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**Review article**

## **Role of knowledge management in developing upstream sector of oil industry a case-study: brazil oil industry**

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### ABSTRACT

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Oil and gas industry of Brazil in upstream and offshore sectors is now a technology exporter and by benefiting from advanced technology is active in countries with oil resources. An overview of developments in Brazil oil industry (especially, Petrobras Company as the national oil company of the country) shows that role of knowledge management and innovation networks have been crucial in success of the industry. This study, with a review of existing research, examined steps of development of knowledge management in Brazil's oil industry. Findings show that the country in oil industry has changed from a follower to an innovator at international level.

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### **1. Introduction**

Oil and gas industry of Brazil was established in 1938 and after more than half century it now has a special place in drilling and upstream sectors of global oil. Most of oil resources of Brazil are offshore resources, and with advanced technologies in upstream sector the industry has achieved a remarkable progress.

Indicator of oil and gas industry of Brazil is Petrobras that plays an important role in international off-shore oil industry, particularly in deep and very deep water operation. The company was founded in 1956 and received monopoly of petroleum exploration and production from the beginning and became the main actor of oil industry in Brazil (Danthas & Bell, 2011).

Regarding growth and development of oil industry in Petrobras, most noted by experts and analysts knowledge and innovation management are the most important tools in obtaining and developing technology Formation procedure and developing knowledge networks which have helped to Petrobras developments. In the study of created knowledge networks, the company in oil industry has changed from a follower to an innovator at international level.

Given the importance of knowledge and innovation management in technology development of oil industry, present study tries to investigate evolutions in Petrobras historically and analytically.

## **2. Knowledge and innovation networks in petrobras**

During late of 1960s and early 21 century, international oil industry as a whole and Brazil's industry as a part left behind some of its most important changes which play a part in development of knowledge and innovation networks of Petrobras. During two or three decays ago, oil companies have gradually led their strategic programs towards core competencies. Certainly, a key factor of innovation in industry is using competitive advantage of various companies, including oil companies and suppliers, universities and research institutes, in cooperative programs. Petrobras has keep pace with global developments in oil industry and tried to establish core competency in upstream sector, and used knowledge and innovation networks in this way (Fishman, 2010).

For better understanding of formation procedure and development of knowledge and technology networks of Petrobras, changes of these networks are examined in four main historical periods:

### **1.2. Late of 1960s to 1984: establishment of first knowledge networks and learning efforts**

Starting with off-shore operations of Petrobras in late 1960s, first knowledge networks of the company associated with off-shore technologies were created. On that time totally few desired technologies were followed by these networks. Major technological activities of networks were focused on simulation methods, equipments, services and operational knowledge. In that period, knowledge flows were mainly unidirectional and operational knowledge flows were from supply chain of Petrobras to Petrobras. Regarding their characteristics, these kinds of knowledge networks are called passive learning networks. According to the target technologies of the networks in this period, changes encouraged managers to enhance company learning and explore relationships with supplier companies as well as S&T organizations. Moreover, simple knowledge flows are converted to knowledge flows including more complex design and science, though these flows are still unidirectional from partners to Petrobras. In above-mentioned technologies networks increased their share in knowledge production in a way that Petrobras' personnel learned more complex technological activities from partners. These characteristics were in fact advent signals of a new type of networks which were known as active learning networks. These networks gradually appeared lately in first period and resulted in knowledge networks entrance into new stage of their activities (Mathias, & Szklo, 2007)

### **2.2. From 1985 to 1991: establishment of an active learning network and presence of an innovation network**

During this period, company's knowledge networks went under a great change in such a way that signals of active learning networks that were emerging in the previous period were established pervasively in studied technologies. One of the key considerations of this period is that the company was more interested in using knowledge networks for learning and this learning was not operationalizable only through purchasing goods, services and/or knowledge. In this period, Petrobras decided that S&T knowledge login into the knowledge networking in order to learn and internalize knowledge. This helped the company to perform its knowledge production activities associated with its R&D independently in future. Therefore, one can say that one of the main objectives of Petrobras has been using knowledge networks to achieve self-sufficiency in technology development. Focus on technology development in

networks converted into attempts to extend design knowledge, science, and technology. Programs related to company's technology development were followed in various fields such as engineering consultancy, technical consultancy projects, participation in common industrial projects, organizational changes, and training plans. For example, in the middle of 1980s, Petrobras began cooperation with COPPE institute in public university of Rio de Janeiro in order to obtain design knowledge of semi-floated platforms. COPPE conducted research about existing designs of semi-floated platforms and provided a handbook with analysis of common designs and parameters of the platforms to Petrobras. In addition, in order to learn principle skills of design the company concluded a consultancy contract with GVA, a Swedish company, in late 1980. Thus, the company could have access to design semi-floated platforms. Furthermore, learning design methods allowed the company to do basic design of platforms independently in the future. In middle of 1980, internal engineering projects were commissioned by the company in order to master designing semi-floated platforms. Then, several projects were taken with the aim of increasing internal capacities of simulation. Petrobras was following knowledge acquisition about coordinates of normal design and designing parameters of semi-floated platforms in cooperation with COPPE. Thereafter, these kinds of cooperation were extended to international level. Petrobras interacted with Swedish Chalmers University in order to obtain tools of designing semi-floated platforms. Also, it cooperated with GVA to acquire skills in structural and off-shore design and design methods of semi-floated platforms using computers. In cooperation with GVA, Petrobras performed designing floated platforms under GVA supervision. In addition, the company cooperated with DNV in order to approach design knowledge flows. In this stage, knowledge included more complex design and science knowledge, though flow of knowledge, science, and technology remained mainly from partners to Petrobras. In this stage, Petrobras showed more interest in cooperation in knowledge production. Another important change in Petrobras' knowledge network was for knowledge resources. Already, knowledge resources were supplier companies including universities, research institutes, and other oil companies. For example, in wells and drilling technologies Petrobras joined several common industrial projects. The company cooperated with Norwegian Oil Company and contractor, Smedvig, to obtain under-water drilling knowledge, implementation, and exploitation operations. Knowledge networks in mentioned scopes gradually took innovation network flavor. During the process bilateral flows of knowledge, science, and technology as well as complementary and balance programs of knowledge production were established. The company founded a R&D center in cooperation with universities and research institutes in order to produce technologies and scientific knowledge. For example in one of these programs, Petrobras interacted with PUC Federal University and IPT to produce knowledge about wells and drilling technologies (Seroa da Motta, 2008).

### **2.3. From 1992 to 1996: establishment of an innovation network and the move towards creation of a strategic innovation network**

During this period, knowledge networks of Petrobras created with established characteristics of innovation networks in previous stage were changed again. During establishment stage, major existing technologies in networks went under changes and at the end of the stage the following changes occurred:

- ✓ An active and inclusive will to use knowledge networks in order to obtain innovative targets was formed. During internalization process of primary reserve of knowledge, science, and technology of off-shore technologies in previous stage, the company concluded that primary targets of technological self-sufficiency were undesired because it is impossible to achieve all the basic knowledge, science, and technology related to exploration and production technologies within the organization and it is important to cooperate in complementary developments. Petrobras believed that it had gained a high level of technical capabilities and is ready to use them to join synergistic cooperation with internal and external partners. Therefore, programs of network technological development approached gradually to network innovative objectives and flows of knowledge, science, and technology became inclusively bilateral. Petrobras pursued cooperation in common innovations with suppliers like Cameron, ABB-Vetco Gray, Flexibras, and Coflexio in established scopes of technologies such as wet Christmas trees, risers, flow-lines, manifolds, and umbilical. In addition, it defined cooperative projects in which bilateral flows of

knowledge and technologies are used to implement ideas that are not only new for the company, but also are novel for the technology path of oil industry. For example, it started cooperation with Bornemnan, Westinghous, and Leistriz in order to develop multi-phase pumping systems (Etzkowitz & Leydesdorff, 2000).

In these interactions based on innovation between Petrobras and its partners, task of knowledge production was divided equally between both parties. In innovative cooperation and major projects, Petrobras was responsible for project coordination and the company and its partners performed other R&D activities.

Similar to learning-based communications of networks in the previous stage, innovative cooperation also included extensive scope of knowledge resources and technology like S&T organizations, other Oil Companies, and suppliers. However, there is a distinct difference between previous stage and the present one and that is increased presence of Petrobras in networks as an important resource of scientific knowledge and technology among partners. But beyond present situation of networks, at the end of the period their new features were appeared. These features resulted in company's move towards establishing more strategic innovation networks in some of technological scopes. In this period, Petrobras considered knowledge networks as a strategic asset that enabled it to achieve diffused evolutionary capabilities outside the company, and therefore it started bilateral technological interactions with competitors and suppliers as well as participation in common programs like unidirectional technology transfer to suppliers. In these programs the company internalized key activities of R&D and designing new equipments and only gave over their production to a partner through basic design transfer.

#### **2.4. From 1997 to early 21 century: establishment of a strategic innovation network**

During this period, Petrobras moved in the path of establishing appeared features of strategic innovation networks specified in the previous stage. The major change of this period was that strategic objectives converted into the driving factor of networks development. In the previous stage main goal of Petrobras was to use cooperation in order to produce common innovation, but in this period it knew that it has a set of knowledge infrastructures that is attractive to other companies. On the other hand, Petrobras found that key capabilities and required specialty of innovation programs are out of its organizational boundaries. Therefore, it used knowledge networks as a strategic tool to obtain diffused capabilities in each area. In this stage, activities of networks technological development continued in new forms and orientation of knowledge flows was accordingly diverse. Unidirectional flows of knowledge and technology into the company that was related to the Petrobras presence in innovative projects of other organizations, was also common. But the major change of this period was increased use of new models of communications with other organizations in order to transfer technology in which Petrobras was the main resource of unidirectional flows of complex knowledge of science and technology to partners.

Petrobras concluded that in order to divide tasks, it should distribute its innovative programs in a "technology system" consisted of universities, suppliers, engineering companies, research institutes, and other Oil Companies. Petrobras decided that its main task, and particularly its R&D center, CENPES, should be coordination and leadership of R&D activities and it is not necessary to develop its all various parts. This key task (coordination and leadership) was conducted through subsystem integration and main principles of knowledge in some of off-shore technologies and establishment of symmetric and asymmetric organizing programs. In symmetric programs both Petrobras and its partners performed their specific specialty and complementary R&D activities, and Petrobras supervised and guided projects. Also, the company cooperated with knowledge and technology organizations and/or suppliers in developmental and inclusive innovations. In asymmetric programs conducted out of the networks, Petrobras joined innovation processes of other Oil Companies or suppliers. In this case, key activities of R&D are performed by network of the partner company. For example, Petrobras joined common industrial projects performed and guided by other organizations. Finally, a new model applied in the last stage that gradually embedded in inter-organizational symmetric programs of Petrobras. In this model, Petrobras was the administrator of major R&D activities inside a network system; for example, it guided common industrial projects and invited other Oil Companies to participate in them.

**Table 1**

general procedure of changes in knowledge networks in oil and gas industry of Brazil.

| Features                                                        | Variables                                                                         |                                                                                           |                                                                                                                                                       |                                                                                                                                                                            |                                                                                   |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|                                                                 | Passive                                                                           | Active for learning                                                                       | Active for innovation                                                                                                                                 | Strategic                                                                                                                                                                  | Passive                                                                           |
| <b>Network targeted development</b>                             |                                                                                   |                                                                                           |                                                                                                                                                       |                                                                                                                                                                            |                                                                                   |
| Technological development activities in desired case of network | Acquisition and simulation of goods, services, and operational knowledge          | Technology adaption, learning and absorption of design knowledge, science, and technology | Innovation and technology development, knowledge, science, and technology absorption in new technologies                                              | Innovation and technology development, transfer of technology between partners, exchange of technology, knowledge, science and technology absorption into new technologies | Acquisition and simulation of goods, services, and operational knowledge          |
| Content and paths of knowledge flows in building capacity       | Unilateral and bilateral flows of operational knowledge                           | Unilateral flows of knowledge, science, and technology as well as design                  | Bilateral flows of knowledge, science, and technology, but still unilateral flows of knowledge, science, and technology as well as design are present | Combination of bilateral, unilateral input and output flows of design knowledge, science, and technology                                                                   | Unilateral and bilateral flows of operational knowledge                           |
| Resources of knowledge flows                                    | Suppliers of goods and services                                                   | Suppliers, scientific and technological institutes, and competitors                       | Suppliers, scientific and technological institutes, competitors, and the company itself                                                               | Suppliers, scientific and technological institutes, competitors, and increased presence of the company itself                                                              | Suppliers of goods and services                                                   |
| Division of knowledge production tasks between self and others  | Asymmetric with external activities of knowledge production in partners` networks | Increased participation in knowledge production through asymmetric systems                | Symmetric knowledge production between self and partners, but still asymmetric outside of it                                                          | Combination of symmetric knowledge production, inter-organizational asymmetric, and intra-organizational asymmetric                                                        | Asymmetric with external activities of knowledge production in partners` networks |
| General pattern                                                 | Passive learning networks                                                         | Active learning networks                                                                  | Innovation networks                                                                                                                                   | Strategic innovation networks                                                                                                                                              | Passive learning networks                                                         |

**3. Conclusion**

As mentioned before, knowledge networks in oil and gas industry of Brazil converted from a passive state into a strategic innovation networks. In the following table the evolution procedure is summarized. According to the above content, knowledge management and its role in technology development in

Brazil's oil industry has been essential and procedure of its knowledge and innovation networks can be an appropriate pattern in knowledge and technology management in our country's oil industry.

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