Institutional Changes and Innovation in the Brazilian Petroleum Industry

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Abstract

The institutional change that has taken place in the legislation regarding petroleum, which has brought Petrobras' position as a monopoly to an end, has also brought with it important connotations in the dynamics of the sectoral system of Brazilian innovation in the petroleum industry. During the phase of monopoly (Phase I), the institutional set-up guaranteed that a certain convergence would be reached among the different functions in the sectoral system of innovation, for Petrobras financed, coordinated, carried out and made use of the new knowledge. At the same time, this system had certain limiting factors, seeing as it was a network dominated by one sole player. With the breakdown of the monopoly (Phase II) the number of actors involved in this system increased, as did the problems of coordination among them. This study aims to analyze some of these problems regarding coordination, shedding more light on CTPetro, whose function is to provide funds to foster the efforts in R&D and to define and link together the strategies of the actors in the sectoral system of innovation. Evidence has pointed towards a tendency in the re-appearance of a "supply side" logic, despite governmental policies that seek to link universities/research institutes to companies.

1. Introduction

The institutional changes, which took place in the 1990s, brought new elements to the dynamics of the sectoral system of innovation in the Brazilian petroleum industry, which may, in fact, be one of the most dynamic systems in the country, from a technological point of view, and the one that carries the most weight in the country's economy. This system of innovation had, and still continues to have, an organizational structure, which is quite verticalized and centered on the leading company – Petrobras. The institutional changes caused by the breakdown in the monopoly in the petroleum sector (Law N° 9478 dated from 1997) have been leading to a redefinition in the roles and in the relationships bearing power within this innovation system.

Law N° 9478 dated from 1997 ratified the breakdown in the monopoly that Petrobras held regarding the activities of the mining for, production, refinement and transportation of petroleum, its by-products and of natural gas, thus enabling other companies operating or rendering services in the sector, be them national or foreign companies, to compete with the state-owned company in all of these segments of activities. With the creation of a new institutional model, a new governmental player emerged, the National Petroleum Agency, which is the regulatory organ responsible for making sure that this industry functions suitably under competitive conditions.

Nevertheless, the most significant institutional change in terms of the institutional setting of innovation is linked to the appearance of a Sectoral Fund, the CTPetro, destined towards financing research activities and the development of the petroleum industry. This fund is financed by a portion of the royalties that has been received from the production of petroleum and natural gas in the country. With the introduction of Law N° 9478, a dramatic increase occurred in the

sum of royalties paid according to the production of petroleum in the country, which went from 5% to 10% over the total value of sales, depending on the profit margin reached by the petroleum company. A portion corresponding to 25% of the additional value obtained over these royalties started to be channeled to financing the CTPetro Fund. It is worthwhile pointing out that the royalties, as well as the other taxes received calculated over production activities, are paid exclusively, up to the present moment, by Petrobras. The sum of resources effectively channeled towards this fund was of R$ 166 million in the year 2000 (see Table 1). The forecast was that this sum would maintain a value of R$ 150 million. Finep is responsible for managing roughly 80% of these resources, for it manages the resources of the FNDCT (*The National Fund for the Development of Science and Technology*), under whose management the resources for CTPetro encounter themselves.

Table 1: Actual Flow and Estimated Flow of Resources channeled to CTPetro (in millions of reais)

1999(*)	2000(*)	2001	2002	2003	Total
38	166	151	151	151	657

(*): resources actually passed on to the fund

Source: Finep, 2001

In order to have a true notion of the weight that these resources represent to the petroleum industry, one can mention that Petrobras invested R$ 335 million in R&D in the year 2000, and also in 2001. Hence, the resources estimated to be channeled to CTPetro are equivalent to less than half of the sum spent in R&D by Petrobras during 2000 and 2001.

Carrying out the Program proved to be no easy task, due to disturbances in the country’s economic state of affairs, which worsened, leading the government, in the hope of curbing expenditures and of increasing its primary budgetary surplus, to re-direct a portion of the resources that were to be set aside for the Fund according to the legislation. Therefore, in 2001, only R$ 116 million were channeled to CTPetro and, in 2002, only R$ 80 million were put into the Fund. In that last year of the president’s four-year term of office, no new Public Calls were issued. This gap between the resources that were effectively used and the sum that had been forecast to be used, according to the institutional mechanism, is undoubtedly an important characteristic that demonstrates how public acts are carried out in Brazilian society. The country’s fragility, from a macro-economic point of view, made it increasingly impossible to put the science and technology policies of the sector into practice.

Even though the sums that reached the fund represented only one third of the resources known to have been spent in R&D in the petroleum industry in 2000 and one quarter of those spent in 2001, these sums have been able to expand and significantly modify the relationships among the actors in this sectoral system of innovation. In this study, the main aim is to analyze in what manner the programs implemented by CTPetro are causing repercussions in the innovative dynamics of this system.

2. Institutional Set-ups in Sectoral Systems of Innovation

An analysis of the institutional changes in the sectoral systems of innovation requires one to resort to bringing together ideas and theoretical concepts stemming from many different schools of thought. In previous works (Furtado, 1999 and Bach et alii, 1999) it was assumed that

the analyses of institutional set-ups were determining factors to enable one to clearly grasp the innovation process, being indispensable for defining methodologies to assess technological programs. Institutional set-ups are made up of a series of elements:

- Actors
  - Roles/functions
  - Rules
  - Mechanisms for Coordination.

Institutional set-ups would have a very strong influence on the way in which new knowledge reached the market and in how it translated into innovation. In a specific technological program, the form in which economic factors would cause impacts would be filtered through these set-ups. In order to better define what is meant by an institutional set-up in a sectoral system of innovation, it is worth recalling how different schools of thought have contributed towards defining this concept.

The neo-institutionalist school (Williamson, 1985) can aid greatly in attempts to grasp institutional set-ups in innovation systems. This school of thought strives to better comprehend how the frontiers are defined between the two basic institutions of capitalism: the firm and the market. These frontiers depend on the type of business activity (its specificity and frequency) and on the manner in which the actors establish relationships of trust among each other and to what extent they are capable of creating conventions.

This view of an institutional set-up, as that of being a division of labor between the firm and the market, may prove useful for the analysis of the innovation process. The concept of internalizing applies to R&D activities, which may be carried out either in-house or outsourced (Teece, 1988; Weinstein, 1992). These activities, which are characterize by the tacit nature of an important portion of the technological knowledge and the frequency at which feed-backs from the production activities are required, are hardly externalized by the firm. Hence, the predominant institutional set-up would be that of a laboratory destined to industrial research, which would have taken upon itself the responsibility of a great portion of the innovative activities in the firm.

Nevertheless, this firm-market binomial is not capable of accounting for the institutional complexity that characterizes a national system or a sectoral system of innovation. They are in fact complex sets of institutions – firms of many different types (of users and of suppliers), research institutes, universities, technical schools, associations of professionals, government agencies, funding agencies, etc. – all of which interact in the innovation process. The relationships, which exist in this system, go way beyond a purely commercial scope. The flow of some types of information that circulates among the actors and the institutions are not the object of any commercial transaction, conforming to what may be coined as “organized markets” (Lundvall, 1992a). A nation’s cultural aspects have a strong influence on the manner in which this knowledge circulates, which lies set within specific routines and social relationships. (Johnson, 1992).

Nelson (1991) clearly states that innovation in a national system depends essentially upon the interaction between the public and the private sectors. The public realm is responsible for making knowledge circulate, holding a higher propensity to produce codified knowledge, which would hold characteristics of a public asset, whereas the firms would produce proportionally more tacit knowledge, which can be more easily appropriated. Obviously, this dividing line is not so clearly defined between the two realms, seeing as the public sector also produces tacit knowledge, but of the kind that has a high capacity of circulating, such as that regarding human

resources created by universities, and the companies produce a key component of codified knowledge, such as patents and scientific articles, which, in the former case, may be appropriated privately, even if in a somewhat incomplete manner. This analytical approach put forward by Nelson enables one to grasp the importance that public research has in the circulation of knowledge within an innovation system, as well as its strong interaction with knowledge that has been generated by companies and appropriated privately.

The national systems of innovation (Freeman 1992, Lundvall, 1988 and 1992b, Nelson 1988, Nelson and Rosenberg, 1992) are defined as the interactions among actors of different institutional natures that work in a cooperative or complementary manner to generate and spread innovations. These interactions are built socially and they themselves represent institutions that have resulted from a learning process, which can be produced in certain productive systems and in certain national or regional contexts.

The starting point of a national system of innovation constitutes the “filière” or “mezzo-industrial system” (Lundvall, 1988). In this type of system, in which a large group of companies establish many links of a productive nature among each other, the learning that takes place between users and producers is of great significance. Companies are not the only organizations that are specialized according to sectors. In many cases, research institutes and training centers are also highly specialized according to sectors. Governmental agencies possess programs that clearly show a tendency towards specific sectors. This group of actors and the interactions among them form what can be defined as a sectoral system of innovation, organized around a “filière” or a production chain.

The analyses of national systems of innovation are quite descriptive (see, for example, Nelson, 1993), or rather, they are incapable of creating a more systematic conceptual framework that could be used to analyze the wide variety of national cases. This theoretical mark also lacks a tool capable of interpreting the relationships that are established among the many diverse institutional actors of a specific innovation system (be it national, sectoral, regional or local).

To make strides in understanding the dynamics of institutional set-ups, the French school in the sociology of innovation has made an important contribution (Callon, 1992). According to this approach, innovation takes place within networks of actors, coined as technical-economic networks, which exchange knowledge among each other being positioned in (scientific, technological or market oriented) poles. The production process and the exchange that takes place within these technical-economic networks involve activities of mediation among these poles. The actors in each one of these poles tend to have their own language. Thus, one of the central issues to be dealt with in the innovation process is that of finding a way for the actors to communicate among each other, by creating mechanisms of translation.

The Callonian topology allows one to better position the actors and to better grasp their respective roles within the sectoral system of innovation. Since innovation is a very complex process, which requires mobilizing very heterogeneous set of activities and resources, coordination, as well as the creation of codes and conventions, are shaping factors in the performance of the system.

The networks may possess many different types of formats, according to each one’s system of coordination. When coordination has been clearly established and is explicitly well-defined to the set of actors, when the conventions produce the same results, regardless of the player, then one can say that the network has taken on a predictable behavior. In such a case, the network is convergent.

On the other hand, when a network possesses a weak level of coordination, or rather, it does not have its own rules or does not hold conventions that are shared by each actor in the set of actors, one refers to this type of network as divergent. In this case, the behavior is unpredictable and the costs of translation are high.

According to Barré and Papon (1992), convergent networks tend to be short or uni-functional. They possess a limited number of participants, explicit contracts and a higher amount of codified information. A research program with well-defined objectives is a clear example. A network dominated by one player tends to be of a convergent nature.

Multifunctional networks which relate to complex multi-lateral relationships tend to face greater obstacles in terms of translation. The relationships tend to be of an informal nature. When they hold cultural aspects or values in common these networks are more likely to become convergent. The advantage that these networks presents is that they are more receptive to the uncertainties that characterize innovations, mainly the more radical ones.

4. The Central Role of Rules

The institutionalist school of thought has generated a series of theoretical concepts that may prove very useful in the analysis of institutional set-ups that are directed towards innovation. According to institutionalists, rules hold an essential role in the functioning of organizations and in any other form of collective action. According to the viewpoint upheld by Commons (1931), collective action works through active organizations (*going concerns*, *organised concerns*), defined through a common objective, rules regarding their activities or functioning and those of the authorities that have been called upon to define and enforce rules (Chavance, 2001). The institutionalists are unanimous in attesting to the importance of rules, both for individual as well as collective action. The role of rules in coordinating individuals within organizations and in an inter-organizational manner is put forth as being fundamental. Rules may hold many different functions. They may give a definite form to certain relationships bearing power among actors. They may be seen as an instigating system that influences the behavior of these same actors. Finally, they hold a cognitive role by incorporating within them the learning processes of an organization or of a social system.

Hayek (1948) makes a distinction among the different types of rules that reflects in a differentiation among two types of order. On the one hand there is the built type of order, which is reflected in an organization and in a company, and, on the other hand, there is the spontaneous type of order, which is organized by itself in the society or the market. A unique type of rules supports each type of order. The rules of organizations are deliberately built. They designate specific tasks to the individuals that make up the organization and they also set the limits of an organization's most important objectives. The rules that govern the spontaneous type of order of a society are not dependent upon any specific objective and they apply to all individuals. The former type of rules evolves at a much faster rate than the latter one.

A recent piece of work written by D. North (1990) holds the virtue of attempting to organize the debate regarding the relationship between institutions and rules. This author associates institutions to rules. These are the conditions created by man that govern the conduct of individuals and organizations. Institutions are viewed as being the rules of the game whilst the organizations are viewed as being the actors. Basing himself upon the contributions made by Hayek and North, B. Chavance (2001) put forward an hierarchy of rules among the rules which institutions are governed by and those that organizations are governed by. Within each of these

types of rules, the author makes a distinction between the rules which have a constitutive nature, based on law, which are more generic and longer-lasting, and the common rules, which are more specific and more subject to changes.

Rules hold a central dimension in grasping the functioning of any social system. They hold an important function in the coordination of collective action although they are not the only mechanism of coordination. They make it possible to define the division of labor among the actors in a specific innovation system. Quite often the rules, especially the implicit ones, act as a decentralized system of coordination which is viewed as an alternative to a centralized hierarchically structured coordination, considered to be of low efficiency. Within the context of this present work, rules will be used as being the basic components of institutional set-ups that, in turn, define the roles and functions of the actors and underpin the mechanisms for coordinating collective action.

5. The Institutional Framework of the Petroleum Industry

Technological programs define specific institutional set-ups. While determining these set-ups, rules play a central role by defining the division of labor among the actors. The influence that rules have upon the general dynamics of a system tends to grow as the system starts to base itself upon a decentralized form of coordination.

The technological programs and the funding policies act as agents that sequence a specific institutional set-up in a sectoral system of innovation. According to the typology of rules defined by B. Chavanche, an institutional set-up in a sectoral system of innovation in the petroleum industry would hold different types of rules that would interfere in the relationships among the actors.

On a wider scope, there are institutional rules that govern the general behavior of the actors. At this level, in first place, come the constitutive rules, such as article 177 of the Federal Constitution, that foresaw the monopoly maintained by Petrobras. This chapter was modified through the Amendment n° 9 to the Constitution dated from 1995 which endowed the state with the right to grant the activities of mining, production, transport and storage of petroleum, its by-products and of natural gas to other companies. The terms and conditions under which the state could grant these rights to companies are defined in the Law regarding petroleum, which establishes the institutional rules common to the sector. Among these, one that stands out is the rule regarding the destiny of a fixed portion of the royalties paid to Science and Technology, which is a rule that has enabled the creation of the CTPetro fund, and of a part of it, corresponding to 40%, to be destined to the Northern and Northeastern regions of the country. The Law also determines the creation of the National Petroleum Agency. The presence of institutional rules not directly linked to the petroleum industry can be noted, which interfere to a great extent in the institutional set-up of the sector. Among these one can highlight the Resolution of the Treasury Department, which restricts the channeling of funds for research and innovation, funds these which will not be recovered, to non-profit institutions, thus barring access to these resources by companies.

At a lower level, there are rules that guide the organization of the petroleum industry and the level of public intervention in the sector. The constitutive rules at this level determine the objectives of the policies of the sectoral fund for petroleum. Decree Law N° 2851, dated from 1998, which established the creation of the CTPetro fund, defines that the portion of the royalties that are due to the Ministry of Science and Technology would be channeled to fund programs of

scientific research and towards technological development of the petroleum industry, according to the interests of the firms operating in the sector. At this level, the main aim of the fund can be seen as being that of funding research destined to meet the needs of the companies in the petroleum and natural gas industry.

Below the constitutive level, there are common rules that are laid down by Public Calls drawn up by Finep (Federal Agency for Innovation) that are essential for determining the institutional set-up that will be taken up as of the creation of the CTPetro Fund. These Public Calls define the roles and functions of the actors and the incentives linked to them.

Rules, mainly those found at lower levels, evolve constantly due to learning processes and to clashes among the actors. Common rules change at a much faster pace than constitutive rules. Hence, the Public Calls are also transformed, revealing a learning process which tends to follow a determined trajectory of institutional change.

6. The Sectoral System of Innovation in Brazil’s Petroleum Industry

The sectoral system of innovation in the petroleum and natural gas industry is formed by a group of heterogeneous actors (firms, research institutes, the government) which are linked and relate among each other. The system has, on its productive side, two distinct groups of firms. The ‘operators’ (the oil companies running the production activities) assume some or all of the operations carried out in the diverse phases of the production chain of petroleum and natural gas, which goes from its extraction to the distribution of the final processed product. The suppliers constitute a heterogeneous group of companies that supply a vast range of goods, from materials to complex equipment, and that render a wide variety of different services that provide support to production, whether at a high or low level of specialization. The outsourcing of activities by operators to specialized suppliers is a long-standing process in the petroleum industry (Dutra, 1993). It dates all the way back to the beginning of the last century, when the petroleum industry was consolidating itself in the United States. The externalization of certain production activities to specialized suppliers is due to the high level of heterogeneity in knowledge and in competencies that must be put to use in the production and processing of petroleum and natural gas.

Only the segment of operators is considered as belonging to the petroleum industry, the suppliers are included in the category of the oil supplies industry. In the present work, when the term petroleum industry is mentioned, the two groups are being referred to. In national accounts, these two groups are classified separately, seeing as the group of the oil supplies industry is not located only in an industrial segment.

Hence, with reference to the segment of operators, generally called the petroleum extraction and refining industry, the OECD classifies them as companies of medium/low levels of technological intensity. The indicators of technological intensity lie at a level below 1% of the industry’s revenues, except in the case of some specific, differentiated companies (Furtado, 1994). Recent studies have shown that the levels of technological intensity in the top 25 American companies have been steadily sliding, starting at 0.95% to 1% in the beginning of the 1990s to reach 0.6% at the end of the decade (Bourgeois and Jacquier-Roux, 2001). Petrobras invested 0.6% of the group’s revenues in R&D in 2001.

The suppliers are located at a higher level that fluctuates in terms of an average value of technological intensity that represents from roughly 2 to 3% of company revenues.

However, some segments of the oil supplies industry have achieved a high level of technological intensity, reaching levels that range from 6 to 7% of company revenues (Furtado, 1994).

The petroleum industry, due to its high level of profitability, receives little public support in terms of its spending in R&D. In the countries that belong to the International Energy Agency, the governments allocated, in 1995, 5.5% of the sum spent on R&D in the energy sector to petroleum and natural gas. This percentage, which falls short of the true weight that this industry holds in the energy sector, reveals that, in fact, the oil companies themselves make a large part of the funding of R&D in industrial areas. Rare are the cases, such as the case of France, where a significant portion of the spending in R&D in the industry (approximately 40%) is covered by public resources (Furtado, 1994). In Brazil, one sole company, Petrobras, has taken up the funding of R&D sectoral activities.

In order to analyze the sectoral system of innovation, a scheme is put forward that divides this system up into some functions and roles around which the institutional actors build up their structures and interrelate. The main functions and roles regarding innovation are: funding of R&D for industrial and academic areas; planning and coordination of R&D activities; execution of R&D activities; funding for capacitating human resources; capacitating specialized human resources at technical and university levels; users of the new technological knowledge; clients that make use of the products and services that incorporate the new technological knowledge; final consumers of products derived from petroleum and natural gas.

Based on this framework for analysis, the aim in this present work is to analyze the institutional changes that have been triggered by the breakdown in the monopoly that Petrobras held over the sectoral system of innovation in Brazil. In a previous work (Furtado, 1995), it was mentioned that the sectoral system in Brazil is highly concentrated on one sole player (Petrobras), which has assumed practically all of the main roles in the system. Any changes made that may come to destabilize the main player may jeopardize the global dynamics of the system. This concentration of main roles attributed can be seen in Figure 1, as belonging to Phase I of the monopoly that Petrobras held.

In Phase 1, Petrobras carried out either partially or fully the large majority of the functions in the sectoral system of innovation. This granted a high level of convergence to this innovation network, as defined by Callon (1992). This network proved to be highly efficient, for, under the coordination of Petrobras, all of the actors spoke the same language. The fact that Petrobras was the player that planned and, at the same time, funded, carried out and used the knowledge generated brought a great level of coherence to this network. The problems regarding translation were much smaller, although they did not cease to exist.[1] The problem which this network presented is that it was structured around one sole central player and hence, it was not highly receptive to diversity and variety in technology.

The actors were in a situation of imbalance among themselves. Resources and attributions were too highly concentrated on Petrobras. This company constituted the most developed hub, while the academic institutes and the supplier companies ended up holding a relatively fragile position in this system. Nonetheless, Petrobras had been investing significant sums of money in

[1] The assessment studies of Procap 1000 (*the Program for Technological Capacitation in Deep Waters*) (Furtado et alii 1998, Freitas 1999, Furtado and Freitas 2001) reveal the complexity of the dialogue among the different departments that led to aborting some important innovations that had been developed by the company.

academic research and in post-graduate courses. In light of this policy, academia had begun to assume the role as an important interlocutor in Petrobras' research projects and programs.

Figure 1: The Functions and Roles of the Main Institutional Actors in the Innovation System in Brazil during Phase 1 (monopoly) and Phase II (the breakdown of monopoly)

Function/Role	Phase I	Phase II
Funding of R&D	• Petrobras assumed the largest portion of the funding	• Petrobras (70%) • CTPetro (30%)
Funding for capacitating HR	• Petrobras provided partial funding • The State provided partial funding	• Petrobras • CTPetro-National Petroleum Agency
Planning and Coordination of R&D activities	• Petrobras assumed the largest portion of the activities attributed	• Petrobras • CTPetro
Execution of R&D activities	• Petrobras carried out practically all of the activities exclusively • Universities and research institutes were responsible for a small portion of these activities	• Petrobras • Universities took on a much larger portion of these activities
Capacitating HR	• Petrobras carried out these activities partially • Universities and technical schools also carried out these activities partially	• Universities and technical schools took up more responsibility over these activities • Petrobras will gradually decrease in its stake of responsibility
Users of the New Technological Knowledge	• Suppliers • Petrobras	• Suppliers • Petrobras • Other operators
Clients of the New Technological Knowledge	• Petrobras	• Petrobras • Other operators
Final Consumers	• Society, in general	• Society, in general

Source: Author's own elaboration

Nevertheless, this was not the case of the national suppliers. They carried out a relatively weak role in the technological efforts that were carried out by Petrobras in order to develop technology for operations at great depths in the sea in the second half of the 1980s and the beginning of the 1990s (see Furtado et alii, 1999). During the '90s, a tendency could be seen for this company, inserted in the Procap (*The Program for Technological Capacitation in Deep Waters*) to seek associations with foreign companies to develop technology, setting national suppliers aside (Freitas and Furtado, 2000).

7. Institutional Changes in the Innovation System in Brazil

With the institutional changes brought on by the breakdown in the monopoly of Petrobras, the risk remains constant that the state owned company, now facing the pressure of competition and a higher tax burden, may come to put aside some of the important missions that had been attributed to it during the period of the monopoly, such as the mission to develop the production of petroleum in national territory. With regards to the national system of innovation, Petrobras carried out a crucial role by funding research activities, post-graduate studies, and the technological development of national suppliers. As a result of the breakdown of the monopoly,

Petrobras may choose to abandon the line of thinking of a public company to take up the role of a company which now faces competition. Trying to anticipate the consequences that could result from such a threat, a new institutional regulation established the creation of the CTPetro Fund. However, the emergence of the Fund has led to a dramatic reformulation in the prior institutional set-up.

The Coordination of the CTPetro Fund

The creation of the CTPetro Fund led to the appearance of a new public player, which stood independent from Petrobras, bestowed with a reasonable amount of financial power and the ability to interfere in the sectoral system of innovation. CTPetro is managed according to the guidelines drawn up in the National Plan for Science and Technology in the sector of petroleum and natural gas. The guidelines and the National Plan for Science and Technology are defined by a Coordination Committee under the supervision of the Ministry of Science and Technology, where, nonetheless, the National Petroleum Agency holds a great amount of influence in the fund’s management. The operational part regarding the execution of the activities carried out by the Fund is left to Finep, which also holds responsibility for managing the FNDCT (National Fund for Scientific and Technological Development), the resources of CTPetro being found in this administration. Resources granted to CTPetro are destined exclusively to universities and non-profit research institutes.

The great risk, in this new institutional set-up, involves the return to a certain pulverizing action in research and a certain ‘supply sided” trend in the funding of research which had always characterized scientific policies in Brazil. A “supply-sided” trend consists in a Science & Technology policy that is concerned about and essentially encourages the supply of science and technology. This trend satisfies, as its highest priority, the interests of the scientific community and is, most of the time, not very well tuned to economic and social demands.

A supply-sided trend becomes a more plausible possibility when a separation exists, in terms of organisations, among the areas of funding, conception, execution and use of new technological knowledge. Such a separation increases the costs of translation and hampers the flow of information in the innovation system. In the case of the CTPetro Fund, a complex system of relationships exists among the actors, who are of distinct institutional natures. The actors that coordinate the fund’s activities have resulted, to a large extent, from state bureaucracies. The members of the fund’s Coordination Committee are, actually, appointed by the Ministry of Science and Technology, in a consensus with the MME (the Ministry of Mining and Energy) and the National Petroleum Agency (the ANP). The fund’s committee is made up of, in addition to a representative from the Ministry of Science and Technology, who chairs the committee, a representative from the National Petroleum Agency, one from the Ministry of Mining and Energy, one from Finep, whose responsibility it is to carry out the executive management of the FNDCT and one from CNPq (*The National Council for Scientific and Technological Development*), who is responsible for the executive management of the resources destined to funding scientific research. Additionally, two members from the realm of business participate in the committee, as well as two members from the scientific community.

The National Petroleum Agency (ANP) is a key player in the pioneering implementation of the fund. It was of utmost importance at the moment of bargaining with the Brazilian Treasury Department in order to obtain the immediate clearance of resources destined to the fund. It provides important technological consulting in the definition of the sectoral planning. Yet, the

management of the fund, being within the scope encompassed by the Ministry of Science and Technology, suffers great pressure from the scientific community. Furthermore, this same scientific community is strongly represented within the staff of the agency itself.

Petrobras’ participation in the management of the fund is another element which cannot be overlooked. The president of the committee, Mr. Antônio Fragomeni , who coordinated the fund in 2001, had held a prior position in the Cenpes-Petrobras (*Petrobras’ Research Center*) and one of the representatives of the industrial sector was the Director at Cenpes.

Allotment of Resources and Financing Mechanisms

CTPetro’s Coordination Committee is responsible, as defined, for allotting the fund’s resources. In the documents containing guidelines drawn up by the fund it has been established that these resources shall be managed and put into use by CNPq (*The National Council for Scientific and Technological Development*), with respect to the training and capacitation of human resources. The remaining portion of the resources shall be maintained under Finep’s management.

The resources made available to CNPq are quite meager. They correspond to around 4.5% of the fund’s total reserves, according to the forecast of the Pluri-Annual Plan for Investments (Ministry of Science and Technology, 1999). These resources are to be used in compliance with the forms of financing that CNPq traditionally uses, which consist, essentially, of grants and financial aid. The projects, in general, are of a moderate value. In 2001, two Public Calls were issued. The first one, covering a total sum of R$ 7 million, was destined to providing support to research programs and research groups in the country that were carrying out studies linked to the chain of knowledge of the petroleum and natural gas industry.

CNPq’s second Public Call of 2001, allotted a sum of R$3 million for creating posts for researchers holding Doctorates to set up residency in the Northern and Northeastern regions of the country. The resources consisted of scholarships and grants for research. The areas of research are limited to upstream areas. Therefore, on the whole, CNPq allots R$ 10 million, a sum which corresponds to roughly 6.6% of the fund’s resources.

Consequently, FINEP is the main actor responsible for the management of these resources. In 2000, Finep issued four Public Calls:

1. Research and Monitoring of Fuel (R$ 20 million)
2. Instruments to gauge the quality of fuel (R$ 5 million)
3. Top priority areas (R$ 55 million)
4. Infrastructure for universities in the Northern and Northeastern regions of Brazil (R$ 20 million)

Public Calls 1, 2 and 4 were destined to specific objectives. The first two represented demands from the National Petroleum Agency to build a network of institutions that could meet the needs of quality control of fuels. The fourth Public Call was related to equipping the universities from the Northern and Northeastern regions of Brazil to grant them the infrastructure

deemed necessary for them to be able to participate in research in the petroleum industry. Only Public Call 03/2000 had the aim of supporting research and development in top priority areas.

The manner in which the resources of Public Call 03/2000 were applied occurred according to the forms of financing of this institution and complied with the rules laid down by the government regarding technological funding in the country, or rather, worked along a certain institutional trajectory that had been developing since the 1990s. Beyond a shadow of a doubt, the PADCT III (*Plan for the Support of Scientific and Technological Development – Phase III*) that had been launched in 1998 served initially as a model for this Public Call. This program introduced the form of a university-company cooperative project which required complementary resources from the firm.

In 2001, a significant amount of evolution could be noticed, due to the institutional learning that had taken place through the experience acquired from the Public Calls issued in 2000. Finep issued three more Public Calls:

- 00/2001 – Public Invitation (R$ 50 million)
- 03/2001 - Cooperative Networks in the Northern-Northeastern regions (R$ 40 million)
- 04/2001 – Innovation (R$ 10 million)

Public Call 03/2001 was destined to setting up research networks in the Northern and Northeastern areas of the country focusing on priority themes. This Public Call was, in a certain way, a continuation of the Public Calls issued in 2000 regarding infrastructure. On the other hand, the Public Call 04/2001 related to Innovation represented an original initiative, for it was destined specifically for supporting new start-ups at universities and research centers. Nevertheless, it was the Public Invitation that had the aim of supporting cooperative projects in R&D between universities and companies on a wide scope. A certain continuity in trajectory can be seen between Public Call 03/2000 and Public Call 00/2001, which will be analyzed below.

Public Call 03/2000

The Public Call outlined the common organizational rules that were most likely to lead to institutional evolution. Therefore, after the institutional change of the breakdown of monopoly and the creation of the CTPetro Fund, the sectoral policies of Science & Technology for the sector have been learning from the first experiences carried out and have been undergoing a process of change which this work will try to demonstrate through the evolution of Finep's Public Call, mainly those that sought to promote the relationship between universities and firms. The model which strives to promote the university-industry relationship through complementary funding by firms was achieved through Finep's Public Call 03/2000. In the most important Public Call issued by CTPetro in 2000, R$ 55 million were allocated. From this total sum, R$ 15 million were initially destined to isolated projects and the remaining $40 million were channeled to cooperative university-research centers/firms projects. However, a minimum percentage was not defined with respect to the complementary resources that the companies should put up.

Giving priority to the cooperative university-industry projects and the demand that the firms provide complementary resources were mechanisms used with the aim of reducing the degree of the supply-sided trends in funding policies. Nonetheless, the results achieved through this Public Call did not confirm its original intention. In fact, of the projects approved, only

53.29%, or rather, R$ 29.8 million, were of cooperative programs between universities-research centers and companies. The sum of complementary funding put up by the firms was in general of 23.8% (complementary sum/total value of the project). The remaining projects were either isolated projects or cooperative programs between only universities and/or research centers.[2]

The complementary sums put up by companies are not always a guarantee as to their true interest in projects. In the projects linked to Public Call 03/2000, the companies took part in the projects in merely a minimal manner. In almost all cases, the companies were not the ones to take the initiative of conceiving and submitting a project to the Funding Committee, whose supervision was the responsibility of the university-research center coordinating and executing the project. It can also be noticed that suppliers had a quite limited participation.

From the total sum of the projects taken up with companies, Petrobras was responsible for 80% of the projects and for 72% of the resources of the fund. The remaining portion was divided up among 17 different firms, of which 10 were suppliers. The projects in which the suppliers participated were allotted 18% of the resources from the fund.

For Petrobras, which holds a large and varied interest in cooperative research with universities, a unique phenomenon could be witnessed, which was that of the approval by the company of the projects holding lower priority. The cooperative projects with Petrobras that were approved received a complementary contribution in resources of 13%, whereas in the projects submitted, the complementary funding represented 22.7%. If the percentage of the complementary funding is analyzed as being an explicit manifestation of interest by the company in the project, one can see that the selective process of Public Call 03/2000 ended up awarding with resources the projects in which the company had a lower level of interest.

These results in the manner in which the resources were channeled in the Public Call of the largest value issued in 2000 are clear indications of the selection mechanisms of projects, which, in a certain manner, awarded projects that held a certain supply-sided focus and also indicate that there was excessive dispersion in the resources. The large level of scope of the 13 areas of top priority[3], in which almost the entire energy chain of petroleum and of natural gas and its surrounding areas were included, benefited many projects that were included although their link to petroleum was of a very weak and indirect nature. The areas given higher priority were not always those related to the priorities of the industry. The project involving the issue of the environment was the one awarded with the largest portion of resources, receiving 18% of the resources of the Public Call, while the project in the area of deep waters ranked third, receiving 10% of the resources.

Public Call 00/2001

Most certainly, the results of this Public Call led the committee administering the CTPetro Fund to review the strategies for financing for the year 2001. The new model of financing that emerged in response to these contradictions is that of the "Public Invitation", in which the firms initially manifested their intention to join a project. This intention of participating in a project had to be negotiated with CTPetro to, in turn, be submitted to the universities and research centers.

[2] The information regarding Public Call 03/2000 can be found in Pereira et al (2001).

[3] Deep waters; New frontiers to be explored; Advanced recovery of petroleum; Oil well engineering; Pipeline; Refining; Natural Gas; Petroleum by-products; New materials; Instruments, Process Control and Detection Methods; Monitoring and Preservation of the Environment; Conservation and rational use of Energy; Information and Planning.

This, however, placed a demand on the firms that they would put up complementary resources into a project, of a sum equivalent to the sum that CTPetro would be granting the universities and research centers, that would not be reimbursed, for the financing of a project. By stipulating a minimum value of complementary resources to the order of R$ 250 thousand, this Public Call was, essentially, destined to large companies. The Public Invitation opened doors for companies to ask for financing of the complementary sum to Finep. The total amount of resources foreseen by the CTPetro fund for this line of financing was of R$ 50 million.

The Public Invitation brought about significant changes in the manner in which Finep destined resources, which was demonstrated by the higher amount of detailing of the areas in which these resources would be applied (18 areas)[4], by a higher level of commitment from the companies, both in the volume of resources as well as in the percentage that these complementary resources represented, and by the fact that the technological demand, which had given origin to the project, should be explicitly defined initially by the company. This selection mechanism shies away from some of the problems identified in the Public Call of 2000, where the projects almost always represented initiatives taken up by the universities/research institutes with a reduced participation by the firms.

Although the rules shifted the center of decision making regarding the conception of the projects from the universities/research centers to the firms, they confirm the option of externalizing the execution of R&D activities to outside of the productive sector in the academic field. This institutional set-up results in higher transaction costs and in increasing costs in translating new knowledge. It is also incapable of solving the problem regarding the lack of internal efforts in R&D in the majority of local firms. The mechanism of the Public Invitation only functions efficiently when it is a measure that complements significant efforts being carried out internally in the firms regarding technology. However, this situation only takes place in large companies that carry out a substantial amount of research.

The Public Call reaped a certain amount of success within the line of logic that had been established. 167 projects received approval to be carried out in 32 universities/research centers, totaling a value of R$ 87.8 million, of which 51.5% were comple-mentary resources that had been put into the projects by 14 firms. On two different occasions, resources from the CTPetro Fund were approved in the value of R$ 42.6 million, a sum lower than the sum that had been previously foreseen in the Public Call.

[4] Adapting the refinery installations so as to make them more suitable for the efficient processing of heavy national petroleum products; The development of equipment, processes and systems to reduce the harmful impacts on the environment caused by oil spills or leakage of by-products; The development of equipment, processes and systems related to the operational safety of the pipelines used by the petroleum and natural gas industry; The development of new types of fuel and petroleum products with high added value; The development of equipment, processes and systems linked to perfecting the logistics destined to meeting the needs of the petroleum and natural gas industry in tropical forest areas; The development of equipment, processes and systems focused on cost reduction for the production of petroleum extracted from deep waters; The development of equipment, processes and systems concerning enhancing the efficiency in the use of petroleum and its by-products; The development of equipment, processes and systems related to the management and control of the production of water in petroleum fields; The development of equipment, processes and systems linked to optimizing, reducing costs and increasing the reliability of the distribution of petroleum and its by-products; The development of equipment, processes and systems destined to reach economic feasibility in the use of alternative sources of energy with regards to petroleum and its by-products, such as biomass, schist, fuel cells, eolian and solar energy; The recovery of areas cleared in tropical forests for extraction purposes; High performance computational tools; Natural gas: its implementation on the market and its technological challenges; the increase in the efficiency of applications; added value to petroleum and its by-products, such as technical and economic feasibility of the fuel cell; the conversion of gas-to-liquids; Mature fields: an increase in the level of recovery; logistics for production output; technical and economic feasibility; Risers and umbilical systems for use in deep waters (drilling, completion, production and exportation); Processes to reduce the levels of sulfur in diesel and gasoline; Process of bio-desulfurization; Reduction of risks in exploratory procedures.

The high level of the barrier for companies to enter into projects putting up complementary resources worked deliberately as a mechanism for concentrating resources. Petrobras, being the largest company in the sector, entered with 84.4% of the firms' complementary resources, which corresponded to a total sum of R$ 41.2 million (12.3% of the Petrobras R&D expenditures in 2001). This value was almost sevenfold of that of the Public Call 03/2000 (R$ 6.5 million). The predominant position of Petrobras was a central aspect in the new Public Call. It can be explained by the high barrier of entering established by the rules of the new Public Call for putting up complementary resources. Only large companies, mainly the state-owned company, were able to support research projects under such conditions.

The implications of the Public Invitation were strongly felt by Petrobras. 158 projects from the company fit into the Public Invitation, of which 25 projects were in partnership with other companies, demonstrating an impulse different from the policy of research in the company. It could clearly be seen that a turnabout was taking place in the company's policies, in the sense of building closer ties and intensifying the exchange of knowledge, within the Brazilian system of research, at a much higher volume than before. Data provided by Petrobras confirm that it spent US$ 33.5 million in scientific and technological cooperation in 2001 and US$ 15.6 million in 2002.[5] The main incentive for partnerships, in addition to CTPetro's own resources, came from the obligation of destining 1% of gross revenues to science and technology within the country (a special participation) for oil fields showing a high level of profitability. On the other hand, the resources destined to cooperative R&D projects with foreign universities and companies have been falling considerably in the last few years (Brasil Energia (Brazil Energy), n° 267, Feb. 2003, p. 20).

Thirteen other firms were included in the Public Call, in addition to Petrobras. These firms may be re-grouped into three important sub-divisions. The first is made up of companies that form the gas network in the country, a network led by Petrobras, which includes the following companies: TBG, Sulgás, Copergás, Msgás, Scgás and Potigás. These companies accounted for 6% of the firms' resources. The second subdivision is made up of companies that are not linked to Petrobras and that belong to the petrochemical sector. Companies that belong to this subdivision include Copene and OPP of the Braskem group, which accounted for 3.6% of the complementary resources. Copene alone took up 5 projects which were carried out by the UFRJ (*The Federal University in the state of Rio de Janeiro*) and the UFBA (*The Federal University in the state of Bahia*). Finally, the last subdivision is made up of suppliers to the petroleum and natural gas industry, a subdivision which includes companies such as Tag, Ecosorb, Itautec and Lubrizol. This subdivision put in 5.2% of the total sum of the firms' resources.

The number of the other companies, apart from Petrobras, and their participation in the projects can be considered small when compared to the economic importance that the petroleum and natural gas sector holds for the country. At first, it could be observed that no petroleum companies took part, except for Petrobras. In this segment, there are large national and international companies that did not take part in this Public Call. The IBP (*The Brazilian Institute of Petroleum*), which had been in charge of bringing together the companies that had participated in the Public Call of 2000, did not submit any new proposals for the Public Call of 2001. The oil supplies industry ended up with a very minimal presence in the process. The four firms whose

[5] The drop in the value in terms of US dollars can be attributed, to a large extent, to the devaluation of the real (Brazilian currency) in 2002, seeing as the real dropped in value, with respect to the dollar, 52.3% during the year, and it can also be attributed to the fact that CTPetro didn't issue any new Public Calls in that same year.

projects were approved were not the ones holding the highest rankings in the industry and, apart from that fact, were fewer than 10 that were approved of in the Public Call 03/2000.

Execution of Projects and Ties to Companies

The projects that were carried out which received funding by CTPetro were, to a great extent, left exclusively up to universities and research institutes. Brazilian legislation restricts the allotment of non reimbursable funds to this type of institution. This is a common institutional rule that has had a dramatic impact on the policies regarding technology in Brazil. This restriction has led the R&D activities of the projects financed by the Fund to be induced to have a predominant supply-sided nature. Indeed, the difficulties encountered to make the objectives explicit and to define a priori the form in which the knowledge will be shared and appropriated represent a strong element of uncertainty in the relationships among the actors that participate in the innovation process. This is an important reason why the internalization of R&D activities has been the institutional set-up of choice for firms. The R&D industrial laboratories have been the form adopted by large companies since the onset of the second industrial revolution to make the innovation process endogenous (Teece, 1988).

Hence, the possibility of achieving a level of externalization in R&D necessary for innovation in the companies is always partial. With the intensification of strategic partnerships among companies and the expansion in the numerous forms of interrelationships between university/company, one can expect there to be a higher tendency towards the externalization of R&D activities. However, the internal component continues to be the overruling one in the innovation process. Therefore, the largest portion of R&D carried out in developed countries is funded and carried out by firms. The research of innovation, carried out in central European countries, according to the guidelines from the Oslo Manual of the OECD corroborates that the internal sources of information is predominant in the innovation process (Barré and Papon, 1992). These characteristics are not present, evidently, in 'peripheral' countries, even in those that have economies of a scale as large as that of Brazil (Quadros et alii, 2001), which is clear proof of the strong influence of a supply-sided trend in these countries' science and technology policies.

The fact that the resources from the Fund are destined exclusively to universities/research institutes clearly demonstrates the supply-side line of logic that exists, in an almost implicit way, in the science and technology policies in Brazil. Nonetheless, the explicit science policy laid down by the FNDCT (*The National Fund for the Development of Science and Technology*) is attempting to go against this tendency by affirming that co-funding is required by the companies.[6] Co-funding, nonetheless, is used more often as a mechanism to identify the technological demands of companies, than as a guarantee that they will put in complementary efforts.

Co-execution of the projects would be the most suitable mechanism of effective absorption, by the companies, of the knowledge generated by universities/research centers. However, in the Public Calls issued by CTPetro only the resources that have been effectively channeled to universities/research institutes are accounted for. The co-execution of the project by the company is practically left out of the issue of being a complementary measure, not being

[6] The remark that there would be, in Latin American countries, a division between explicit and implicit Science and Technology Policies was put forward by A. Herrera (1971).

accounted for in the project.[7] So much so, that the funding policy encourages the execution of R&D activities in universities/research centers but not in companies, where it is most needed.

A visit to some of the companies participating in the Public Call of 2001 revealed that the projects, in the large majority of the cases, were being co-executed by the university and the company. This observation holds true, at the same time, for Petrobras as well as for other large companies such as Copene (currently Braskem). Moreover, it is also valid for suppliers such as TAG, which develops, through a partnership with Unifacs (from the state of Bahia) a spherical valve for use in deep waters.

The option of including in the instrument concerning funding only the R&D that is externalized by the firm, as assumed by the science and technology policy, is justifiable from the point of view of some specific state-run techno-structure segments, for the firms would only be putting in a low level of technological efforts. The firms would be responsible for a small portion of the spending in R&D in the country (38%, in fact). Hence, there would be no place to channel these resources to if they were to be destined to companies.

This thesis is questionable for the funding policy would not be leading companies to carry out R&D activities internally, but rather, to outsource them, being forced, moreover, to bear the financial burden of partially financing research holding a high level of uncertainty. Therefore, the policy would not be remedying the situation of the lack of R&D activities being carried out inside the firms.

Users of the New Scientific and Technological Knowledge

Perhaps the largest difficulty to be found in this policy lies in the institutional relationship created between the generator and the user of new knowledge. What guarantee exists that the new knowledge generated by the program will be effectively re-used in the production system? It was previously mentioned that the problems of lack of synchronization between the supply and demand of new knowledge were already present in the institutional set-up of the sectoral system of innovation in Brazil that existed during Phase I, when the functions of financing, executing and using the new knowledge were integrated in one single organization, Petrobras. In Phase I, a convergent network existed, although problems persisted in the network regarding translation among the different poles and functions.

During Phase II, a real institutional separation took place among the different functions in the innovation process of the CTPetro Program. Within this context, it is quite likely that problems related to translation became even more accentuated, which is a characteristic feature of open innovation networks. This separation would lead to making problems concerning relationships between generators and users of new knowledge tremendously large.

CTPetro's science and technology policies have tried to correct this distortion by introducing rules that have demanded, in an increasingly emphatic manner, that projects be carried out in conjunction with companies. The definition of the objectives of the research projects is based on identifying the technological demands of the companies. This policy had two phases. In the Public Call of 2000, the university-industry model of relationship was adopted as institutionalized by the PADCT III (*Plan for the Support of Scientific and Technological Development – Phase III*), in which the project, which had been the university's/research center's

[7] In the Public Invitation of 2001, it was stated that the project could cover other resources from R&D carried out by the company, but that these resources would not be included in the value of the complementary resources.

initiative, should be able to accept a business client, which would make its contribution through complementary resources. This model was improved upon in the Public Invitation. This new format determined that the initiative of defining the topic of the project was to be left up to the company. One could observe that the topics, in general, stemmed from initiatives made by companies that were successful in identifying partners in universities. The large companies Petrobras and Copene, which carried out R&D activities on a regular basis, had already taken part in cooperative projects with universities, even before the CTPetro Fund was created (in fact, finding support in public resources from the PADCT and the RHAE - Human Resources in Strategic Areas - Program). This measure made it possible for them to identify partners in universities for issues which they considered to have top priority and in which the company had interest in co-funding.

Establishing a contractual relationship between a firm and a funding agency, on the one hand, and a university/research center, on the other, may be seen as being a complex task. There is a certain asymmetry in the amount of information held by the actors in this relationship, which tends to grow larger as the difference in scientific and technological capacitation among the actors grows. Hence, the lower the technological capability of the clients (funding agencies/companies), the lower their chances will be to adequately define targets and to demand that the objectives be carried out. Moreover, the companies will also hold a lower capacity to make adequate use of the new knowledge generated. Therefore, asymmetry in information as defined by the theory of the Principal-Agent depends directly on the level and on the difference in technological capabilities among the institutional actors. The larger the asymmetry, the greater the problems related to translation will be within the innovation network. In the case of the Public Invitation there was, on the one hand, the choice of the topics of the projects to be made by the companies and, on the other hand, their commitment to carrying out R&D activities on a regular basis. These two elements led to a reduction in the asymmetry of information. On the contrary, since many competencies that existed in companies and universities complemented each other, there was a cross-fertilization of competencies.

It is fitting to divide the users of the knowledge generated by the CTPetro projects into two different categories. The first is made up of the direct users, which may be petroleum companies or suppliers. In this case, the clients of these firms may be considered the second users or clients of this new knowledge (see Figure 1). The users have always interacted with suppliers, seeing as many products in the petroleum industry are made customized to the users’ needs. The technological programs abroad (Furtado, 1997) tend to induce this type of interaction since it is beneficial both to the generation as well as to the dissemination of new knowledge. Nevertheless, there have not been, in fact, any cooperative projects between petroleum companies and suppliers that were financed by the CTPetro Program.

The low level of involvement of suppliers in cooperative projects is another factor that stands out in the Public Calls issued by CTPetro. In the Public Call 03/2000, participation reached the mark of only 10 companies and it dwindled to 4 in the Public Invitation. The fragile link in the current policy lies mainly in the area of suppliers, which, on an international scale, have made significant technological efforts and have been responsible for generating an appreciable amount of new technological knowledge in the petroleum industry. In Brazil, these suppliers have played a much more limited role. The assessment of the economic impacts of Petrobras’ technological programs in deep waters (Furtado et alii, 1999 and Freitas and Furtado, 2001) has demonstrated that the local suppliers, with some rare and noteworthy exceptions, have had a very small role in the generation of new technologies up until the beginning of the 1990s,

when the model that reigned was still that of imports substitution and the strategy upheld was nationalistic. In a later stage of opening the market to free trade, these links with national suppliers became lost to an even greater extent, whereas the links to universities/research centers were maintained and even strengthened.

The period of the 1990s proved to be quite unfavorable to Brazilian suppliers, which lost market share on both the domestic and foreign markets. The sectoral policy of Science and Technology has not shown any indications of attempts to correct this weakness in the sectoral system of innovation in Brazil, that has become cut off from the capacity of innovation of local suppliers. The companies were almost unaware of the Public Calls issued by CTPetro, although ONIP (*The National Organization of the Petroleum Industry*) participated directly in the Managing Committee of CTPetro. Out of a total of a sample of 21 suppliers under analysis, in a study requested by ONIP, these industries amassing R$ 2 billion in revenues, only 3 of them stated being aware of the program (ONIP, 2001). Furthermore, it is quite likely that the financing mechanisms, which require high sums of complementary resources, would not work to encourage suppliers to become interested in taking part in projects of CTPetro.

6. Conclusions regarding the Dynamics of the New Institutional Set-up

The main features of the new institutional set-up are shown in Figure 1. During Phase II, financing of R&D started to be shared by the State (Brazil's Federal government) and by Petrobras. Petrobras still invests a larger part of its resources in R&D activities carried out within the organization. Even so, the portion of resources that have been allotted to outsourcing R&D in national universities and research institutes has risen substantially.

In fact, although the sum of resources held by CTPetro is much smaller than the resources that Petrobras has, these resources have been accompanied by complementary resources put up by companies[8] and, hence, they have a much greater amount of leverage.

The set-up of the planning and coordination functions has become dramatically different. Although Petrobras has been playing a key role, through its technological programs, such as Procap and Pravap, as well as through internal planning of R&D activities, the new institutions entering the realm have begun to depend much more heavily on resources from the Federal government. This implies that there is a distinct form of coordination. Within this context, the programs carried out by CTPetro have taken on an important role in directing research. Nevertheless, the capacity that CTPetro has demonstrated for coordinating has shown itself to be limited. CTPetro's Pluri-annual Plan, with its 14 areas of top priority, has been overly generalized. No clear technological targets have been set to be reached. A clear model of a supply-sided offer at the counter was reproduced in the Public Call of 2000. In light of a certain amount of dissatisfaction within government circles themselves (ANP – National Petroleum Agency-CTPetro, 2000) institutional learning took place which resulted in new rules for the Public Invitation, which foresee that the companies should be responsible for defining the topics of the projects to be developed through a partnership with universities or research centers.

In the plan for executing the R&D activities, important re-arrangements should take place. Although Petrobras has not appeared to be reducing the sum of resources that it destines to R&D activities, neither with respect to the activities it carries out itself nor, much less so, with respect

[8] In the Public Invitation of 2001, the companies were required to put up resources equivalent to the resources being put up by CTPetro to finance research projects that were to be carried out in universities and research institutes.

to the resources it allots to R&D activities carried out by universities, it is hoped that the latter are being benefited by a large flow of new resources. Therefore, universities and research centers should start to take up a more prominent role in technological research in the petroleum industry. In compensation, the suppliers, which are the weak link in the sectoral system of innovation and have carried out limited efforts in R&D activities, have not been attracted to participate in CTPetro’s programs. They have maintained a very timid presence in cooperative projects.

The greatest risk presented by the new institutional set-up of innovation is that the R&D activities carried out by universities and research institutes may hold very weak ties to production activities.

It may be considered that the institutional set-up of Phase II led to a much more open network than the prior one. Open networks, due to the fact that they have a much wider variety of technology than a network of one sole organization, portray certain advantages when they function properly, such as the virtue of being more resilient in times of crises and to the depletion of technological trajectories. However, the success of these networks depends on the ability to effectively coordinate the activities and the strategies of each one of its authors.

Open networks present much larger problems in terms of coordination. The higher the number of institutional actors that interfere in the innovation process, the higher the costs of translation tend to be. The implicit character of technological knowledge and the uncertainties as to the results of research make it more difficult to reach a suitable inter-organizational relationship.

Problems linked to coordination revealed themselves with more magnitude during Phase II. One can see quite clearly a return to a science and technology policy that has a supply-sided nature, since the difficulties encountered in translation and in relationships among different poles and functions in the sectoral system of innovation tend to favor the predominance of partial lines of logic.

CTPetro, which in its type of performance follows the model defined by the FNDCT (*The National Fund for the Development of Science and Technology*) managed by Finep, has sought to build closer ties between the university/research centers and the industry. This relationship has proven to be problematic, seeing as the universities and research institutes cannot make up for the lack of technological capacitation encountered in the firms.

The universities and research centers have internal lines of logic that differ from those of companies. Even if policies may solicit interaction, the asymmetry in information that exists between the executors and financing agents of R&D activities and the strong presence of the interests of the scientific community in the diverse moments of decision-making can explain, up to a certain extent, the tendency of a supply-sided logic to prevail.

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