Systems & Management 12 (2017), pp 70-82

SYSTEMS & MANAGEMENT
Electronic magazine

UNIVERSITIES, PRODUCER AND USER GENERATING INNOVATION AND VALUE: A CASE OF SUCCESS IN THE THEMATIC NETWORKS OF PETROBRAS

Ricardo Rezende Ramos[1], **Marta Lucia Azevedo Ferreira**[2]

1 Petróleo Brasileiro SA (Petrobras)
2 Celso Suckow da Fonseca Federal Center For Technological Education - RJ

ABSTRACT

This article discusses the topic of technological cooperation in the Brazilian oil sector from the perspective of academy-industry interactions and open innovation through a case study. We present the management of a cooperative Research and Development (R&D) project between two Brazilian universities, a national medium-sized supplier (producer) and Petrobras (user) within the framework of the C&T-Industry Integration Network in the National Productive Process (RICT), one of the thematic networks created by the operator to enable technological cooperation. We verified that the continuous and systemic interactions among the partners were essential for the development of technological innovation by integrating different fields of knowledge such as industrial networks, automation and mechanics and resulted in a new wireless communication system to be implemented in Petrobras industrial plants. In addition, the project generated value through the generation of specialized human resources, new scientific publications, research agendas, ideas, concepts and solutions, as well as the creation of a technology-based company. Despite the challenges inherent in the management of the cooperative multi-partner R&D project, the previous experience of academic research groups interacting with industry and the learning generated were of great relevance for both Petrobras and the supplier company.

Keywords: Academy-Industry interactions; Open Innovation; Multi-partner Technology Cooperation; Thematic Networks; Petrobras.

1. INTRODUCTION

The regulatory mark for the structuring of the Brazilian innovation system is recent, and it is set at the creation of the Sectoral Funds of Science and Technology (S&T) starting in 1999, notably the Green-Yellow Fund among these, which is aimed at stimulating the interactions between universities and companies. New mechanisms to promote these interactions also came after implementation of the Innovation Law 10,973 / 2004 and the Welfare Law nº 11,196 / 2005. In the oil sector, which is the focus of this article, the self-sufficiency declared in 2006 and the discoveries of petroleum reserves in the pre-salt layer announced in 2007 opened up to the country ample economic opportunities attached to institutional, regulatory and technological challenges. Petróleo Brasileiro SA (Petrobras) had its exclusive monopoly from 1953 to 1995 and the concession regime was formalized in 1997 (Petroleum Law 9,478), which received new production sharing and onerous assignment schemes in 2010, resulting in a hybrid regime with a still strong presence of the company.

The creation of the Petroleum and Natural Gas Sector Fund (CT-Petro) in 1999, the Human Resources Training Program of the National Petroleum, Natural Gas and Biofuels Agency (PRH-ANP) stimulated Petrobras' cooperation with Brazilian universities, as well as the Research and Development (R&D) clause present in the concession contracts since 1998 and regulated by ANP from 2005 on. It established that at least half of the investments corresponding to 1% of the gross revenue from the oil fields with a large volume of production that pay special participation, should go to Sci-

PROPPI / LATEC
DOI: 10.20985/1980-5160.2017.v12n1.1166

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

entific and Technological Institutions (ICT) accredited by the Agency, that is, universities and national research institutes (Ferreira, 2015; Mendonça *et* Oliveira, 2013; Ramos, 2014).

In 2015, a new regulation emerged from the Research, Development and Innovation Clause (RD&I) present in concession contracts, production sharing and onerous assignment, although the concession regime prevails for most of the total area of Brazilian sedimentary basins. ANP Resolution 50/2015 and the ANP Technical Regulation No. 3/2015 set forth guidelines and standards for the mandatory application of resources by oil companies in these activities, as well as the rules for proving their execution and the expenses incurred. Technical Note No. 01/2015, in turn, addressed the criteria and penalties in cases of non-compliance with contractual obligations. It is worth mentioning that ANP Resolution 47/2012 and ANP Technical Regulation No. 07/2012 had already established the rules, conditions and technical requirements for the accreditation of ICTs eligible to participate in projects financed with the resources foreseen in the RD&I Clause.

The Agency reports that from 1998 to 2015 the mandatory investments in RD&I related to the concession contracts of the oil companies amounted to R $ 11.2 billion, of which R $ 10.6 billion was invested by Petrobras, representing 95% of the total (ANP, 2016). The company accounts for the great majority of contracts, technological cooperation partnerships and mainly of agreements signed with Brazilian universities. Thus, in this article, the topic of technological cooperation is treated from the perspective of Petrobras' management of a cooperative Research and Development (R&D) project with two Brazilian universities and a national medium-sized supplier. This project is part of the S&T-Industry Integration Network in the National Productive Process (RICT), one of the thematic networks that were created by Petrobras in 2006 to facilitate the application of the obligatory resources. After this brief introduction, section two presents the methodology adopted, section three reviews the literature on the topic, section four addresses the case mentioned, section five goes on the final considerations and then the bibliographical references used.

2. METHODOLOGY

This article is based on a thematic research of applied nature with exploratory purpose. The selected method was a case study, which brings together multiple sources of evidence, both quantitative and qualitative. Although not aimed at statistical generalizations, this method allows analytical generalizations that can reveal universal truths, since no case is completely independent of the social context in which it is found. It also allows to clarify the decisions of the actors involved, the reasons why these are taken and executed and if their results are achieved (Yin, 2010). Although characterized as a single case study for having Petrobras as a company representative of the sector and coordinator of the RICT, other analysis units were contemplated, such as two universities and a supplier company.

The study used indirect documentation techniques, such as bibliographical and documentary research and also intensive direct processes, based on observation and interviews. We combined participant and systematic observation with informal, focused, peer-to-peer interviews with professionals involved in cooperative R&D activities in the three organizations (Gil, 2011; Marconi et Lakatos, 2012). It is worth mentioning that the active, direct and systematic observation of the facts and the use of different types of interviews - which have different levels of structuring - allowed the authors to quickly access private data and information and the clarifications needed to follow the observed subjects, and capture their opinions and perceptions (Gil, 2011). In fact, observational evidence and interviews are the main sources of case studies (Yin, 2010).

3. INNOVATION SYSTEMS, ACADEMIA-INDUSTRY INTERACTIONS AND OPEN INNOVATION

Unlike the invention, which has a technical character, innovation encompasses technical, economic and business aspects, challenging philosophers, historians, sociologists and economists to understand the relationships that link the production of technical-scientific knowledge to the productive system. The advances in the understanding of the meaning of innovation occurred after a number of empirical studies were conducted in developed countries in the late 1960s by economists of the Schumpeterian tradition, distancing themselves from simplistic views of technology as an artifact and innovation as a linear process (Kline, 1985; Kline et Rosenberg, 1986; Stokes, 1997). The literature on innovation systems emerged in the 1980s from the concept of the National Innovation System (SNI) as a set of actors, networks and institutions and their interactions, which affects and contributes to the development of a country's capacity for innovation and learning.

SNI's strict vision approaches the concept of an S&T system, considering only the institutions that directly affect the capabilities and innovative strategies of the companies and has Nelson as main representative (1992, 1993). Investments in R&D undertaken by nationally-based companies are critical and driven by government policies, with the technical-scientific educational structure as a prominent base. This includes universities, institutes and public research laboratories, especially in the fields of science and engineering. Another highlight is the cooperation between universities and companies for the creation of technological communities.

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

The complex linking between science and technology is a key feature of SNI as pointed out by Nelson (1992), but most innovation efforts are made in firms by combining internal and external sources of information, which requires learning skills and capabilities (Cohen et Levinthal, 1990). R&D areas are the gateway to technological learning and innovation processes (Cohen et Levinthal, 1989). Companies still need to build and accumulate technological training (Bell et Pavitt, 1993) and identify their dynamic capabilities, that is, those that leverage innovations (Teece et al., 1997). Thus, the countries' structural learning capacity depends fundamentally on firms, universities, institutes and public research laboratories (Meyer-Krahmer et Schmoch, 1998). In the case of developing countries, this is an essential condition for the catching-up processes or for reducing the disparities regarding developed countries (Mazzoleni et Nelson, 2007).

Freeman (1987, 1995) and Lundvall (1988, 1992) provide a broader view, establishing SNI as a network of public and private innovation support institutions that involves explicit and tacit knowledge and formal and informal relationships, in addition to incentive and appropriation systems, labor relations and government policies and institutions. These authors emphasize dynamics, interactivity and learning inside SNI. As knowledge became a strategic resource, learning gained relevance (Lundvall, 1992). Intangible assets also become increasingly important (Foray, 2004).

Learning should be understood as a process of obtaining different types of knowledge, skills and training, which does not mean the same as acquiring information. The institutional framework and production structure directly affect the relationship between producers and users, which, in turn, influence the scope and direction of technological innovations. As companies depend on external sources for the acquisition of information, knowledge, and technical, scientific and organizational skills, they interact with governments, universities, research institutes and laboratories and also with other companies and organizations to generate innovations (Hippel, 1988).

The closer the academy is to the productive sector, the more adherent the professional qualification and technological cooperation will be to its needs. These interactions need to be stimulated, although they can not be generalized, since research of broad social and long-term interest needs to be maintained in universities (Lundvall, 2002, 2007). Besides, the need for bonding of academia and industry is restricted to certain disciplines, technologies, sectors and companies.

Nelson (1990) and Pavitt (1998) highlight the disciplinary specificities in the field of engineering. The first asserts that, in general, academic research generates inventions or pilot versions of projects that the industry will later develop and commercialize, as in the case of construction and testing of new design devices. For the second, academic research increases the capacity of industrial research to solve complex problems through the following channels and mechanisms: useful new knowledge; Engineering design tools and techniques; instrumentation; training of scientists and engineers; contextualization of knowledge; insertion in national and international professional networks; and spin-offs.

Brooks (1994) points out the variety of interactions according to the field of technology considered, and Pavitt (1991) adds the influence of the era of new technologies to the convergence between universities and companies. The transfer of knowledge occurs indirectly through skills, methods and instruments and the most important is the provision of trained personnel in research with the possibility of working in applied activities. As knowledge is embodied in people, the need for personal interaction, movement and participation in networks at national and international level becomes relevant to stimulate its diffusion. This tacit dimension of knowledge is central to the learning processes and its nature is localized both geographically and linguistically (Pavitt 1998; Polanyi, 1958, 1966).

Pavitt (1984) categorized the sector specificities, indicating the prominence of R&D activities in intense and science-based and scale-intensive sectors. In the first case, large companies predominate and their technological trajectories are strongly conditioned by scientific advances, facts that highlight the role of engineering areas and their interactions with universities, as in the pharmaceutical, chemical and electronic sectors. In the second case, where large firms also dominate, their innovations are introduced from projects and from the creation and operation of complex production systems, as in the oil sector, although the deep and ultra deepwater exploration and production segment have reached the innovation level of other science sectors (Morais, 2013).

Santoro and Chakrabarti (2002) highlight the influence of the size, structure and proficiency to build competencies and solving problems of the companies in the search for relationships with universities, such as research support, cooperative research, and knowledge or technology transfer. In addition to the supply of graduates in sufficient quantity and quality, universities also contribute in exposing companies to new ideas. As Nelson points out (1990), the university is the locus of scientific-technological public knowledge, and provides to the industry the technical personnel and ideas focused on process and product innovation.

Laursen and Salter (2004) add that the size of firms, the amount they spend on R&D and the adoption of the open innovation strategy are associated with the use of universities as external sources, which makes their direct contribution to industry highly focused in a small number of sectors

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

and companies. According to Hippel (1988) and Chesbrough (2003, 2006), the use of a wide range of external sources and agents expands technological opportunities and accelerates the pace of innovation generation, which is particularly relevant in the oil industry, in the exploration and production segment and also in the Brazilian context, which marked by the challenges of the new pre-salt technological paradigm. It is worth mentioning that Petrobras adopts this strategy, practicing technological cooperation with multiple partners (Alonso et al., 2007; Ferreira, 2015; Ramos, 2014; Ramos et Ferreira, 2014). Relationships with universities differ from relationships with producers/suppliers and users/customers, and thus deal with different management styles (Du et al., 2014).

As Lundvall (2002) argues, the public research system plays a relevant role in the development of new standards and scientific instrumentation, as well as in the training of student and graduate problem solving skills. Faulkner et Senker (1994) also emphasize the contribution of university and government laboratories through their experience and the characteristics of technology and the sectoral configuration, the latter being observed based on the size of the companies, their accumulated technological capabilities, their innovation characteristics and their propensity to interact.

According to Salter et Martin (2001), academic research is of high importance in sectors strongly based on basic and applied research, such as the petroleum industry. They also highlight the importance of knowledge spillovers, derived from the geographical proximity between universities and companies, as also addressed by Breschi et Lissoni (2001). Moreover, besides it facilitates the exchange of information, knowledge and technology among the researchers involved, the informal channels and trust relationships based on personal and continuous interactions also favor the adjustment of expectations and motivations and positive attitudes towards the cooperative work, supporting the narrowing of relationships. When knowledge is of a less complex nature and more subject to coding, geographic proximity is less relevant than when knowledge is more complex and of an eminently tacit nature (Arundel et Geuna, 2004). In addition, there are other dimensions of proximity that facilitate such spillovers, such as organizational, technological, industrial, social, cultural, cognitive, institutional and behavioral (Boschma, 2005).

It should be noted that the boundaries between formal and informal channels are not always clear and that universities and companies are organizations with distinct missions and work orientations, as a reflection of cultures in which different approaches to confidentiality, intellectual property rights and management styles prevail, which means different motivations to cooperate and attitudes towards this cooperation. More than reaching immediate results, technological cooperation provides new learning opportunities for each of the organizations, bringing them benefits on the longer term (Cyert et Goodman, 1997; Katz et Martin, 1997). Although universities do not contribute equally to the technological progress of the industrial sectors, they are the most important source of technological opportunities (Klevorick et al., 1995).

Challenges emerge, however, when long-term academic benefits need to adjust to the short-term needs of companies for common projects. Divergences may hinder the smooth progress of cooperation, generating deviations from agreed objectives and outcomes and undesirable impacts on both sides. For universities, traditionally, the results relate to new contents, curricula and teaching methodologies, as well as new research agendas. For companies, the results involve new processes, products and organizational practices. The question of the appropriation of the generated knowledge is sensitive and has relevant potential to generate conflicts. Effects, in turn, have a less tangible nature than the results, meaning the new opportunities opened by cooperation for each of the organizations (Perkmann et al., 2011). The results and benefits or effects arise from the interaction of multiple factors (Barnes et al., 2002; Mora-Valentin et al., 2004).

The availability of different types of resources, in addition to the qualification and motivation of the researchers involved, are critical elements for the success of technological cooperation, although this depends also on organizational incentives (D'Este et Perkmann, 2011). And here is the reason why the management of the cooperation process to ensure its stability and continuity becomes critical, requiring multiple channels of interaction (Cohen et al., 2002; D'Este and Patel, 2007). It is about reducing the possibilities of conflicts and stimulating common learning in each organization, which does not always lead to the appropriation and commercialization of the generated knowledge. In other words, it is about minimizing the chances of negative effects and continually seeking positive impacts for both sides, which are often subtle and long-term. Overcoming barriers and obstacles requires close and cooperative links (Bruneel et al., 2010; D'Este et Perkmann, 2011).

Carlsson (2006) points out that in addition to the national dimension, innovation systems can be analyzed in three complementary fields, such as technological, sectoral and regional, turning in this case to specific geographical areas, both supranational and subnational fields. The sectoral dimension is an excellent tool of analysis, taking into account all other dimensions of innovation systems, in order to understand the innovative processes that occur within its borders. Although Patel and Pavitt (1994) characterize the Brazilian innovation system as incomplete due to the small size of the technological infrastructure and its low articulation

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

with the companies, the oil sector represents exactly the opposite of this perspective due to the use of this infrastructure and the developed networks, comprising an interesting case study (Ferreira, 2015; Garcia et al., 2011; Ramos, 2014; Ramos et Ferreira, 2014; Righi et Rapini, 2011; Turchi et De Negri, 2013).

As defined by Malerba (2002), a sectorial system of innovation and production involves a set of existing and new products for specific uses and actors or agents that operate inside and outside the market for the creation, production and sale of these products. This system has a base of knowledge, technologies and inputs, in addition to existing, emerging and potential demand and includes the following actors: individuals (scientists, businessmen and consumers); companies (suppliers of materials, producers and users, in addition to their specific areas such as R&D, marketing and production); organizations (universities, government and financial agencies, trade unions and technical associations); and groups of organizations (industrial associations).

Although the scientific advances contribute significantly to the technological development, the latter is specific to the industries and the companies that select, from the different sources of information, the relevant knowledge and technologies of internal and external origin, according to the characteristics of the technology itself, of production scales and of the technological strategies adopted, these latter aligned with companies' corporate strategies. As stated by Tigre (2014), the activity sector and its competitive standards explain the technological environments in which the companies operate, since they have particular structural characteristics, an aspect highlighted by Malerba (2003) when referring to the knowledge and sectoral technological domain. The heterogeneity of the actors and the learning processes in networks represent the interaction mechanisms shaped by the institutions.

Tigre (2014) also points to the formation of R&D networks as a global trend, due to the high costs of these activities associated with greater scientific and technological interdependence and complexity, technological convergence and the need to reconcile products and services with existing technological standards. The interactions between universities and companies tend to become fundamental, given the complementary characteristic of these organizations. In fact, technological cooperation focused on the identification and processing of relevant information and the strengthening of innovative capabilities through the aggregation of complementary skills and qualifications is of particular importance in the dynamic environment of the oil industry, making it a viable option for large companies such as Petrobras.

Morais (2013) adds that oil companies around the world have set up R&D centers and have become associated with universities, public research institutes and laboratories and other companies in order to enable the generation of new scientific and technological knowledge as differentiated systems, equipment and services have become necessary for exploration and production in ever deeper waters. These technological cooperation agreements have led to the generation of process and product innovations essential to the advance in deep and ultradeep waters and also to the refining and processing of oil for the production of fuels and derivatives. As we will discuss below, Petrobras followed the international trend, being a successful case of absorption capacity and technological accumulation through knowledge networks (Dantas et Bell, 2009, 2011; Ramos, 2014; Ramos Et Ferreira, 2014).

4. MULTI-PARTNER TECHNOLOGICAL COOPERATION: A CASE OF SUCCESS IN PETROBRAS THEMATIC NETWORKS

Petrobras was critical in establishing and developing the Brazilian oil industry, having achieved international respect as an integrated energy company operating in the fields of exploration and production, refining, commercialization, transportation, petrochemical, derivatives, natural gas, electricity, gas-chemistry and biofuels. Throughout its evolution towards excellence, the company has always had external technological partners. As technological challenges are becoming more and more complex, the need to overcome them through cooperative research has intensified, involving a wide and varied spectrum of disciplines, ICT and partner companies (Dantas et Bell, 2009, 2011; Ferreira, 2015; Morais, 2013; Turchi et al., 2013).

Petrobras' technological cooperation with national ICTs - especially universities - plays a prominent role in this context, which is why the company created, in 2006, the thematic networks, which constitute a new channel for the application of resources from the R&D Clause based on knowledge networks (Ferreira, 2015, Mendonça et Oliveira, 2013, Ramos, 2014, Ramos et Ferreira, 2014, Ramos et al., 2013). They emerged in the context of the company's technological direction from the foci or themes generated, guiding technological projects and programs. The company invested US $ 132 million in R&D in 2001, US $ 730 million in 2006 and US $ 989 million in 2010, investing US $ 1.1 billion in 2014 and becoming one of the largest R&D investors in the energy sector in the world (Petrobras, 2014).

The R & D Clause created in 2005 provided investments in projects and programs of basic, applied and experimental research in the construction and installation of prototypes and pilot units and in technological services. In addition, it comprised expenditures subject to the prior authorization of the ANP, with training of human resources, technological

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

management of projects and programs, implementation of laboratory infrastructure and hiring of associated personnel, and also with R&D projects and programs. The updating of the R&D Clause that occurred in 2015 - now called the RD&I Clause - expanded the possibilities of applying the mandatory resources, while also expanded the ANP's activities through the creation of the Technical-Scientific Committee (COMTEC). It became responsible of deliberating on the application of these resources in the cases of induction of demand through notices or invitations addressed to ICT, oil companies and other Brazilian companies, or through orders linked to structuring projects and programs (ANP Resolution 50/2015 and ANP Technical Regulation nº 3/2015).

As Ferreira (2015) points out, Petrobras created the thematic networks aiming at integrating multiple competencies, exploring technological opportunities and complying with the R&D Clause. They have a minimum of approximately five universities involved, which means heterogeneous environments, i.e., with different visions, competencies and infrastructure conditions, although the teams focus on the same theme. In that year there were 36 thematic networks and today there are 49 of them involving more than 100 ICT distributed in the following areas: exploration (6); Production (17); Supply (15); Natural gas, energy and sustainable development (9); And technological management (2). Thus, universities and some research institutes of recognized excellence distributed throughout the national territory have gathered around interdisciplinary themes of strategic interest to the company. Through this technological management model, Petrobras has been establishing several networks with Brazilian universities, not only for the execution of R&D projects, but also to make feasible investments in laboratory infrastructure, when necessary.

4.1. The Thematic Network for S&T-Industry Integration in the National Productive Process (RICT)

As shown by Ramos et al. (2013), Ramos (2014), Ramos et Ferreira (2014) and Ferreira (2015), among the several existing thematic networks, only one stands out as having the goal of fostering integration between ICT and companies that supply the petroleum chain since its inception and for not being under the direct management of the Research and Development Center Leopoldo Américo Miguez de Mello (Cenpes) - body responsible for the Petrobras technological system. This is the RICT that recruits, in addition to the ICTs, national companies or consortium of companies in R&D projects that involve equipment, products and services aimed at substitution of imports and the development of infrastructure and human resources. The integration between these agents becomes more complex than in the other thematic networks, since the generation of innovative engineering technologies and solutions needs to support local companies and promote the training of human resources, thus contributing to the increase of Local content and the competitiveness of the supplier companies in the sector.

It is worth mentioning that in the RICT, as in the other thematic networks, investments in ICT laboratory infrastructure can be made feasible, provided that Petrobras understands that they are necessary for technological research. However, such investments must undergo prior evaluation by the ANP, which may or may not grant the authorization, so that they are accounted for as required under the R&D Clause. Research in the petroleum sector is highly dependent on high-level laboratory infrastructure, especially when taking into account the uncertainties of the new pre-salt technological paradigm, which increase the risks and costs of the innovative process (Ferreira, 2015). It is also worth mentioning that the ANP is responsible for evaluating whether the resources applied by Petrobras in the technological projects are, in fact, spent on R&D. So far, the definition of research themes and technological partners has been carried out by Petrobras. Figure 1 below shows the governance model of technological cooperation within the RICT.

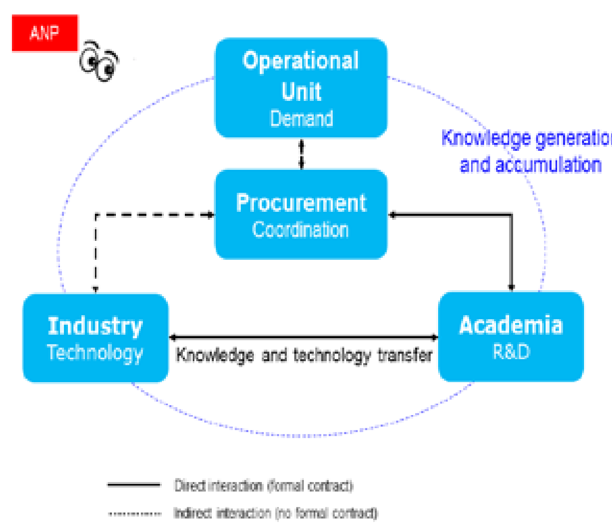

Figure 1. Governance model of technological cooperation in the framework of the RICT

Source: Ramos et Ferreira (2014)

The interviewees at Petrobras pointed out that the projects that make up the RICT portfolio have the following characteristics: they meet demands from the company's operating units; Are heavily dependent on scientific-technological frontier knowledge; Are necessary for the development of other projects, such as laboratory infrastructure; And can only be carried out in partnership with national supplier companies. Project and manufacturing detailing skills gain relevancy as well as the relational skills of project managers. In fact, establishing criteria, rules and procedures that align

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

the portfolio of projects with the business model is one of the critical factors for corporate success, since it incorporates the logic of creation, delivery and value capture, establishing the link between Technology and strategy, that is, between technological development and the creation of economic value (Chesbrough, 2003, 2006, Siqueira et al., 2015).

4. 2. The Scope of the Cooperative R&D Project

The RICT's portfolio of technological projects includes an emblematic and successful case of a cooperative R&D project with two Brazilian universities and a medium-sized local supplier (Ramos et al., 2014; Ramos et al., 2013). This multi-partner alliance began in 2008 with an expected duration of two years and estimated extension of further two years. The partner ICTs were the University of the State of Rio de Janeiro (UERJ) and the Federal University of Rio Grande do Sul (UFRGS) and the supplier company was Coester Automação Ltda., which has been operating in the Brazilian market for more than 50 years and currently offers solutions for automation of valves and transport systems. The project was about researching and developing innovative technologies for a valve control system with wireless communication, training skilled labor, and modernizing academic laboratories for conducting research, projects, and testing.

Based on this project, Ramos (2014) showed the applicability of the performance evaluation model of technological cooperation between academia and industry suggested by Perkmann et al. (2011). However, this article intends to highlight the RICT as a consistent tool to foster technological innovation and human resource training, integrating the interests of the public research sector represented by the universities (UERJ and UFRGS), the producer / supplier (Coester) and the user (Petrobras), as shown in Figure 1. The importance of interactions between producers and users was highlighted by Lundvall (1988, 1992) and Hippel (1988). In addition, the systemic model of innovation, with its multiple and complex interactions and feedbacks of knowledge flows in the various stages of the production chain, emphasizes the need for new forms of internal and external integration of companies when seeking sources of information (Kline et Rosenberg, 1986; Rothwell, 1994).

We expected that RICT could offer Petrobras and its suppliers not only tangible results in terms of innovative processes and products, but would also function as an efficient and effective mechanism to stimulate the cooperative attitude among the actors, generating mutual benefits. This intangible dimension of cooperation has remained one of the main challenges of R&D projects in the RICT portfolio, precisely because of the institutional heterogeneity involved when it is intended to unite scientific and technological partners with market partners. The learning processes and the mechanisms of interaction require different management styles (Du et al., 2014; Malerba, 2002, 2003).

The project in question originated from the request of a Petrobras operating unit sent to the Market Development Management responsible for the strategic development of the supplier market belonging to the corporate supply agency, the Executive Management of Materials. It was found during the kick-off of the project that there was no commercially available wireless communication protocol for field networks approved to operate in industrial plants in accordance with the strict performance and safety requirements of the oil industry. The technological demand would then correspond to an R&D project aimed at the generation of a technological solution of industrial communication networks to be coupled to intelligent electric actuators, even if they were already available in the market.

This pilot network of electrical actuators with wireless communication would be installed in an industrial plant of Petrobras in substitution of manual actuators of on/off valves. It is worth mentioning that electric actuators are responsible for the actuation of valves (opening or closing) that control the flow of oil and by-products in processing plants or outflow ducts. The challenge would be to develop a wireless communication system to drive industrial valves capable of generating savings in cabling installation and the possibility of installing the equipment in difficult access locations in refineries, land terminals and platforms, i.e., in several different industrial plants.

The initial stage of negotiation of the project coincided with the creation of the RICT, which had the necessary financial resources to support the desired technological development. According to the ANP requirement, the resources of the R&D Clause should be spent on ICT and, thus, two universities with experienced research groups in the industrial automation area were selected to conduct the R&D project. The inclusion of academic research groups has become convenient, not only because of compliance with the R&D Clause, but especially because of the need to conduct research on previously disruptive technologies. As discussed in the literature, the petroleum sector is strongly based on basic and applied research, or in other words, it requires personnel trained in research with the possibility of working in applied activities. Figure 2 below illustrates the governance structure of technological cooperation highlighting the actors involved in the R&D project and their links.

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

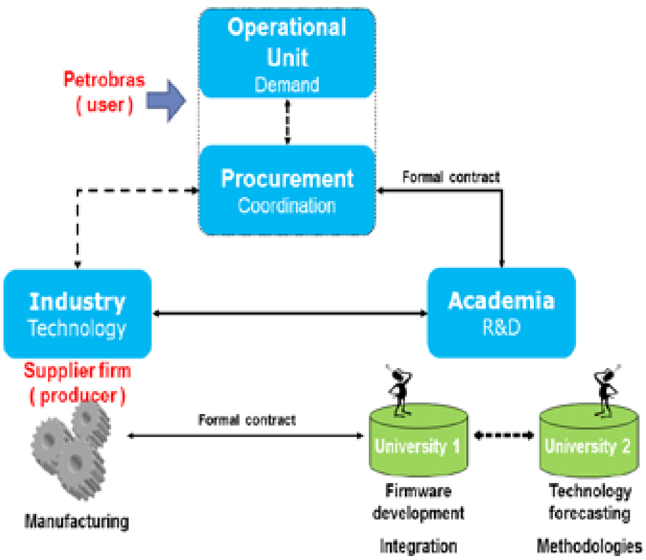

Figure 2. Governance structure of technological cooperation within the RICT
Source: Ramos et Ferreira (2014)

It is relevant to add that one of the universities was responsible for developing the firmware and integrating it with the actuator hardware, cooperating in a direct and intense way with the supplier company. The other university was in charge of the technological prospection and the development of methodologies for the integration of wireless industrial networks. However, both were in charge of carrying out the training of personnel, both of Petrobras and Coester. Some of the activities carried out by the universities were related, which led to the creation of common events that were organized, either autonomously by them, that is, without the intermediation of the project manager at Petrobras, but also under manager's direct action. In this case, Petrobras manager was responsible for stimulating interaction among the actors from meetings and workshops to discuss technical topics, including decision-making related to the definition of technological routes, such as the choice of the wireless communication protocol to be adopted.

4. 3. The Results and Impacts of the Cooperative R&D Project

Several results were achieved during the course of the project and as a result of it, considering the aggregate quantitative data of the partners, as follows: more than 40 articles and scientific papers in peer-reviewed journals and conferences; 10 master graduates in science and engineering in the area of wireless industrial networks; 03 PhDs in science and engineering in the field of wireless industrial networks; 03 ideas for new R&D projects; 07 new concepts/solutions between direct project results and spin-offs related to hardware and software; 01 innovation in the form of copyright of computer program registered in the National Institute of Industrial Property (INPI) corresponding to firmware (implementation of wireless protocol stack); 01 student-researcher involved in the project contracted by Petrobras; And 01 technology-based company created by one of the researchers directly involved in the project (spin-off).

A sensitive aspect pointed out in the literature and highlighted by the authors concerns the appropriation of the knowledge generated in the scope of technological cooperation (Ferreira, 2015, Ramos, 2014; Ramos et Ferreira, 2014). The level of flexibility regarding publications and intellectual property rights that involve patenting, commercialization and licensing of technologies is relevant and the project manager adequately contemplated this aspect, contributing to the maintenance of the motivation and the engagement of academic researchers, as suggested by the literature. Due to the large number of articles published by dissertations and theses, it is important not to prohibit ex-ante publications in scientific journals that are so important to these researchers. In fact, project managers need to be flexible in analyzing and evaluating what should be considered proprietary content or not. In the case in question, many publications were generated even before the application for copyright of the firmware developed by the researchers, which was later granted by INPI.

The continuous use of internal and external sources of information to feed the innovative process also deserves a mention, having been a hallmark feature in all phases of the project (research, development, manufacturing and testing). As pointed out by Chesbrough (2003, 2006), the use of multiple sources and external actors broadens the spectrum of technological opportunities and accelerates the pace of innovation generation. Figure 3 below shows a simplified version of the open innovation model proposed by the author, which represents the development process of the valve control system with wireless communication. In all phases of technological cooperation there was a joint participation of the actors involved and even the contribution of external actors, that is, those without direct contractual link, as providers of technologies essential for the testing stage and those involved in the generation of the communication gateway. Once the testing and evaluations stages were over, the new wireless communication system developed in the scope of technological cooperation was already installed in the Petrobras operating unit, thus meeting the internal technological demand that gave rise to the project.

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

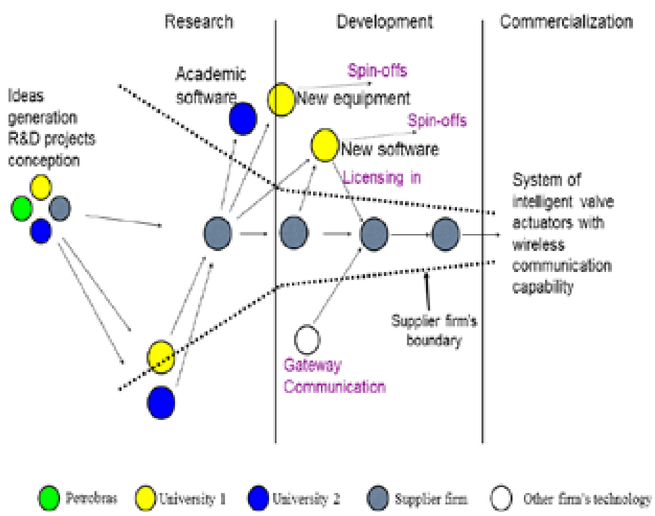

Figure 3. Product research and development according to open innovation model
Source: Ramos et Ferreira (2014)

In this cooperative R&D project, the interactions generated positive results and impacts for each of the actors, opening new opportunities for learning (Cyert et Goodman, 1997; Katz et Martin, 1997). More qualified scientists and engineers became available to be hired by Petrobras, Coester and other companies; Master's and PhD guidelines paved the way for new scientific publications and research agendas, and new ideas, concepts, and solutions emerged. It is also worth mentioning the computer program copyrights, which could result in economic returns in the form of royalties for the universities and for Petrobras (and eventually for individual researchers) after the commercialization of the technological solution begin. We stress the importance of the flexible management of intellectual property over the scientific-technological knowledge generated in the scope of cooperation due to the uncertainty inherent in the innovative process (Freeman et Soete, 1997).

Given the complexity of interactions and the diversity of information sources for innovation involved in the R&D process, identifying the determinants of the results achieved, the relative weights of their contributions, and the positive benefits or impacts generated is challenging task. Nevertheless, some inferences can be made regarding the latter, such as:

- without the active participation of the user (Petrobras), it is most likely that the producer/supplier (Coester) would not have reached the product with the characteristics and functionalities required for application in industrial plants, or in other words, this could have been a winding road; According to Lundvall (1988, 1992), there are advantages and challenges in the interactions between producers and users from SNI perspective;

- without a flexible management of the cooperative R&D project in relation to the publication of scientific articles, it is very likely that academic researchers would lose interest in the project activities and decrease their engagement, as pointed out by D'Este et Perkmann (2011) and Du Et al. (2014).

- if the producer/supplier (Coester) did not have any investments in internal R&D and the ability to deal with externally rooted partners, it would most likely have difficulty in interacting with the university to absorb the knowledge generated during the applied research stage, a fact supported by the work of Cohen et Levinthal (1989, 1990);

- If the user (Petrobras) had not maintained a patient, flexible and realistic attitude regarding the challenges inherent to the innovative process in the scope of cooperation with multiple partners, the cooperative R&D project could have been canceled in the initiation stage due to the low interest in its continuity; the aspects related to flexibility in management and understanding of institutional differences are addressed by Cyert et Goodman (1997), Du et al. (2014), Ferreira (2015), Ramos (2014) and Ramos et Ferreira (2014).

Most of the results obtained represent intangible assets whose valuation is not trivial and whose public policy implications are not well understood (Lev, 2001). The benefits or impacts generated are also difficult to quantify (Perkmann et al., 2011). These aspects require specific treatment by practitioners and policymakers, since, in the knowledge and learning economy, intangible assets are increasingly embedded in products, brands, intellectual property, people, labor relations, Knowledge and organizational alliances (Foray, 2004; Lundvall, 2002).

In fact, would the result of a cooperative R & D project like the one described above only have value in generating a new technology or equipment for the industry? How much is a master or doctor in science and engineering worth? How much is the knowledge revealed in a master's thesis, doctoral thesis or scientific publication worth? Answering these questions is a significant challenge, both in academic and corporate settings, as well as in public policies (Lev, 2001; Perkmann et al., 2011). Furthermore, how should universities manage the cooperation of their research groups with industry, especially given its public nature? How is the management of technological projects carried out at the university level? It is worth considering - as mentioned by Pavitt (1984) and illustrated by Tigre et Noronha (2013) - that the electronics sector is highly intensive in knowledge and benefits from the progress of science and public investment, as proven in the cases of Korea and Taiwan (Mazzoleni et Nelson, 2007).

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

Thus, it is imperative that both universities and companies be able to manage their formal and informal channels of interaction more and more effectively. As discussed in the literature review, academia-industry interactions are especially relevant in science-based and scale-intensive sectors that are heavily dependent on scientific advancement as a source of information for innovation. In the petroleum sector, the creation of a teaching and research environment in knowledge border was one of the main benefits of the R&D Clause and multi-partner technological cooperation. In addition, the expansion of interactions between them contributes to the strengthening of the Brazilian innovation system. In fact, the understanding of the relationships that link the production of technical-scientific knowledge to the productive system has been increasing and becoming increasingly important for the development of technologies, sectors, regions and countries (Ferreira, 2015).

5. FINAL CONSIDERATIONS

The topic of technological cooperation is central to the literature on innovation and was treated from the perspective of Petrobras' management of a cooperative R&D project with two Brazilian universities and a medium-sized national supplier within the scope of the S&T-Industry Innovation Network in the National Productive System (RICT). The article aimed to highlight the relevance of the knowledge networks between the academy and the productive sector for compliance with the RD&I Clause present in the concession contracts, production sharing and onerous assignment regulated by the National Agency of Petroleum, Natural Gas and Biofuels (ANP). In line with the open innovation model adopted by Petrobras, RICT was one of the thematic networks created to enable technological cooperation with external partners based on demands from operational units involving scientific-technological high knowledge and, at the same time, increase the index of local technological content of products, systems and services.

Access to external sources of information, knowledge and technology lies at the heart of the new technological strategies of large companies that seek to expand their market share or create new markets based on technological leadership in their sectors and segments. Thus, companies that adopt the model of open innovation such as Petrobras - as opposed to the models of closed innovation - seek to take advantage of the synergies between the stock of external and internal knowledge, betting on the formation of networks with a view to reducing the complexity, risks and costs of innovative processes. The premise is that external R&D activities can generate significant economic value, while internal activities remain relevant to ensure the realization of this value.

Evidence from the cooperative multi-partner R&D project analyzed suggests that the continuous interactions established were essential for the good performance of the innovative process involving products of high intensity in scientific knowledge, since the technological solution generated integrated different fields such as industrial networks, automation and mechanics. The prior experience of academic research groups and the learning processes generated by effective interactions were crucial to partner performance. The results and impacts obtained show the importance of interactions between universities, the producer and the user for innovative performance, when appropriate analytical criteria are adopted in relation to the technology to be developed, the choice of partners, the governance of cooperation and management of projects.

The cooperative work of individuals with a view to the generation of new scientific and technological knowledge can give rise to future innovations, spillovers and spin-offs, proving to be fertile in applied fields such as engineering, which responds directly to the problems generated by practical experience. As discussed in the literature review and in the case study, academia-industry interactions still obey technological, sectoral and entrepreneurial specificities. Even so, universities are the most important source of technological opportunities. The management of the innovation process is a critical element, since the good progress of cooperation depends on the adjustment of expectations, motivations, goals and results, in order to generate positive benefits or impacts for each of the actors. The willingness to cooperate precedes the common search for consensus towards the effective cooperation and the commitment of the partners is fundamental so that the results and expected benefits are reached, as we aimed to demonstrate in this article.

REFERENCES

Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP). (2016), Boletim ANP Petróleo e P&D nº 30 [Boletim], ANP, Rio de Janeiro, RJ, disponível em: www.anp.gov.br/Pesquisa e Desenvolvimento/Boletim Petróleo e P&D (Acesso em 10 de março de 2016).

Alonso, P. S. R., Rovina, P. S., Martins, R. M. L. (2007), "Turning innovative ideas into commercial equipment: the approach at Petrobras", paper presented at the OTC 2007: Offshore Technology Conference, Houston, Texas, US, 30 April-3 May 2007.

Arundel, A. et Geuna, A. (2004), "Proximity and the use of public science by innovative european firms", Economics of Innovation and New Technology, Vol. 13, No. 6, pp. 559-580.

Barnes, T., Pashby, I., Gibbons, A. (2002), "Effective university--industry interaction: a multi-case evaluation of collaborative R&D projects", European Management Journal, Vol. 20, No. 3, pp. 272-285.

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

Bell M. et Pavitt, K. (1993), "Technological accumulation and industrial growth: contrasts between developed and developing countries", Industrial and Corporate Change, Vol. 2, No 2, pp. 157-210.

Boschma, R. (2005), "proximity and innovation: a critical assessment", Regional Studies, Vol. 39, No. 1, pp. 61-74.

Breschi, S. et Lissoni, F. (2001), "Knowledge spillovers and local innovations systems: a critical survey", Industrial and Corporate Change, Vol. 10, No. 4, pp. 975-1005.

Brooks, H. (1994), "The relationship between science and technology", Research Policy, Vol. 23, No. 5, pp. 477-486.

Bruneel, J.; D'este, P., Salter, A. (2010), "Investigating the factors that diminish the barriers to university-industry collaboration", Research Policy, Vol. 39, No. 7, pp. 858-868.

Carlsson, B. (2006), "Internationalization of innovation systems: a survey of the literature", Research Policy, Vol. 35, No. 1, pp. 56-67.

Chesbrough, H. W. (2003), Open innovation: the new imperative for creating and profiting from technology, Harvard Business School Press, Cambridge, US.

Chesbrough, H. W. (2006), Open business models: how to thrive in the new innovation landscape, Harvard Business School Press, Cambridge, US.

Cohen, W. M. et Levinthal, D. A. (1989), "Innovating and learning: the two faces of R&D", Economic Journal, Vol. 99, No. 397, pp. 569-596.

Cohen, W. M. et Levinthal, D. A. (1990), "Absorptive capacity: a new perspective on learning and innovation", Administrative Science Quarterly, Vol. 35, No. 1, pp. 128-152.

Cohen, W. M.; Nelson, R. R., Walsh, J. (2002), "Links and impacts: the influence of public research on industrial R&D", Management Science, Vol. 48, No. 1, pp. 1-23.

Cyert, R. M. et Goodman, P. S. (1997), "Creating effective university-industry alliances: an organizational learning perspective", Organizational Dynamics, Vol. 25, No.4, pp. 45-57.

Dantas, E. et Bell, M. (2009), "Latecomer firms and the emergence and development of knowledge networks: the case of Petrobras in Brazil", Research Policy, Vol. 38, No. 5, pp. 829-844.

Dantas, E. et Bell, M. (2011), "The co-evolution of firm-centered knowledge networks and capabilities in late industrializing countries: the case of Petrobras in the offshore oil innovation system in Brazil", World Development, Vol. 39, No. 9, pp. 1570-1591.

D'Este, P. et Patel, P. (2007), "University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?", Research Policy, Vol. 36, No. 9, pp. 1295-1313.

D'Este, P. et Perkmann, M. (2011), "Why do academics engage with industry? The entrepreneurial university and individual motivations", The Journal of Technolology Transfer, Vol. 36, No. 3, pp. 316-339.

Du, J.; Leten, B. et Vanhaverbeke, W. (2014), "Managing open innovation projects with science-based and market-based partners", Research Policy, Vol. 43, No. 5, pp. 828-840.

Faulkner, W. et Senker, J. (1994), "Making sense of diversity: public-private sector research linkage in three technologies", Research Policy, Vol. 23, No. 6, pp. 673-695.

Ferreira, M. L. A. (2015), Formação e capacitação em engenharia no setor de petróleo: a cooperação entre ANP, Petrobras e universidades do estado do Rio de Janeiro, Tese de Doutorado em Políticas Públicas, Estratégias e Desenvolvimento, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ.

Foray, D. (2004), The economics of knowledge, The MIT Press, Cambridge, US.

Freeman, C. (1987), Technology policy and economic performance: lessons from Japan, Pinter Publishers, London, UK.

Freeman, C. (1995), "The National System of Innovation in historical perspective", Cambridge Journal of Economics, Vol. 19, No. 1, pp. 5-24.

Freeman, C. et Soete, L. (1997), The economics of industrial innovation, third ed., The MIT Press, Cambridge, US.

Garcia, R., Araújo, V. C., Mascarini, S., Santos, E. G. (2011), "Os efeitos da proximidade geográfica para o estímulo da interação universidade-empresa", Revista de Economia, Vol. 37, No. 4, pp. 307-329.

Gil, A. C. (2011), Métodos e técnicas de pesquisa social, 6. ed., Atlas, São Paulo, SP.

Hippel, E. von (1988). The sources of innovation. Oxford University Press, New York, US.

Katz, J, S. et Martin, B. R. (1997), "What is research collaboration?", Research Policy, Vol. 26, No. 1, pp. 1-18.

Klevorick A. K, Levin, R. C., Nelson. R. R., Winter, S. G. (1995), "On sources and significance of interindustry differences in technological opportunities", Research Policy, Vol. 24, No. 2, pp. 185-205.

Kline, S. J. (1985), "Innovation is not a linear process", Research Managemen, Vol. 28, No. 4, pp. 36-45.

Kline, S. J. et Rosenberg, N. (1986), "An overview of innovation", em Landau, R. e Rosenberg, N. (Eds.), The positive sum strategy: harnessing technology for economic growth, National Academy Press, Washington, D.C., pp. 275-306.

Laursen, K. et Salter, A. (2004), "Searching low and high: what types of firms use universities as a source of innovation?", Research Policy, Vol. 33, No. 8, pp. 1201-1215.

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

Lev, B. (2001), Intangibles: management, measurement, and reporting, Brookings Institution Press, Washington, D.C., US.

Lundvall, B. A. (1988), "Innovation as an interactive process: from user-producer interaction to the National System of Innovation", em Dosi, G.; Freeman, C.; Nelson, R. R.; Silverberg, G. e Soete, L. (Eds.), Technical change and economic theory, Pinter Publishers, London, pp. 349-369.

Lundvall, B. A. (1992), National Systems of Innovation: towards a theory of innovation and interactive learning, Pinter Publishers, London, UK.

Lundvall, B. A. (2002), The university in the learning economy [Working Paper nº 02-06], Danish Research Unit for Industrial Dynamics (DRUID), Aalborg, Denmark, DK.

Lundvall, B. A. (2007), "Higher education, innovation and economic development", paper presented at the World Bank's Regional Bank Conference on Development Economics 2007, Beijing, China, CN, January 16-17, 2007.

Malerba, F. (2002), "Sectoral systems of innovation and production", Research Policy, Vol. 31, No. 2, pp. 247-264.

Malerba, F. (2003), "Sectoral systems and innovation and technology policy", Revista Brasileira de Inovação, Vol. 2, No. 2, pp. 329-375.

Marconi, M. A. et Lakatos, E. M. (2012), Metodologia do trabalho científico: procedimentos básicos, pesquisa bibliográfica, projeto e relatório, publicações e trabalhos científicos, 7. ed., Atlas, São Paulo, SP.

Mazzoleni, R. et Nelson, R. R. (2007), "Public research institutions and economic catch-up", Research Policy, Vol. 36, No. 10, pp. 1512-1528.

Mendonça, R. W. et Oliveira, L. G. (2013), "Local content policy in the Brazilian oil and gas sectoral system of innovation", Latin American Business Review, Vol. 14, No. 3-4, pp. 271-287.

Meyer-Krahmer, F. et Schmoch, U. (1998), "Science-based technologies: university-industry interactions in four fields", Research Policy, Vol. 27, No. 8, pp. 835-851.

Mora-Valentin, E. Montoro-Sanchez, A., Guerras-Martin, L. A. (2004), "Determining factors in the success of R&D cooperative agreements between firms and research organizations", Research Policy, Vol. 33, No. 1, pp. 17-40.

Morais, J. M. (2013), Petróleo em águas profundas: uma história tecnológica da Petrobras na exploração e produção offshore, Ipea: Petrobras, Brasília, DF.

Nelson, R. R. (1990), "Capitalism as an engine of progress", Research Policy, Vol. 19, No. 3, pp. 193-214.

Nelson, R. R. (1992), "National Innovation Systems: a restrospective on a study", Industrial and Corporate Change, Vol. 1, No. 2, pp. 347-374.

Nelson, R. R. (Ed.). (1993), National Innovation Systems: a comparative analysis, Oxford University Press, Oxford, UK.

Patel, P. et Pavitt, K. (1994), "National innovation systems: why they are important, and how they might be measured and compared", Economics of Innovation and New Technology, Vol. 3, No. 1, pp. 77-95.

Pavitt, K. (1984), "Patterns of technical change: towards a taxonomy and a theory", Research Policy, Vol. 13, No. 6, pp. 343-373.

Pavitt, K. (1991), "What makes basic research economically useful?", Research Policy, Vol. 20, No. 2, pp. 109-119.

Pavitt, K. (1998), "The social shaping of the national science base", Research Policy, Vol. 27, No. 8, pp. 793-805.

Perkmann, M., Neely, A, Walsh, K. (2011), "How should firms evaluate success in university-industry alliances? A performance measurement system", R&D Management, Vol. 41, No. 2, pp. 202-216.

Petróleo Brasileiro SA (Petrobras) (2014). Tecnologia Petrobras 2014. [Relatório]. Petrobras, Rio de Janeiro, RJ, disponível em: www.petrobras.com.br/pt/nossas-atividades/tecnologia-e-inovacao/relatorio-de-tecnologia/ (Acesso em 10 de março de 2016).

Polanyi, M. (1958), Personal Knowledge: towards a post-critical philosophy, The University of Chicago Press, Chicago, US.

Polanyi, M. (1966), The tacit dimension, The University of Chicago Press, Chicago, US.

Ramos, R. R. (2014), "Lessons from a multi-partner R&D collaboration initiative in Brazilian oil and gas industry", paper presented at the IAMOT 2014: International Management of Technology Annual Conference, Washington D.C., US, May 22-26, 2014.

Ramos, R. R., Pinheiro, G. R. V., Neto, L. B. et al. (2013), "University-firm partnership in the field of wireless industrial networks: R&D and laboratory infrastructure building", artigo apresentado no Rio Automação 2013: VII Congresso Rio Automação, Rio de Janeiro, RJ, 16-17 de maio, 2013.

Ramos, R. R. et Ferreira, M. L. A. (2014), "Parcerias tecnológicas universidade-empresa: um estudo de caso nas Redes Temáticas da Petrobras", artigo apresentado no CNEG 2014: X Congresso Nacional de Excelência em Gestão, Rio de Janeiro, RJ, 8-9 de agosto, 2014.

Righi, H. M. et Rapini, M. S. (2011), "Metodologia e apresentação da base de dados do Censo 2004 do Diretório dos Grupos de Pesquisa do Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)", em Suzigan, W. ; Albuquerque, E. M. e Cario, S. A. F. (Orgs.), Em busca da inovação: interação universidade-empresa no Brasil, Autêntica Editora, Belo Horizonte, pp. 45-72.

Electronic Journal of Management & System
Volume 12, Number 1, 2017, pp. 70-82
DOI: 10.20985/1980-5160.2017.v12n1.1166

Rothwell, R. (1994), "Towards the fifth-generation innovation process". International Marketing Review, Vol. 11, No. 1, pp. 7-31.

Salter, A. J. et Martin, B. R. (2001), "The economic benefits of publicly funded basic research: a critical review", Research Policy, Vol. 30, No. 3, pp. 509-532.

Santoro, M. D. et Chakrabarti, A. K. (2002), "Firm size and technology centrality in industry-university interactions", Research Policy, Vol. 31, No. 7, pp. 509-532.

Siqueira, L. D., Crispim, S. F., Gaspar, M. A. (2015), "A utilização do modelo de negócios conceitual no gerenciamento de projetos de tecnologia da informação", Sistemas & Gestão, Vol. 10, No. 4, pp. 575-586.

Stokes, D. E. (1997), Pasteur's Quadrant: basic science and technological innovation, Brookings Institution Press, Washington, D.C., US.

Teece, D. J., Pisano, G., Shuen, A. (1997), "Dynamic capabilities and strategic management", Strategic Management Journal, Vol. 18, No. 7, pp. 1163-1180.

Tigre, P. B. (2014), Gestão da inovação: a economia da tecnologia no Brasil, 2. ed., Elsevier, Rio de Janeiro, RJ.

Tigre, P. B. et Noronha, V. B. (2013), "Do mainframe à nuvem: inovações, estrutura industrial e modelos de negócios nas tecnologias da informação e da comunicação". Revista de Administração, Vol. 48, No. 1, pp. 114-127.

Turchi, L. M. et De Negri, J. A. (2013), "Impactos tecnológicos das parcerias da Petrobras com universidades e centros de pesquisa", em Turchi, L. M.; De Negri, F. e De Negri, J. A. (Orgs.), Impactos tecnológicos das parcerias da Petrobras com universidades, centros de pesquisa e firmas brasileiras, Ipea: Petrobras, Brasília, pp. ix-xviii.

Yin, R. K. (2010), Estudo de caso: planejamento e métodos, 4. ed., Bookman, Porto Alegre, RS.