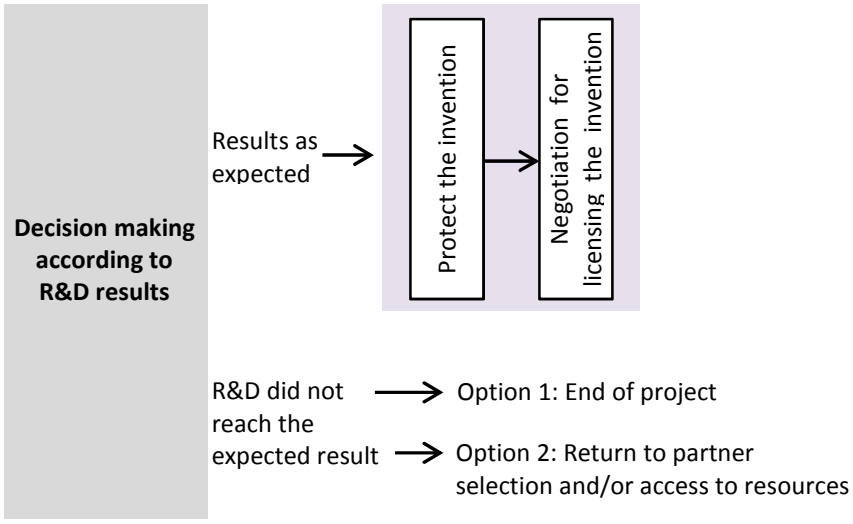
c) helping with access to resources, mainly funds, confirming what Dalziel (2010) has affirmed about some intermediaries who do not undertake technology development activities themselves, but instead provide funding for such activities. Also Howells (2006) states that intermediaries help finding potential capital funding and organising funding or offerings for innovation. Regarding human resources, the findings of the thesis confirm what Alexander and Martin (2012) declared about intermediaries in the interface of universities and firms, that they should establish boundary-spanning activities through the effective mobilisation of human resources.

d) influencing the management of relationships, mainly regarding contracts with the definition of rules for the engagement of partners into collaborative projects, that helps in the prevention of opportunism. That role agrees with Alexander and Martin (2012) who affirm that the intermediary helps the identification of the type of research projects, the collation of costs, the control of the key phases of negotiation, the authorisation of, and follow-up on progress of each contract. Also in the words of Batterink *et al.* (2010), the innovation process management relates to enhancing communication, learning and other forms of interaction and alignment among partners.

e) influencing the definition about the results of the project. In this case, the intermediary does not influence directly R&D activities, as already mentioned. However, it has a role regarding the decision making according to different results of R&D activities performed by the partners. It means that the intermediary influences the decision about how the flow of the project will be from different results of R&D activities.

There are three possible follow-ups for the role of the intermediary: a) if the result of R&D activities accomplishes what was previously expected, the intermediary may influence the results of the project by helping the protection of the patent or by commercializing the license of the technology; b) if the R&D activities do not reach the expected result, the intermediary may influence the end of the project; or c) if the R&D activities do not reach the expected result, the intermediary may return to helping with partner search and access to resources, in the cases when the collaborative project will keep being executed. Figure 25 illustrates the three possible different roles of intermediaries that vary according to the result of R&D activities.

Figure 25 - Influence of intermediary on the decision making according to the results of R&D



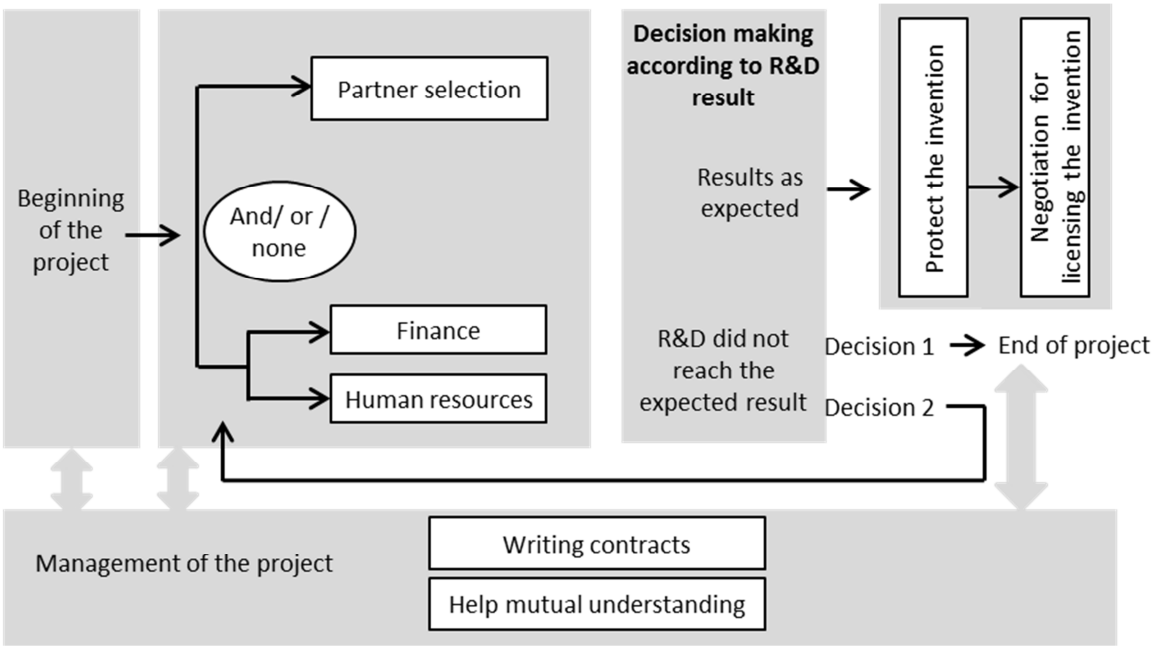
The intermediary does not influence R&D activities. However, as Figure 25 shows, it has an influence in the decision about the future of the project according to the success or failure of R&D activities regarding the results that were expected.

Summing up, the main discoveries of the study, that were different from the framework initially designed, are: a) the influence of the intermediary in initiating a whole collaborative R&D project; b) the activities of partner search and fostering the interaction between possible partners are joint actions; and c) the intermediary has an influence on the decision making about the results of R&D activities either if they

reach or do not reach the expected results. Adding up these three main theoretical findings of intermediaries in collaborative R&D projects, a new framework is suggested to reflect the intermediary's roles as seen at Figure 26.

The empirical evidences matched with theoretic propositions allowed the improvement of the framework of collaborative R&D projects established upon the flow of activities previously mentioned. Rather than trying to impose a conceptual framework upon the field of R&D, that is different in many characters, and thus attempting to validate or invalidate specific predictions of the intermediary's role, we intend instead to utilise the process of collaborative R&D only as a guide to the understanding of the subject. The purpose is to demonstrate the main elements involved in a collaborative R&D project that may be influenced by intermediaries. The framework at Figure 26 reflects the practices and indicates the concepts with which we better understand the phenomenon of intermediaries' influence.

Figure 26 - Collaborative R&D project influenced by intermediaries



The grey arrows connect the different stages of the R&D project. The straight black lines stand for the flow of activities.

The two Decision points from the first framework (Figure 11) were turned into one big decision point (the stage of Decision making according to R&D results) due to the exclusion of the stage of Execution the R&D activities from the framework.

As one may note in Figure 26, the five main moments where the intermediary influences are highlighted in grey boxes. They refer to a) the beginning of the project; b) partner selection and access to financial and human resources as fundamental elements of planning a collaborative R&D project; c) the decision making according to R&D results; d) the management of the project; and e) the results of the project, as previously explained in more details at Figure 25.

After presenting the contributions of the thesis for the study about intermediaries of collaborative R&D, the next section presents some implications for organizational practices of intermediaries and firms. One must bear in mind though that each collaborative R&D project will have its own specificities as regarding to the culture of the organizations involved, the technology being developed, experience and history of collaboration between the partners, and public policies of the region.

6.2 MANAGERIAL IMPLICATIONS AND RECOMMENDATIONS FOR INTERMEDIARIES

The studied cases showed that the intermediary does not always search for new partners with common goals. Therefore, this evidence confirms the overall assumption of this thesis, that the intermediary helps in different aspects of a collaborative R&D project. Although the role of finding partners is very common among private brokers, one may note that *other elements of a collaborative R&D project get the same amount of importance* among all the intermediary's activities. Considering this, one may suggest to intermediaries that it may be beneficial to offer varied services rather than focusing on one particular type of brokerage. As seen, many times the partners already know one another, or they may search for external partners themselves. Therefore the intermediary should offer different services such as the main findings of the research concerning the influences received by collaborative R&D projects. In an ongoing project or an existing partnership, the

intermediary may help by suggesting a new project to partners according to external calls; facilitating the access to financial resources; organizing the process of filing a patent; and negotiating the license of technologies.

This thesis has emphasized that, for innovative firms, the services provide by intermediaries may result in successful benefits. Nevertheless, the potential gains from intermediaries' services do not only depend on choosing any intermediary or any service. As activities are singular in each R&D project, also singular has to be the services provided by the broker. Firms may have to rely on their own knowledge of the project in order to contribute with input for the intermediary's best approach to the client's needs.

Another contribution of this research arises from one of the findings discussed in the previous chapter concerning the intermediary being responsible for the start of a R&D project as a whole. Previously found in the literature, there were two flows of action for finding partners: a) beginning by the organization needing a solution for its R&D project; or b) beginning by the organization that has a technology that could be embedded into another development in order to build a prototype or product. We add that *the intermediary may be the third actor responsible for starting a collaborative R&D project*, even when the intermediary is not active in R&D - i.e. the intermediary is not a knowledge broker according to the term explained by Hargadon and Sutton (1997).

Considering that the intermediary may be responsible for the start of an entire R&D project, intermediaries wanting to offer this service should know very well the capabilities of the organization to which they work for. If we consider the case of TTOs embedded in Universities, they should master the research groups and keep in constant contact with the academics in order to scan the possibilities of new researches when there is an external call. Considering the case of private intermediaries, as the company 100%Open and virtual brokers as Yet2.com, Innocentive, NineSigma and YourEncore (GIANIODIS *et al.*, 2010; HACIEVLIYAGIL *et al.*, 2007; HOSSAIN, 2012; VERONA *et al.*, 2006), as the possibilities of clients are huge, they may keep a constant eye on market sectors and be present in events in order to keep in contact with many possible clients. In case of an external call, the intermediaries would be able to identify which firm or organization could be interested in beginning a project.

6.3 MANAGERIAL IMPLICATIONS AND RECOMMENDATIONS FOR FIRMS

From the three studied R&D projects, only in the case of Sedetec there was a repetition of the partnership. The University and the firm started a second project regarding the same technology. The other two cases did not show a second R&D project performed by the same partners. Although the Sedetec was not involved in searching for partners and putting them together in the case of Force for Elastomers, this situation may add a contribution to the study of intermediaries regarding the measurement of the effectiveness of the intermediary's services.

If the broker was responsible for identifying partners with common goals, and the relationship progresses for a second project, it may be an indicative that the selection made by the intermediary was right. Considering this, we suggest some measures for the evaluation of the effectiveness of the intermediary's role on searching for partners with common goals. Different levels of results may be expected:

a) the intermediary's search for partners may be considered positive if *the relationship was established* among the organizations introduced by the intermediary;

b) the intermediary's search for partners may be considered positive if *the activities of the established relationship resulted in a novelty* since the goal of the collaborative R&D project is to generate discoveries; and

c) the intermediary's search for partners may be considered positive *if the partners collaborated for a second time*.

Using measures, the firms involved in R&D may be able to evaluate the benefits of hiring or involving an intermediary in the process of searching for partners. Moreover, intermediaries themselves will be able to specify which contributions they expect to offer to clients. For example, the second measure does not depend on the intermediary because innovation is risky and many R&D projects do not reach a positive result. However, if "right" partners are put together, that may increase the possibility of reaching the expected result from R&D. For firms that want to be involved in collaborative R&D, measures may be useful also to analyse if the involvement of an intermediary may generate transaction costs.

Given the contributions of the research for theory and practice, the next sub-chapter brings some suggestions of areas for further research.

6.4 RECOMMENDATIONS FOR FUTURE RESEARCH

Large-scale empirical research would be suitable to statistically estimate the intermediaries' roles presented here, and to help identify the contexts and environments in which these roles would vary. Possible issues are, for instance, how the intermediary can influence in building *trust* among the partners. Another area for further research could be how a virtual innovation broker gets to fully understand the needs of the client in order to search for the most suitable partner, compared to relationships face-to-face between the client and the intermediary.

There is also a need to enrich and complement the understanding of differences and commonalities regarding practices of intermediaries from different institutional settings as within universities or private brokers. Most importantly, as intermediaries may belong to the network of actors in Innovation Systems, the analysis of the importance of *public policies* on the intermediary's work is essential. These questions deserve new studies to allow an in-depth understanding on the subject and therefore the improvement of intermediaries' roles in innovation.

6.5 LIMITATION AND CONCLUSION

The research attempted to cast some light upon an area that has not been completely explored, both in theory and in practice. Particularly regarding collaborative projects for research and development, the study highlighted some general findings and contributions about intermediaries' roles considering different specificities of each analysed project.

Even though having provided theoretical and empirical contributions in several respects, like any research, this study is subject to limitations. The generalizability of the findings, though, is restricted by the traditional limitations of qualitative studies

regarding the small number of cases what deprives statistical generalizations (EISENHARDT, 1989; YIN, 2009). As explained at the Methodological Procedures chapter, the use of some techniques such as multiple sources of evidence; developing a protocol for interviews; and having a draft reviewed by key informants, enhances the scientific reliability and validity of the research. Nevertheless, the contributions of the research are supported by theoretical background what grants some degree of generalization to the conclusions.

The intermediary influences several activities in a collaborative R&D project; some of them may also be *performed* by the intermediary, i.e. drafting contracts. However, the scope of actions of intermediaries is limited by the knowledge and understanding that they have about the client's business, culture and R&D practices. This limitation appears mainly when the intermediary is a private firm providing services to varied clients; it decreases when the brokerage is performed by TTOs in R&D projects involving partnerships with universities. On the other hand, when we consider TTOs as intermediaries, the scope of reaching different partners is restricted to projects regarding academic research.

Another caution to generalizations about intermediaries deals with their influence on the participation of SMEs in collaborative projects. The topic SMEs may act as a moderator variable when considering intermediaries' role of fostering relationships and coordinating projects. Especially for SMEs, which possibly have less financial resources to spend with R&D activities, the services of an intermediary may be expensive, generating transaction costs. This analysis has to be considered by firms engaged in, or willing to engage in collaborative R&D through the services of brokers.

To conclude, we point out that the analysis in two different contexts, the United Kingdom and Brazil, did not search for comparisons. As Hossain (2012) affirms, "intermediary market for innovation is mostly prevailing in a few advanced countries". Therefore, the results about intermediaries' influence may depend on the country and on the industrial segment in which the R&D project is being performed. Finally, we believe that the research may contribute to the understanding of the field of intermediaries in collaborative R&D projects by the given findings and contributions as well as may complement the extant literature on this field.

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APPENDIX A – QUESTIONS FOR INTERVIEWS

Questions for intermediaries

1. How do you search for new partners?
2. Do you use the internet to do so? Do you go to trade fairs, etc?
3. Do you search partners for R&D projects among suppliers and clients of the company?
4. How do you evaluate if the company is suitable to be a partner? What characteristics do you consider?
5. Is the search different if the possible partner should be from the academia or the industry?
6. If an organization has a technology (i.e. university) and wants a commercial partner, what do you do? On the other hand, if an industrial organization needs a technology for its new product in development, how do you search for partners who can build the solution?
7. If the possible partner does not belong to the net of relationships of the company, how do you make them meet?
8. Do you organize events where companies can meet?
9. If a joint project needs people for R&D, what do you do to help them?
10. Do you recruit people for R&D? How?
11. Do you help joint projects get funding from third bodies? How?
12. Do you provide facilities for the joint R&D activities? Or help companies to establish them?
13. Do you write contracts or help companies to elaborate them?
14. Do you establish the rules for partners to belong to the relationship? How do you make organizations to agree with them? Or do you help partners to establish them?
15. Do you define or help organizations to define each partner’s tasks in the project?
16. Do you suggest or validate technical standards to be used among the partners?

17. If there is a conflict between partners, do you get involved? What do you do then?
18. How do you help projects to prevent opportunist behaviour from partners?
19. Do you help partners to define about the results of the project, as IP ownership?
20. Do you help partners to define about sharing the commercial (financial) results of the project?
21. Are you responsible for distributing the commercial result among the partners?
22. Do you help partners' activities during research? How?
23. Do you help partners' activities during technology or product development? How?

Questions for companies in R&D projects

1. How did you identify skills and knowledge you did not have for innovation which could be complemented by a partner? Did the intermediary help you to identify these lacks of skills and knowledge?
2. Did you know exactly what kind of partner you needed?
3. Did you help the intermediary to narrow your search for a possible partner? How?
4. How did the intermediary help you evaluate if the company is suitable to be a partner?
5. Did you search for a partner because you had a technology and wanted a commercial partner? Or you needed a technology for your project of new product and a partner which could develop the solution?
6. How did the intermediary make you meet with your partner when the two organizations didn't know eachother?
7. Have you ever been to an event organized by the intermediary for organizations to meet possible new partners?
8. How did you hear about possible partners that the intermediary had identified?
9. Have you ever met a new partner through the internet?
10. Did the intermediary help you hire people to work at the R&D project? How? If you hired people with the intermediary's help, what would you have done without

it? If not, did you try the intermediary's help in this matter before hiring through different channels?

11. Did the intermediary help the project get funds? If so, how would you have applied for funds without the help from the intermediary? If not, did you try its help and the intermediary couldn't help?
12. Did the intermediary help the project with facilities and infrastructure for innovation activities? What did the intermediary do?
13. Did the intermediary help you and your partner to write the contract for the relationship?
14. When the organizations in the project got to know each other, did everyone know the rules of engagement and each one's tasks? Was this kind of information previously explained by the intermediary?
15. If the rules of engagement and each one's tasks weren't previously defined, did the intermediary help the organizations to establish them?
16. Have you ever had a problem/ conflict with partners and solve it with the help from the intermediary?
17. Have you ever had to negotiate with partners about technical standards to be used among all the organizations involved in the project? Did you have the intermediary's help for that?
18. Did the intermediary help the organizations in the project define about the results of the project? How?
19. Did the intermediary help the definition of IP ownership (if there was an IP resulting from the project)?
20. Did the intermediary help the organizations define about the commercial (financial) results of the project?
21. Does the intermediary manage the distribution of commercial results?
22. On research activities, did the project have the intermediary's help? How?
23. On product development activities, did the project have the intermediary's help? How?