CAN NATURAL RESOURCES SECTORS PROVIDE AN ALTERNATIVE FOR TECHNOLOGICAL DEVELOPMENT? THE CASE OF THE BRAZILIAN OIL AND GAS SECTOR

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Can Natural Resources Sectors Provide an Alternative for Technological Development? The Case of the Brazilian Oil and Gas Sector

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1 INTRODUCTION

The building of innovation networks is in the root of a nation's capacity to capture knowledge and innovative externalities that deliver free lunches offered by technical progress. Similar thesis has been put forward by Perez (2008) that argues that learning and capability accumulation may be driven from natural resource industries in Latin America. Her arguments are based on the fact that these industries represent opportunities for local production of components of global corporations' value chain and for the establishment of technological networks where knowledge would be embedded.

The oil and gas industry represents the kind of opportunity stressed by Perez (2008), but, unlike other industries, value chain coordinators may be domestic players as national oil corporations (NOCs) may guide the establishment of knowledge networks. This paper aims at presenting the opportunities for learning and capability accumulation in Brazil, stressing the availability of financial funds, the existence of production and technological capacity and the intricate flows of knowledge that have been historically implemented in the Brazilian oil and gas industry.

The report is organized in seven sections, including this introduction. The second section is dedicated to present the organization of the industry, stressing the opportunities for technological development that NOCs may face. The third section shows the importance of the oil and gas industry in the Brazilian economy. The fourth section presents the financial funds available to science and technology (S&T) in the oil and gas industry and the main guidelines of innovation policy in Brazil. The fifth section is dedicated to present national content policy and the oil and gas firms' network formed by Petrobras leadership in Brazil. The sixth section argues for the existence of misconceptions and shortcomings in innovation and national content policies. The seventh section presents the main conclusions.

2 CHARACTERIZING THE BUSINESS

The oil and gas industry is characterized by its incapacity to differentiate product. Therefore, cost reducing technology trajectories and the creation of new possibilities to exploration and extraction of new previously inaccessible reserves dominate its innovative process (Bower and Young 1995). In this case, scale economies are an important trajectory to be followed by players in the industry. However, this industry is also characterized by working in different and specific geological conditions which create obstacles towards the achievement of scale economies. As a consequence, economies of scope have become a more important driving force to cut costs (Bridge 2008).

The need to achieve scope economies required the development of specialized suppliers that would custom services and equipments to the specific needs of oil and gas operators. These suppliers were responsible for knowledge transference across and inside oil provinces. The technological importance of these suppliers increased after the sharp decline in oil prices during the 80's and oil operators decided to reduce R&D efforts from a historic average of 1% of sales to 0.5% (Furtado and Ribeiro 2007, Jacquier-Roux and Bougeois 2002). Service and equipment suppliers began then to increase their technology intensity.

In order to achieve scope economies, the industry relied on specialized service and equipment suppliers that guaranteed the transference of technological capabilities across different geological scenarios. This important advance in organization became possible due to the pattern of competition between oil and gas operators. Oil companies compete through a process of risk control, managing the identification and acquisition of oil provinces, the rhythm of production in oil and gas reservoirs and logistics of supply. Service and equipment suppliers compete through service quality, innovation and the up-bringing of solutions in extreme exploration and production conditions and cost reduction (Acha and Cusmano 2005).

Furtado and Ribeiro (2007) and Jacquier-Roux and Bougeois (2002) argue that the tendency for the labor division across these two groups of firms increased since the 1980's, when oil prices went down and oil operators decided to reduce R&D efforts from an average of 1% to 0.5% of total sales. This decrease in R&D intensity has been accompanied by an increasing technological role played by service and equipment suppliers. Though the increase of importance of suppliers in oil and gas technological scenario, operators still are responsible for a substantial part of the industry's total technological effort. Figure 1 shows R&D expenditures and intensity for the main oil and gas companies and oil and gas equipment and service suppliers. Suppliers appear to be much more technologically intensive, however, the largest R&D budgets are still held by oil and gas companies.

On the other hand, service and equipment suppliers changed their strategies. First, they engaged in a very aggressive movement of mergers and acquisitions resulting in greater diversification of their activities. This process generated the four large integrated companies (Schlumberger, Baker Hughes, Halliburton and Weatherford) and in some way it is still going on (Iootty 2004). Second, these companies largely increased their technological intensity and diversified their technological portfolios (partially explained by the M&A process). Jacquier-Roux and Bougeois (2002) show that the decrease in technological activity of oil companies was compensated by an increase in technological intensity of service and equipment suppliers. Figure 1 shows R&D expenditures of the major oil and gas companies and service and equipment suppliers. Some important observations may be derived from the values presented. First, service and equipment suppliers have greater technology intensity when compared to oil and gas companies. Second, the volume of expenditures of oil and gas companies are still very large. This coincides with the observation made by Acha and Cusmano (2005) that oil and gas companies still perform an important role as network coordinators in the industry. Third, Statoil and Petrobras appear amongst the highest R&D oil and gas companies expenditures. Petrobras has the highest R&D intensity when compared with the 12 largest R&D budgets, while Statoil has the fourth greatest R&D intensity.

Jacquier-Roux and Bougeois (2002) argue that the relationship established between oil and gas companies and their suppliers has changed from short run commercial relations towards long run partnerships. The main reason for the undertaking of long run partnerships is associated with geological and sea (in the case of offshore upstream) heterogeneity that may require development of specific solutions. Therefore, innovation is a constant theme in the relations between these actors. Additionally, competition strategies of oil companies have allowed the formation of consortia that focused on general technologies to extend technological frontiers. These consortia also have allowed learning by newly established NOCs. Furtado and Freitas (2005) state that Petrobras' learning and capability building process largely relied in consortia agreements with other oil companies and cooperative R&D with independent suppliers. In this case, as highlighted by Bridge (2008), the oil and gas industry offers appealing ground for learning and capability building.

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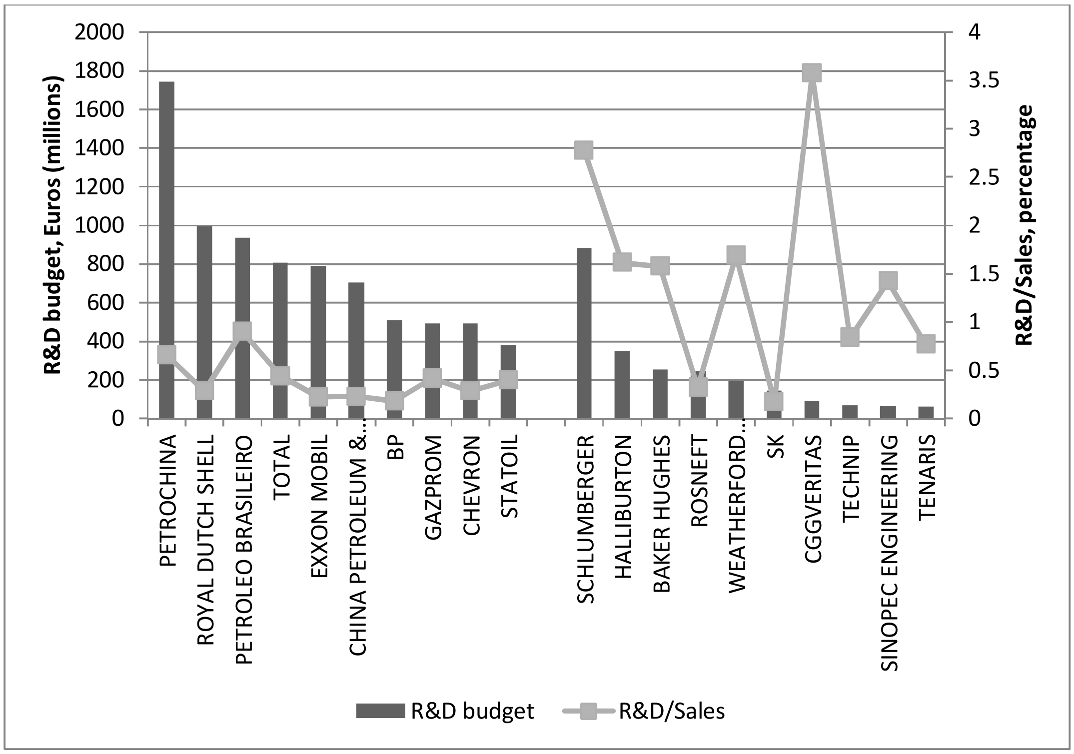
Figure 1. R&D Expenditures (current million British pounds) and R&D Intensive (R&D/Sales) of Oil and Gas Major Companies and Service and Equipment Suppliers, 2012



Source: DTI 2013.

3 NATIONAL PANORAMA

3.1 A Historical Summary of the Brazilian Case

Unlike most NOCs, Petrobras was not created, as a way to appropriate oil's windfall gains. On the contrary, the nationalistic foundation of the company was carried out in a moment when very little oil was available in the country. Petrobras had important goals to achieve such as: (i) to save foreign currency; (ii) to provide secure oil and fuel for the country's need; and (iii) to find oil in Brazilian territory. Due to oil scarcity, Petrobras had to rely on sound management and to develop technological and productive capabilities to achieve its goals and provide resources for its investment strategy. In a sense, Brazil's oil and gas is a consequence of Petrobras, not the reverse.

The progress of Petrobras was most of the time accompanied by the development of a domestic equipment and service supplies industry (ESSI). The first steps towards supplier development were taken in downstream under the seventies' import substitution policies. Ribeiro and Furtado (2009) list four components of this policy: (i) encouragement to technology transfer to Brazilian domestic producers, through licensing agreements or joint ventures; (ii) the creation of a trade organization ABDIB[1] to disseminate norms and quality standards; (iii) the creation of a Procurement Department inside Petrobras to qualify suppliers, provide technical supervision and develop new products not present in the Brazilian market; and (iv) the practice of higher prices in the domestic supplies market. In a sense, the capabilities used to manage the supply chain and to transfer technology were accumulated through refinery plant operation.

The growth of offshore upstream activities wasn't however accompanied by the same development of the ESSI. The lack of previously accumulated capabilities in domestic industry and in Petrobras plus the need to rapidly expand oil production in order to save foreign currency determined the acquisition of foreign equipment and service. This trend was intensified by the nineties liberalization policies and the new model after the end of state monopoly over oil exploration and production. Petrobras' knowledge transfer programs to suppliers, such as quality and standard controls, were discontinued and the preference towards domestic supplies attenuated. Furthermore, the interruption of Petrobras' downstream investments practically left the Brazilian ESSI without client.

The nineties regulatory regime attempted to organize the supplies industry and provide science and technology resources for capability building for operators and Universities. On the ESSI side, the most important step was the creation of National Organization of the Petroleum Industry (ONIP), a private non-profit organization whose mission was to maximize the national benefits of the oil and gas development. On the capability building front, two initiatives were carried out: (i) the establishment of CTPETRO, a science and technology fund that managed around R$ 673 million from 1999 to 2006; and (ii) the destination of 1% of the rents from high productivity oil fields to be allocated by operators in R&D activities (ANP R&D funds). Half of the resources have to be used in universities, while the other half may be invested in industrial R&D. From 1998 to 2008, the volume of resources from this budget source were R$ 3.8 billion. However, very few resources were directed to ESSI companies.

In the beginning of the 2000's, the domestic ESSI presented high idle production capacity. The lack of downstream investment and the new procurement policy implemented by Petrobras did not foster domestic content. In 2003, there was a new shift in the conduction of the oil and

[1] Associação Brasileira das Indústrias de Bens de Capital.

gas business and its involvement with ESSI in Brazil that may be represented in two important initiatives: (i) a change in licensing and bidding procedures by ANP, the Brazilian Oil Regulation Agency, that began to include operators' compromise to achieve domestic content. At a first moment, the required domestic content in new projects was 60%. Later tenders have proposed 70% of domestic content; and (ii) the creation of the PROMINP, a governmental program that has the mission to maximize domestic industry's share of oil and gas supplies in competitive bases. The PROMINP is headed by governmental officials, Petrobras, the BNDES (National Bank for Economic Development and Social Act), one representative of ONIP and one representative of operators (IBP). The creation of PROMINP added two important features to ESSI coordination: (i) government plays a more prominent role in guiding decisions. This has made a difference in the supply of funds and people for carrying out industry initiatives; and, more importantly, (ii) Petrobras commitment.

Immediately after the implementation of contractual clauses for domestic content, Petrobras began to pursue domestic content goals even in licensed block that did not include the clause. Petrobras increased technology transfer practices. The company implemented a new program for standard and quality control of some of its suppliers (PGQMSA) that consists of supervision and monitoring of production procedures of its supplies. The company gathered information on best practices, then established patterns for its suppliers, and has been monitoring them since its implementation. Petrobras also increased the size of its program for supplier development. This program may involve the supply of new products or the development of suppliers to substitute for previously imported equipments.

The PROMINP relied at first in three initiatives: (i) Petrobras, EPC contractors and ESSI trade unions made joint initiatives to increase standardization of equipment and acquisition procedures and transparency and to identify bottlenecks for domestic supplies; (ii) PROMINP and trade unions organized a program for human resources formation, which was identified as the most important bottleneck for industrial development. In the last five years, this program has trained more than 80,000 workers in different skills levels; and (iii) PROMINP began the identification and the pursue of policy measures to ensure competitive conditions for ESSI.

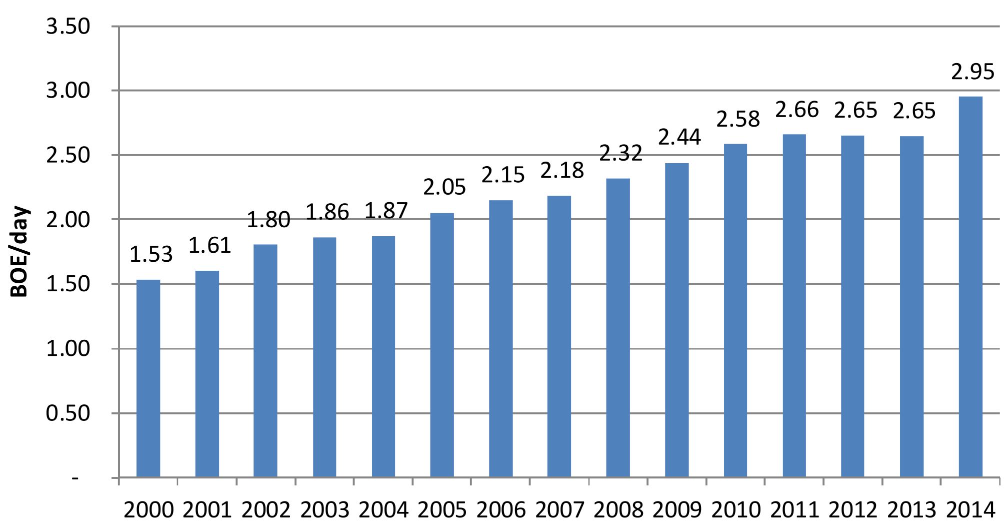
The discovery of the Pre-Salt province, in 2007, opened new challenges and opportunities for the Brazilian oil and gas industry. Not only necessary scale was achieved but also some solutions are still unknown and some technological trajectories have not yet been established. In order to deal with these technological challenges, CENPES (Petrobras R&D lab) prepared a strategy that involved doubling its facilities but also a closer interaction with the main Petrobras' integrated suppliers.

Petrobras also adopted a discretionary policy towards foreign integrated service companies and more innovative subsea technology suppliers that involves the establishment of R&D facilities near CENPES. The main operative reasons for attracting these labs are the need for proximity and the guarantee of dedication to Petrobras' research and production interests. The long run goal is to increase the country's absorptive capacity.

3.2 The size of the oil and gas industry in Brazil

It is clear that Brazil has become an important player in the oil and gas industry. Brazil almost doubled its oil and gas production since 2000 (see Figure 2). In 2013, Brazil produced around 3% of the in the world's oil and gas and was the 12th most important oil and gas producer. Expectations are that production, due to the pre-salt discoveries will rise to 5.2 million barrels a day, in 2020 (see Table 1), taking the country to the top five positions in terms of production. Nonetheless, data does not allow asserting that Brazil will be an oil dependent country. In 2012, Brazil still held a deficit in the oil and gas trade balance and the yearly per capita oil trade surplus in terms of figures expected for 2020 will be limited to one figure.

Figure 2. Evolution of Oil and Gas Production in Brazil, 2000-2014, millions barrels of oil equivalent per day (BOE/day)



Source: ANP. http://anp.gov.br/?pg=69299&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1423685522125.

Table 1. Oil production and oil dependence in countries' economy, selected countries, 2012

	Oil production (M bbl/day)	Oil consumption (M bbl/day)	Surplus (M bbl/day)	Population (millions)	Yearly oil surplus per capita (units)
Saudi Arabia	11.73	2.89	8.84	28	115
Norway	1.9	0.22	1.68	5	123
Russia	10.4	3.2	7.2	143	18
USA	11.11	18.49	-7.38	313	-9
Brazil	2.6	3	-0.4	198	-1
Brazil (2020)[1]	5.2	3.5	1.7	214	3

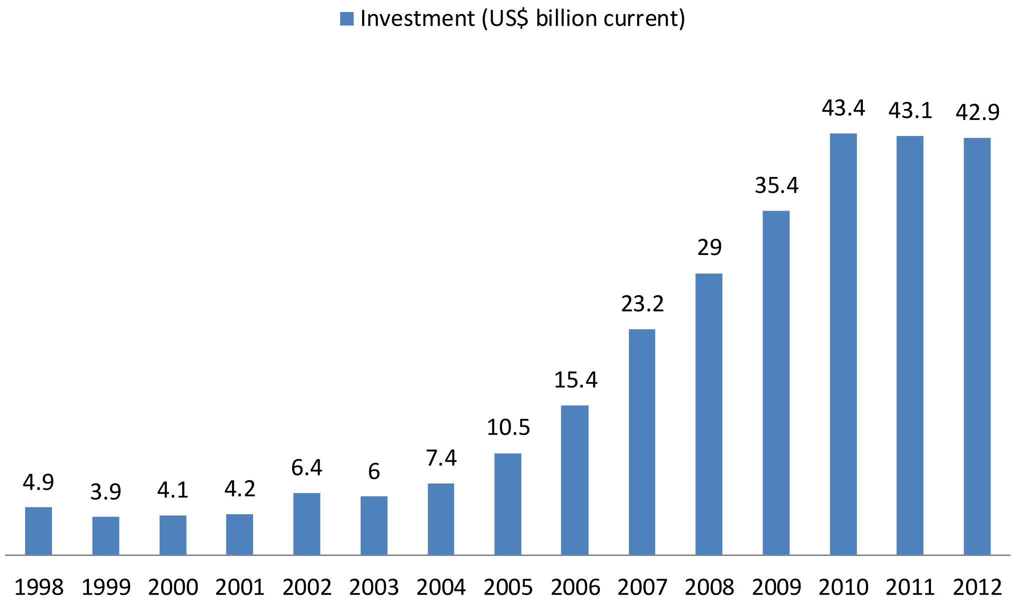
Source: Own elaboration using data from ANP and World Bank.
[1] Data from Petrobras.

According to the Yearly Industrial Survey carried out by the Instituto Brasileiro de Geografia e Estatística (IBGE), the oil and gas industry represented, in 2012, 14.7% of the value added of the Brazilian Mining and Manufacturing Industry.[2] It is the second most important two-digit industry in Brazil, after Manufacture of Food Products. The oil and gas sector is also central to the financing of the Brazilian state. According to Affonso and Castro (2010), the collection of taxes – the value added tax (ICMS), the income taxes plus royalties and special participation – from the oil and gas sector amounts to 3% of the Brazilian GDP (more or less 8% of total tax income).

The most important contribution from the oil and gas sector to the Brazilian economy occurs in investment (see Figure 3). BNDES (2014) estimates that during the 2014-2017 period, the oil and gas sector will invest R$ 488 billion (in 2013 prices), which would correspond to 12% of the expected investment in fixed capital in Brazil. This investment has strong impact in the demand for goods and services in Brazil. One example of this importance is the performance of the shipping industry. In 2002, before PROMINP was created, the shipping industry employed 13,539 people. In 2012, it employed 48,561 people.[3]

[2] This value is obtained summing divisions (two digit) 6 and 19 of ISIC 4. It should be stressed that Petrobras as a company is listed in division 19, Manufacture of coke and refined petroleum products.
[3] Data obtained from IBGE Pesquisa Industrial Anual 2002 and 2012 editions.

Figure 3. Petrobras' Investments, 1998-2012, US$ billion, current



Source: Petrobras, http://www.investidorpetrobras.com.br/pt/destaques-operacionais/investimentos/historico-de-investimentos-nominal/historico-de-investimentos-nominal.htm.

4 INSTITUTIONAL INNOVATIVE FRAMEWORK: DIRECTING RESOURCES TO INNOVATIVE ACTIVITIES IN THE OIL AND GAS INDUSTRY

4.1 CTPETRO: Resources from royalties to S&T

The end of the state monopoly over the exploration and production of oil was accompanied by a cluster of regulatory measures that attempted to appropriate and distribute oil rents. These measures included the establishment of royalties and special participation that were directed to federal, state and municipal governments. A share of these resources[4] should be directed to the Oil and Gas Science and Technology Fund (CTPETRO). The main goal of CTPETRO is to stimulate innovation in the oil and gas supply chain, the development of human resources and the establishment of technological partnerships between businesses and universities. The fund is managed by FINEP, a Brazilian federal agency for the financing of innovation, and CNPq, another federal agency that aims to support research in science and technology.

[4] 25% of the Union's share that surpasses 5% of oil and gas production.

The resources collected by CTPETRO may be used by universities and non-profit research centers. Business firms may benefit from these resources whenever they engage in partnerships with these agents, but no resource may be directly received by them.

Therefore, universities and research centers may demand these resources to:

(i) obtain research grants for students and capability building activities;
(ii) organize conferences and other science and technology disseminating activities;
(iii) science and technology projects; and
(iv) projects that are demands of companies and other oil and gas institutions.

CTPETRO is the most important of the many sectoral science and technology funds created during the 90's liberalization process. In 2013, the total resource collection of these funds amounted to R$ 4.3 billion and CTPETRO alone collected R$ 1.4 billion. Table 2 shows the values collected by CTPETRO from 2006 to 2013, in US$ current. Two factors affect the total resources collected by the fund; (i) production; and (ii) oil prices. It is shown that the amount of resources available has increased along the years due to production (Figure 2) and price changes. Nonetheless, resources destined by the budget law to FINEP and CNPq did not increase, that is, S&T resources have been used to fulfill fiscal targets. For instance, in 2013, for the total royalty income (US$ 663 million) destined to S&T funds, only US$ 76 million were allowed to be spent in S&T projects. The MCT collected these funds and used them in three different destinations: (i) the implementation of Human Resources Programs in 45 undergraduate and postgraduate programs selected by the National Oil and Gas Regulating Agency (ANP), adding to US$ 11.5 million; (ii) transference to CNPq to be used in S&T programs destined to university researchers, US$ 9.9 million; and (iii) in 46 projects run by FINEP, valuing US$ 17.4 million.[5]

One should nonetheless be aware that the change in the regulatory system from concession to production sharing agreements has altered the way royalties and special participations are distributed, destining the whole amount of resources to education and health. This change has left a cavity in the financing of S&T initiatives in the oil and gas sector.[6]

[5] US$ 2.2 million were destined to management expenses.

[6] FINEP (2013) Relatório de Gestão do Exercício 2013. Fundo Nacional de Desenvolvimento Científico e Tecnológico. http://www.finep.gov.br/pagina.asp?pag=numeros_contas_anuais.

Table 2. Values destined to CTPETRO, 2006-2013, US$ millions current

	S&T Resources from Oil and Gas Royalties	Resources destined by budget law	Resources Committed to Approved Projects	Total Disbursement
2006	322	55	54	21
2007	386	72	71	56
2008	580	64	63	44
2009	403	61	47	26
2010	512	69	67	32
2011	789	57	35	14
2012	736	52	23	15
2013	663	76	41	14

Source: Ministério da Ciência e Tecnologia.

4.2 The ANP's R&D Clause

Apart from CTPETRO, R&D investments may also benefit from the 1% R&D clause created by ANP. According to this clause, oil companies must invest in R&D 1% of their revenues from high productivity oil fields. The clause establishes the following criteria for distribution of these resources: (i) up to 0.5 percentage point in the concessionaires' own facilities, or in their affiliates, or in national companies; and (ii) at least 0.5 percentage point in R&D institutions accredited by ANP. If resources are not applied in R&D according to these rules, oil companies should pay an additional fine. Figure 4 shows the evolution of the resources collected from the 1% R&D clause. Again, growth in prices and production explain the rise in the values.

The main objective of the 1% clause was to guarantee that the 90's market oriented Petrobras would still maintain its R&D investment and its main R&D lab (CENPES). In fact, Petrobras has been able to keep R&D investments and has remained a technological leader throughout the years.

The clause also provided very important resources to universities. Universities were central to the capability accumulation of Petrobras. Furtado and Freitas (2004) argue that in two of seven central technology development project carried out under PROCAP 1000, two had universities as a central partner for development and capability building.[7] Therefore, it would be natural to have universities as partners as the oil business in Brazil grows. From 2006 to 2013, the ANP R&D clause has provided R$ 4 billion to investments in the universities. These resources have supported more than 1,200 projects developed in universities throughout the country. The

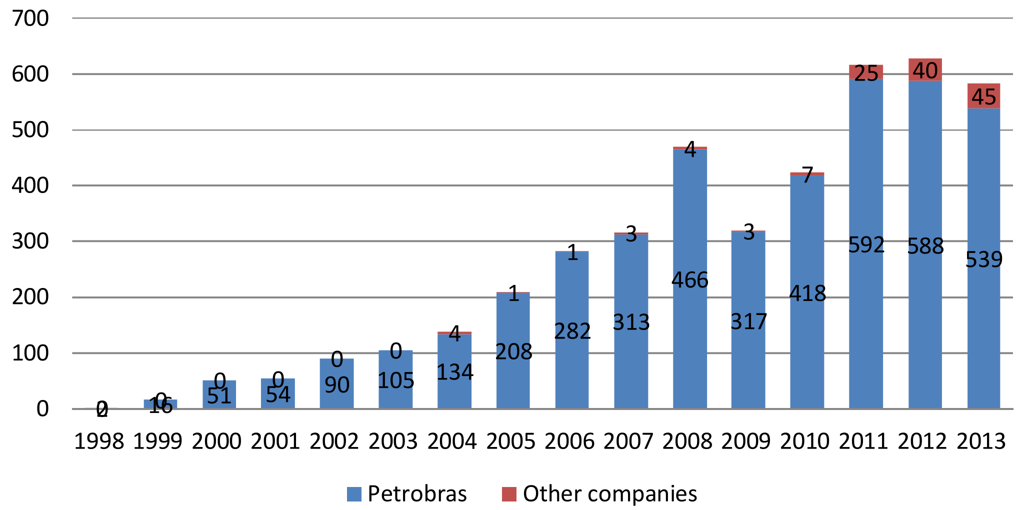
[7] The PROCAP 1000 was a Technological Project carried out by PETROBRAS from 1986 to 1992. PROCAP aimed at developing technological and production capabilities to operate in water depths up to 1000 meters.

resources are relatively concentrated in universities in Rio de Janeiro state (1/3 of total resources) and São Paulo state (13%), but Petrobras (the main fund raiser) has been making efforts towards regional decentralization.

At least in the initial applications, the resources have been mainly applied in the building and equipment for universities' research facilities. ANP estimates that from 2006 to 2009, R$ 1.4 billion were applied in the building of laboratorial infrastructure, while R$ 264 million were paid to human resources. The university projects have been organized in thematic areas that are shown in Table 3. If funds directed to PROMINP, Human Resources and Science without frontiers program are added, we can see that 1/3 of the total sum were dedicated to personnel training and education.

One further observation from Figure 4 is the increasing share of resources from other oil companies apart Petrobras. Increasingly foreign companies are bind to spend resources in R&D in Brazil. Whenever resources are of small amount, oil companies direct them to university projects that may help their activities in Brazil. In this sense, the effect is similar to those of Petrobras' applications in universities. However, when resources are large, foreign oil companies may begin to think about establishing their own R&D labs in Brazil. This seems to be the case of the BG Group that has been obliged to spend almost R$ 200 million in R&D, the second largest amount after Petrobras. This has motivated the company to open an R&D lab in the UFRJ campus, where CENPEs is located, called BG Group's Global Technology Centre. The BG Group intends to invest US$ 2 billion in this R&D lab up to 2025. The GTC will mainly source R&D projects with partners in Brazil. This includes private suppliers with many of these companies now establishing research facilities in Brazil. It will also be responsible to establish links to university and to focus human resources training, in order to attend the legislation.

Figure 4. Evolution of Resources from ANP's R&D Clause, 1998-2013, US$ current



Source: ANP (2014) *Boletim ANP Petróleo e P&D*, 16, december.

Table 3. ANP R&D Clause Resources to Universities and Non-Profit R&D Labs by Thematic Area, 2006-2013

	Number of Projects		Resources	
Area	N	%	R$ current	%
Exploration	131	10	253,149,348	6
Production	276	22	712,645,636	18
Downstream	196	16	326,253,682	8
Gas, Energy and Sustainable Development	202	16	285,891,195	7
Management and Innovation	7	1	6,064,637	0
Regional Centers	58	5	203,431,462	5
Prominp*	6	0	437,255,639	11
Multiareas	157	12	485,970,471	12
Human Resources	195	15	564,477,596	14
Science without frontiers**	15	1	393,810,834	10
Stratigraphic Test Well	16	1	298,684,561	8
Total	1,259	100	3,967,635,060	100

Source: ANP (2014) *Boletim ANP Petróleo e P&D*, 16, December.

* PROMINP is the National Program for Mobilizing the Domestic Oil and Gas Industry. Most of the resources are dedicated to the National Program of Personnel Qualification, which qualified around 100,000 workers for the Oil and Gas Industry, including suppliers.

** Science without frontiers is a national education program that sends postgraduate and undergradute students to foreign universities, either to obtain a complete degree or to short period stays.

4.3 Impact in University Research

CTPETRO and the ANP R&D clause have strong impact on universities and other public research center. Bazzo and Porto (2013) try to capture the impact of these funds on the establishment of research agreements between Petrobras and universities and non-profit research centers. They show that, between 1982 and 2000, 48 innovating projects were carried out between Petrobras and this network of research institutions, while between 2000 and 2007, this number raised to 108. It seems clear that the new policies had strong impact on the interaction between Petrobras and research labs.

This interaction is quite important for the universities and non-profit research labs. Porto, Turchi and Rezende (2013) have assessed the impact of Petrobras' innovation networks on universities. They made investigation through questionnaires on 601 Brazilian university registered research groups during the years 2008-2009. These groups had around 16.6 thousands researchers of which more than 8 thousands were involved in Petrobras' contracts and demands. The same research concluded that, in the last five years, 3.7 thousands papers, 2.4 thousands master dissertations and 1.7 doctoral thesis were published related to these Petrobras' linked resources. Petrobras' resources were used in the building of 165 research labs and in the reform of more than 200 other labs.

Furthermore, the Petrobras network has also impact on cooperation. Fioravante and Aguirre (2013) show that Petrobras' suppliers are more likely to cooperate with universities and public research labs than a control sample. Rocha and Bueno (2008) show, using Brazilian Innovation Survey for 2003, that oil and gas suppliers have strong innovative behavior when compared to other Manufacturing and Mining companies in Brazil. Nonetheless, they have lower R&D expenditures. They then explain this behavior due to the larger cooperative relations oil and gas suppliers establish with their clients (Petrobras) and outside industry agents, such as universities.

4.4 Innovation Policy in Brazil

In the beginning of the 2000's, the amount of supply of funds to innovation averaged less than R$ 1.5 billion a year. From 2004 on, the Brazilian innovation policy suffered a major shift and, in 2010, the governmental funds to innovation reached almost R$ 10 billion a year. The increase in the amount of expenditures was due to important policy initiatives carried out by the government. The Innovation, Technology and Trade Policy (PITCE) was the first governmental step in terms of a general innovation policy framework. Since then a large number of policy instruments and regulations have been put in place to strengthen Brazil's science and innovation potential. The Innovation Law (2004) was designed to strengthen the university–industry research relationships, promoting the shared use of science and technology infrastructure by research institutions and firms, allowing direct government grants for innovation in firms and stimulating the mobility of researchers within the system. The transfer of university knowledge to companies would be achieved mainly by means of the obligatory creation of Technological Innovation Nuclei (TIN) at universities and by the release of laboratories and equipment to be shared between science and technology institutions (STI) and companies. Furthermore, for the first time in the country the public resources could be transferred as non-refundable funds to enterprises, sharing the costs and risks of innovative activities. The enactment of this law thus permitted the creation of the Economic Subsidy program, in 2006, coordinated by FINEP, which provides resources for research and development (R&D) activities at the company.

Law 11.196 was enacted in 2005 to reinforce advances of the Innovation Law. It was replaced in 2007 by Law 11.487, which became known as the "Goodwill Law" (Lei do Bem). This Law speeds up and expands incentives for investments in innovative activities, authorizing the automatic use of fiscal benefits for companies that invest in R&D and are within requirements, without any need of a formal request. The special tax regime and fiscal incentives for companies created by the Goodwill Law stipulate, among others: deductions from income tax and social contributions on net profits due to expenses on R&D (between 60% - 100%), reductions in taxes on industrial products due to the purchasing of machines and equipment for the performance of R&D (50%), economic subsidies through scholarships for researchers in companies and an exemption from the Contribution for Intervention in the Economic Domain (CIDE) due to patent deposits. It also includes funding to firms who hire employees with Masters Degrees and PhDs. The subsidy can reach up to 60 per cent of the salary in the North East and Amazon regions and 40 per cent in the rest of the country for up to three years.

In order to broader the focus of the industrial policy, the Productive Development Policy (PDP) was launched in 2008 with the objective of sustaining the process of economic growth, increasing investment and economic growth rates. The main challenges are the expansion of supply capacity in the country, preserving the robustness of the balance of payments, raising the innovation capacity and strengthening micro and small enterprises. Four priorities were to be achieved by 2010: the increase of investment rate, the expansion of Brazilian exports in world trade, the increase of R&D expenditures and the increase in the number of SME exporters. PDP also includes the establishment of spending targets and tax breaks for key sectors like IT, biotechnology and energy as well as plans to increase international trade from 1.18 per cent in 2007 to 1.25 per cent by 2010, with an emphasis on high tech exports. Targets include boosting the number of micro and small businesses that export goods and services by more than 10 per cent in 2010. One of the main objectives of the strategy embodied in PDP, although not explicit, is to raise the innovation capacity of the productive sector. In fact, it is not clear what is meant by innovation capacity and no indicators are offered in the policy document to measure the achievement of the objective. The main goal set is to raise private business research and development (R&D) expenditures to 0.65% of gross domestic product (GDP) by 2010, over 0.51% of GDP in 2005. In addition, the accessory objective set is to double the number of patent deposits of Brazilian enterprises in the local patent office (INPI) and triple the number of patent deposits abroad.

In 2011, the government launched the Plan Brasil Maior. Mostly, it maintained the measures and goals that were already present in PDP. There are however two important differences. First, the plan created EMBRAPII, inspired in the good historical results obtained by EMBRAPA in providing technology and innovation for the agricultural sector. The main objective of EMBRAPII is to provide support and connect science and technology institutions to business firms. It is a bridging institution that is supposed to link knowledge available in universities and R&D laboratories with the needs of the industrial sector.

The second novelty of the Plan Brasil Maior is the creation of INOVA EMPRESA. An analysis of the Brazilian innovation policies allows the conclusion that the changes that took place in of Lula's first term government were rich in providing supply instruments to innovation policy. However, there was no design for demand instruments. INOVA EMPRESA tries to fulfill this gap by linking supply instruments to demand. INOVA EMPRESA is therefore split into sectoral progams. One of the most important sectoral programs of INOVA EMPRESA is INOVA PETRO. INOVA PETRO unites financial funds available in FINEP and BNDES with the technical support available in PETROBRAS to define priorities and targets to be achieved by financing instruments in the oil and gas value chain. It therefore targets technologies associated with surface oil processing technologies, subsea technologies and equipment and oil wells installation technologies. INOVA PETRO will count with R$ 3 billion of funds from BNDES and FINEP up to 2017.

5 NATIONAL CONTENT POLICY

National content clauses have been present in oil and gas exploration and production contracts since the first bidding round that took place in 1999. The main purpose of local content requirements is “to allow locally established goods and service providers to participate in the oil and gas supply chain and increase their market share in a competitive basis” (ANP 2012).

Until the fourth round, the clause established that preference to domestic suppliers, but did not have any particular national content target. Rounds five and six, that took place in 2003 and 2004, contracts established minimum percentages based on whether blocks were located onshore, offshore shallow water or offshore deep water. In 2005, authorities established a methodology to measure local content. In 2007, minimum and maximum local content levels were established per equipment. This regulation still holds up to today. Thus, regulation has become stricter as time has gone by. Moreover, monitoring has also become tighter and ANP has been playing an increasing role in this matter.[8] In fact, local content has begun to play a central role in oil and gas policy in Brazil and the fulfillment of these requirements have become a central concern for policy makers, oil companies and major suppliers.

In order to measure national content, authorities have developed a rule book to be followed by oil and gas suppliers from the 7th round on. This rule books submits to certification every item and sub item acquire by oil and gas companies activities and their EPCs in their exploration and production. National content targets are established per item and sub item.

5.1 Oil and gas suppliers’ in Brazil

In order to become a Petrobras’ supplier, the firm has to fulfill requirements established by the company to obtain a certificate of supplier (CRCC) that authorizes departments in the company to acquire certain goods or services from the firm. Apart from formalities associated with the legal status of firms, Petrobras requires social responsibility, environmental and health certifications (respectively, ETHOS, ISO 14001 and ISO 18001). If the supplier provides critical products, product quality certification (ISO 9001) is required.

Firms that obtain the CRCC increase their value in the market due to the signaling of product quality it represents. Two examples may be given of this kind of value. One firm had its

[8] Regulation ANP no. 9/2007, which establishes the frequency, the format and the content of local investments reports made with exploration and production development activities, is hereby approved and Regulation ANP no 19/2013 establishes specific local content certification model and presents a local content booklet.

property structure changed. There were two partners. One of them left the partnership to open one company in the same line of business. The certificate was negotiated as part of the deal. Another case was related to an affiliate of a multinational enterprise. This affiliate had production facilities in Brazil. However, in the case of Petrobras, most of the sales were done by a foreign affiliate of the multinational and the Brazilian affiliate had the function of maintenance and sales office in Brazil. However, it maintained its plant certified by Petrobras because the certificate would guarantee supply to other sectors such as steel mills and paper and pulp. Nonetheless, firms that become Petrobras' suppliers have their overall costs increased in order to cope with the requirements of the certifications. This has been stressed by some of the suppliers. They tell that they leave one type of market that takes price as the most important variable and enter another market where quality has an important role.

According to IPEA (2011), between 1998 to 2007, Petrobras demanded goods and services from 8,046 suppliers from the manufacturing industry and selected services industry. These contracts involved a demand of R$ 232 billion (2008 constant prices). De Negri et al. (2011) show that, on average, Petrobras's suppliers[9] are larger, have a larger percentage of scientific personnel (2.21% against 0,73 of industry average), engineers (1,71% against 0,51%), greater wages (R$ 1691 against R$ 932) and better education (10.1 against 8.8 years). Therefore, Petrobras' suppliers are amongst the most qualified firms in the Brazilian economy. This quality may be a consequence of either the necessary upgrade to obtain the CRCC or a previous quality already in the firm that allows it to become a supplier.[10] So, one important question would be if Petrobras adds value to its suppliers. In order to analyze the impact of Petrobras procurement on firm performance and capability building, De Negri et al. (2011) use propensity score matching techniques to define a control group with respect to a set of characteristics. Analysing the treated sample (Petrobras suppliers) against the control sample, they find that Petrobras' procurement and continued has positive effect on firm growth, labor force education level and wages (which may be an indicator for productivity). They however find a negative impact on exports. Though no test is run by De Negri et al. (2011), this negative effect may be result of the redirecting of resources towards the greater opportunities provided by Petrobras. Interviews from Oliveira and Rocha (2008) review that most Petrobras' suppliers that were exporters in the moment of the interview, became exporters before supplying for Petrobras. Again, anecdotes can throw some light into the matter. Two turbine producers were interviewed and both firms were exporters. The first one had been a Petrobras supplier

[9] Data from RAIS (2006).

[10] This is the case, for instance, of WEG a major supplier that developed its capability in other activities, before becoming a Petrobras supplier or even of most subsidiaries of multinational enterprises.

during the 70's, but with the investment reduction during the 80's and mostly the 90's had to go in search of new markets. Due to the capacity accumulated in supplying to Petrobras they were able to reach external markets. However, the recovery of the Petrobras investment agenda during the 2000's had opened new opportunities for them. The second company had accumulated capabilities in supplying equipment to the ethanol industry and, as a consequence, had begun to export. [11] So, it seems that the events before becoming a Petrobras supplier are quite important. During this period, capabilities are accumulated. Furthermore, becoming a Petrobras' supplier does provide extraordinary opportunities for growth, but it may shut the doors or deviate from other markets.

5.2 National content policies and the opportunity to learn and accumulate capabilities[12]

National content policies and the operational scale of the oil and gas industry opened extraordinary opportunities for firms to enter new markets. Table 4 compiles information from interviews to oil and gas suppliers from some product lines. In most cases, the oil and gas market may provide the necessary scale to introduce product lines that otherwise would not be achieved. This is particularly important as firms established in these product lines report that learning by doing is one of the most important sources of knowledge accumulation (see Table 5).

Table 5 shows the sources of knowledge in oil and gas supplies companies in selected product lines. The sources are divided into those that are developed inside the company or through direct contracts of knowledge transference and sources of information external to the company. Most sectors rely heavily on learning by doing as a source of knowledge and innovative efforts directly associated with production seems to be their most important source of learning. In some product lines, these are the sole internal source of learning. Flanges, forged and tubular fittings and valves are the most elementary of these sectors. They are dominated by small (less than 100 employees) and medium size companies (100 to 249 employees). Most of these companies do not have engineering departments and are going through new efforts to put them into operation as Petrobras is pushing them on the issue. In valves, for instance, there is lack of capability to produce the valves' signature as some companies do not dominate finite element calculus necessary for this task. The situation is different in lifting and handling equipment and in instruments. In these sectors, the dominant companies are multinationals with little or no production in Brazil. In instruments, for instance,

[11] It should be acknowledged that these interviews took place in 2005.

[12] The following pages rely on the author's experience interviewing oil and gas suppliers. Part of the results here commented are presented in Oliveira and Rocha (2008).

the main providers of Petrobras are multinational that maintain in Brazil representation offices.

A different situation is represented by structural and metal products. In this case, engineering departments exist but are unable to provide companies with product projects that require the control of process engineering. Therefore, the most successful companies in Brazil rely on projects that are made elsewhere or license projects structured by foreign companies. One example of this lack of capabilities are the new refineries built by Petrobras that have all the engineering for structural metal equipments contracted from a foreign company that subcontracted Brazilian structural metal products companies to build the equipment. Two important issues are associated with this lack of engineering capabilities. On the one hand, there is lack of qualified personnel. This has been a consequence of the discontinuity of demand in this industry. During the 70's until the mid-80's, companies were capable of undertaking their own projects. However, after the conclusion of the wave of investments of Petrobras, these companies had to dismantle their engineering departments. Therefore, even with problems to attend the whole Petrobras demand and the need to expand capacity, these companies are still reluctant to compromise with high fix costs, such as the constitution of an engineering department. On the other hand, the sector is composed by a large number of mid-size companies that dispute the market. A consolidation of the property of these companies could give some of the scale necessary to have an engineering department. However, the predominance of family enterprises may be a great obstacle for this consolidation. This is an issue that may be extended to most sectors where national capital dominates.

Table 4. Efficient Scale and Product Gap in Selected Oil and Gas Supplies Industry Product Lines

Sectors	Efficient Scale Operation	Scale of Domestic Market	Product Portfolio	Reasons for Gaps in Product Line	Bechmarking	National Content
Basic Steel	Large	Sufficient	Product Gaps	Market segmentation		
Tubes and Pipelines	Medium	Sufficient	Product Gaps			
Flanges, Forged and Tubular Fittings	Small	Sufficient			Low	
Structural Metal Products	Medium	Sufficient	Product Gaps	Technological Capabilities		
Drilling Material	Small	Sufficient	Product Gaps			
Subsea	Medium	Partially Sufficient	Product Gaps			Low
Pumps	Medium	Sufficient	Product Gaps	Metrology Infrastructure		
Compressors	Small	Partially Sufficient	Product Gaps	Large Equipments		Low
Motors	Large	Partially Sufficient	Product Gaps	Large Equipments		
Turbines	Medium	Partially Sufficient	Product Gaps	Large Equipments		
Lifting and handling equipment	Medium	Partially Sufficient	Product Gaps	Large Equipments		
Valves and city gates	Medium	Sufficient	Product Gaps	Technological Capabilities	Low	
Electrical motors and power generators	Large	Sufficient				
Electrical Transformers and Substations	Large	Sufficient	Product Gaps	Metrology Infrastructure		
Instruments	Large	Insufficient	Product Gaps	Scale		
Engineering Services	Medium	Sufficient	Product Gaps	Technological Capabilities		
Construction and Building	Large	Sufficient	Product Gaps	Technological Capabilities		

Source: Own elaboration from interviews with Petrobras' suppliers

Table 5. Sources of Knowledge in Selected Product Lines in the Oil and Gas Supplies Industry

Sectors	Internal Sources			Technology Transference		External Sources of Knowledge			
						Intra-industrial		Extra-industrial	
	R&D	Engineering	Learning by doing	Technology Transference	Parent Company	Client	Supplier	Universities and R&D labs	Certification Institutes
Basic Steel	■	■				■			
Tubes and Pipelines		■				■	■		
Flanges, Forged & Tubular Fittings			■			■			
Structural Metal Products			■	■		■			
Drilling Material			■			■	■	■	
Subsea	■	■	■		■	■		■	■
Pumps		■	■		■	■			
Compressors		■	■		■	■			
Motors		■			■				
Turbines		■	■			■	■		
Lifting and handling equipment			■		■	■			
Valves and city gates			■			■			
Electr. motors and power gen.	■	■							
Electr. Transformers & Substations		■							
Instruments					■				
Engineering Services		■	■	■		■		■	
Construction and Building		■					■		

Source: Own elaboration from interviews with Petrobras' suppliers

There is however a large number of product lines where firms have engineering departments. Most of the companies undertaking engineering efforts supply tailored engineered products. The understanding of the role these efforts play requires the classification of product lines according to the origin of the capital ownership of their leading firms. Subsea, motors, pumps and compressors are dominated by multinational companies. In the case of motors, pumps and compressors, apart from their engineering capabilities in Brazil, firms have stressed the role played by their parent firms in knowledge transference. For these firms, the role of the Brazilian subsidiary is to adapt knowledge from their parent firms to the conditions established by the demander. In subsea, the relation with Petrobras is more important and, therefore, firms need to establish R&D facilities in Brazil.

The sectors where the national capital maintains the leadership and have important engineering capabilities should be split into two types. On the one hand, there are sectors that supply engineering services. This is the case of construction and building (EPC business) and the independent engineering firms. Though engineering activities are carried out, they are still not sufficient to achieve international practice.

On the other hand, there are those sectors where firms have developed important technical capabilities in engineering but where the oil and gas business are only part of the demand. In most of these sectors, Brazilian companies are quite competitive internationally. This is the case of steel and electrical motors. The main supplier of steel for the oil and gas business is Usiminas which is a major exporter of steel. In the case of electrical motors and generators, WEG has been a major player not only supplying for the electrical sector but also exporting important part of their production. WEG is also one of the firms in Brazil with the largest R&D portfolio. Two product lines have intermediate capability level: tubes and pipelines and turbines. The turbine sector is dominated by two Brazilian companies. TGM expanded its business due to the alcohol sector and to capabilities accumulated by professionals that were originated from an ABB factory that was closed. It exports around 25% of the value of production, mainly to Latin America. During 2005 and 2006, Petrobras developed TGM as a supplier of steam turbine. NG is the other turbine supplier. It was created to supply steam turbine for the Petrobras' refineries that were built during the 70's. After the mid-1980's the company had some troubles with lack of demand and had to adapt itself. Today, it maintains an important level of exporting activity (also to Latin America) and has been renewed as a Petrobras supplier.

In sum, some product lines have showed very little innovative effort. They have production capabilities but are unable to perform innovation. They lack engineering departments where they may be necessary and therefore are dependent of engineering executed elsewhere. This engineering may be executed by Petrobras, through product specification or by some other firms (mostly foreign firms) that license their technology.

Some other sectors have higher innovative efforts for they have engineering departments that design and adapt products for the needs of the oil operator. These sectors are able to follow innovations developed in other parts. However, one should be aware of some cases of foreign dependence. This dependence may be related to a foreign parent firm or to a foreign project provider.

There are some sectors that have well developed technological activities. Some of these sectors don't have R&D departments, but their engineering departments are able to follow the state of the art and adapt products for their needs. In some other sectors, R&D departments have the size of international competitors. However, firms in these sectors are quite independent from Petrobras.

Two main characteristics may be applied to oil and gas suppliers' interactions with other agents: the overall interaction with Petrobras as client and the lack of interaction with extra-industrial sources of knowledge. In the former case, apart from informal user-supplier linkages, Petrobras' relationship with its service and equipment providers has been formalized in three main procedures or programs:

i. The certification procedure for entering in Petrobras' master vendor list;

ii. The management of different measures of product quality guarantee for its suppliers; and

iii. The cooperative development of new products with its suppliers or the development of new suppliers for existing products.

5.2.1 Quality Guarantee Program for Services and Materials

Quality control may be divided into two main procedures: the technical audits for suppliers (ATF) and the Quality Guarantee Program for Services and Materials (PGMQSA). The ATF is composed of inspections that may be more or less intensive during production and delivery of the product, according to the supplier qualification established by the Procurement

Department. Usually the intensity is associated to the product line. Suppliers complain a lot about audit procedures saying that they increase their costs. However, they agree that some of the required procedures make their products better.

The PGQMSA has long run targets. It does not have the objective to stop a production or measure the quality of a product that is being delivered. Instead the program aims to increase the quality of suppliers. It consists of inspection visits to investigate the application of the state of art techniques of production. The planning of the program required a complete investigation of the state of the art of technology in all covered product lines. After the inspection, each firm receives a grade and this is used by project managers in the choice of companies that will participate of their vendor list. Though some suppliers have lost their certification after implementation, the main objective of the program is to increase the compliance of state of the art norms and procedures in order to reduce the number of unconformities in product delivery.

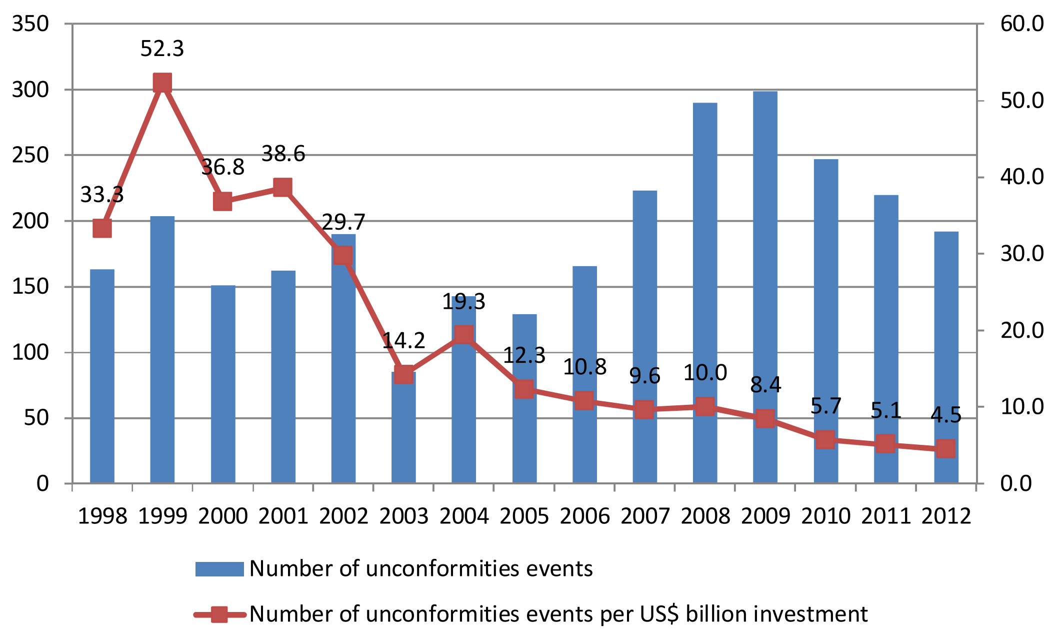
The program has achieved its goal and the number of unconformities has decreased radically with the number of unconformities of PGQMSA covered products per US$ billion of investment approaching zero (see Figure 5). Moreover, the inspections at the PGQMSA served as a consultancy for the companies. Most of them improved their processes during the program. This has been detected by Petrobras' officials in their yearly inspections. One example of the type of impact is the introduction of engineering departments in valve producers in order to be able to calculate and store the signature of produced valves.

Though technical characteristics appear to have improved in Petrobras' sake, aggregate indicators for companies' conduct and performance are not so clear. Rocha (2011) analyzes the conduct and performance of PGQMSA suppliers in Valves, Structural Metals and Pumps products. Three main results are found. First, PGQMSA providers had, in general, better conduct and performance before PGQMSA inspections began when compared to either other Petrobras' suppliers or non-Petrobras suppliers. Differences are larger however when comparing small firms in the three samples than when comparing large firms.

Rocha (2011) then compares firms performance and conduct inside the sample of PGQMSA suppliers and between PGQMSA suppliers and their counterparts amongst non-PGQMSA Petrobras suppliers and non-Petrobras suppliers. In the first case, the main finding is that after inspections, small PGQMSA firms perform better than large PGQMSA firms. Their productivity, the engineers to total employees ratio, total number of employees grow faster than large PGQMSA firms. This suggests that PGQMSA has more impact on small suppliers, which seems to agree with the overall perception that small firms have more difficulties in following technical requirements.

The second conclusion is that, in general, PGQMSA firms do not outperform their non-PGQMSA counterparts in most indicators. The only two indicators where PGQMSA seems to have positive influence is: (i) in small firms' rates of growth; and (ii) small firms' number of engineers to total employees ratio. In both cases, after inspections PGQMSA small firms present higher rates of growth than their non-PGQMSA pairs either Petrobras' suppliers or not. One possible interpretation about the latter result is the establishment of a club that guarantees advantages through market protection, that is, PGQMSA get the right to be the sole providers of the Petrobras market that has grown much faster than most markets (see Figure 3). So again, preparing to become a Petrobras supplier seems to be the most important feature.

Figure 5. Number of unconformities and number of unconformities per US$ billion of Petrobras' investment



Source: Ferraz (2013) http://www.inmetro.gov.br/qualidade/comites/pdf/apresentacoes/12_encontro/Marcelo_Farias_Visao_da_Petrobras.pdf and Petrobras, http://www.investidorpetrobras.com.br/pt/destaques-operacionais/investimentos/historico-de-investimentos-nominal/historico-de-investimentos-nominal.htm.

5.2.2 Development of new suppliers

Petrobras has a program for the development of new suppliers or the development of new products by existing suppliers. This program is undertaken by the procurement department of

Petrobras but may have explicit involvement of internal R&D personnel and its intention is transference of knowledge required to have to product produced under the adequate conditions. The development of new products together with suppliers is at the center of Petrobras' success in deep waters. One striking case is the subsea equipment that made it possible for Petrobras to achieve its level of production.

There is however one important shortcoming in the relationship of Petrobras with most suppliers located in Brazil. Very rarely knowledge flows go in both ways in a purposeful manner. Mostly Petrobras is directing knowledge to its domestic suppliers. This characteristic makes evident the problems associated with innovative capabilities in the domestic supplying industry. Though suppliers were very likely to acknowledge the importance of Petrobras as source of knowledge, they very rarely pointed out situations where they contributed to innovative gains by Petrobras. Some exceptions occurred in some independent engineering companies and in subsea equipment.

5.3 Large Service and Equipment Companies and their R&D labs

In recent years, the following multinational oil and gas service and equipment supplies companies have established R&D labs in the Technological Park of the Universidade Federal do Rio de Janeiro: Schlumberger, Baker-Hughes, Halliburton, FMC, Tenaris-Confab, Siemens, General Electrics, Vallourec and Georadar, where the main Petrobras R&D lab, CENPES, is also located.[13]

Rocha and Urraca Ruiz (2011) analyze the R&D internationalization strategies of three of these MNC, Schlumberger, Baker-Hughes, and FMC, using patent data and interviews to their CEOs in Brazil and to the CENPES CEO. They argue that three main features have attracted these companies' R&D investments to Brazil:

(i) the size of the pre-salt oil and gas province,
(ii) Petrobras' accumulated capabilities and
(iii) the existence of qualified personnel.

However, firms' strategies seem to follow different tracks. FMC already had R&D labs in Brazil. In fact, the FMC plant in Brazil is originated from the acquisition of a previously domestic company (CBV). CBV was a valves supplier that was developed by Petrobras and became an important supplier of many subsea products. Therefore, the new R&D investments carried out by FMC aim to consolidate its position as equipment supplier of Petrobras. Their R&D facilities

[13] Apart from BG.

in Brazil should be able to understand their main customer's needs and adapt headquarter accumulated knowledge to be transferred to local subsidiary, displaying a clear asset exploiting strategy.

Schlumberger and Baker and Hughes have established their R&D labs in Brazil to carry out specific projects with Petrobras. They will dedicate personnel to work together with Petrobras and intend to use the knowledge produced in these projects in local production and afterwards intend to transfer it to other subsidiaries, which seems to adapt to the definition of asset augmenting strategies.

The authors argue that Petrobras has become a network coordinator and if the good scenario is maintained, it may be possible for Brazil to have a cluster of R&D labs that will be one of the references in the oil and gas sector:

> "This experience may also help to understand the role of R&D policies in the attraction of MNC's R&D activities. It is clear that a number of handbook policy measures have been carried out. Institutional requirements have been fulfilled. Brazil has developed good technological skills in the area. Since the seventies, Brazilian universities have been involved in technological cooperation with Petrobras and the country has established science and technology funds that provide the adequate resources for universities to carry out high level research. Furthermore, the existence of the UFRJ Technology Park and its specialization in oil and gas technology consolidates a learning atmosphere that may attract this kind of investment. … Most importantly, the Brazilian state or its state-owned company used their bargaining power to establish regulation and promote discretionary actions that were crucial for the attraction of these investments. Petrobras bargained with MNC and made the establishment of these labs a part of the whole deal. The presence of non-renewable resources reserves and the state control over rents and licensing were key features for the success of this strategy. These types of measures have already been used successfully in other oil and gas scenarios. Nonetheless, an important characteristic of the UFRJ Technological Park is its location in a developing country. Previous successful experiences of attraction of foreign R&D technological efforts have been documented in oil and gas sector in developed countries, such as Norway and the UK. This new experience may show a route for the use of natural resources as a drive for the promotion of technological development and fruitful cooperation with foreign capital in developing countries. This

may be particularly important in Latin America where there is abundance of natural resource rather than labor endowments".

6 MISCONCEPTIONS AND SHORTCOMINGS

We have presented here the oil and gas business as an important opportunity for the technological and productive development of the Brazilian industry. It has provided financial resources to science and technology activities, learning and capability accumulation opportunities to domestic industry and has been able to attract important foreign investments. Nonetheless, there are some important misconceptions and shortcomings in the policies that have been carried out by governmental authorities.

6.1 National Content Policy

One important misconception comes from the national content requirements adopted by ANP. Many countries that have discovered large oil and gas fields have established national content policies. Hatakenaka et al. (2006) make a detailed description of the Norwegian and British cases for the North Sea oil and gas basin. In both cases, government intervened. In the British case, government established clear national content targets and, in the most successful Norwegian experience, government did not establish targets but was able to carry out policies that guaranteed the attraction of foreign capital that worked together with indigenous firms in order to develop local technological capacity. Learning and capability accumulation took place and some of the most successful Norwegian companies were able to migrate their experience towards other oil and gas basins, such as the Brazilian Campus deep waters basin and the recent experience in the pre-salt basin.

In the case of Brazil, the opportunity that was envisioned in the beginning of the first Lula's term was real and was not being exploited by previous policies. National content policies were central for the launching of the shipping industry in Brazil that was able to provide products and accumulate capabilities in the building of platforms and many types of ships. However, policies did not provide the correct incentives for firms to gain competitiveness. The Brazilian regulation however has two clear misconceptions.

The first one is the excessive bureaucratic environment that required the development of new certification companies and in many opportunities was responsible for delays in the investment agenda of Petrobras and for increasing costs in the production of exploration and exploitation equipment.

The second misconception arises from the incapacity to select. Once market selection is left out, selection criteria require discretion and no discretion mechanism has been adopted. As a consequence, all services and equipment have been covered by national content policy. This is quite puzzling once it has been clearly shown (see Oliveira and Rocha 2008) that firms' and sectors' technological capacity differ. Unlike Norwegian policies where authorities used discretion to choose how and when technologies were to be transferred and when no intervention should take place (see Hatakenaka et al. 2006), Brazilian has extended protection to all sectors. As a consequence:

(i) Operators and contractors are not able to select those activities that represent greater opportunities to fulfill national content targets and have to comply requirements for every firm, in fact, national content policies has become the well known market reserve policy;

(ii) it is well documented that productivity growth and export propensity in Brazil are closely linked to the firms import to production ratio. At least this factor of competitiveness can't therefore be exploited by firms that attend to the national content policy. At the same time, export performance was totally forgotten policy instrument. One way to overcome lack of domestic market selection is to rely on foreign markets. Firms exports could have been regarded as part of the national content achievements.

In this moment, Brazil has very important challenges to face in carrying out national content policy. It has become a major obstacle not only to oil and gas operators but to major oil and gas supplies companies. It has slowed down investment and increased costs above what was first planned and it is a risk to be overcome to guarantee the future of the oil and gas business in Brazil.

6.2 Innovation Policy

Mazzucato stresses differences between two perceptions of governmental intervention towards innovation. On the one side, there are those that view policies as intervention mechanisms that **correct for market imperfections**; on the other hand, there are those that perceive government intervention as **builders of networks**. Mazzucato treats those two perceptions as two different policy frameworks.

The first perception about innovative policies is generally focused on correcting market imperfections, such as uncertainty or lack of appropriablity. Proposed mechanisms to correct for these market imperfections are typically the structuring of property rights instruments and the correction of market prices under the effect of externalities. In this case, resources may be channeled through the financing of R&D activities, the building of financial mechanisms and institutions, such as venture capital funds, the supply of non-reimbursable funds or the implementation of subsidies and tax exemptions for innovative activities.

The second perception emphasizes the interactive character of innovative activities and therefore stresses the importance of structuring innovative networks. In this case, emphasis is directed towards the interaction between different set of actors such as universities, research institutions, small and large firms. Supply and demand tend to be linked.

In the case of Latin America, one may pose two important characteristics for this second type of policy design to take place. First, there should be a network coordinator that has accumulated capabilities and can provide knowledge flow and establish requirements to be fulfilled by network participants. Second, in some way, the State must control procurement and financial funds in order to provide the correct incentives for innovative effort to take place. These two characteristics are present in the oil and gas sector in Brazil and however a network policy has not been established. The first attempt to build such a policy has been the INOVA EMPRESA/INOVA PETRO program that nonetheless is too recent in order for us to have an assessment of the program.

Apart from problems of policy conception, another shortcoming arises from changes in regulation. When pre-salt discoveries were announced, authorities decided to change the regulatory market from concession to sharing. These changes were accompanied by political pressures over the distribution of resources across Brazilian states and municipalities and by the federal government will to align municipalities and states incentive towards education and health expenditures. As a consequence a major change in regulation ended up in the directing of total amount of royalties and special participations to education and health, creating troubles in the financing of CTPRETO.

7 CONCLUSIONS

Brazil has been able to accumulate capabilities in the oil and gas industry through the work of its NOC, Petrobras, and the formation of a network of public and private agents that was able to build a strong oil and gas supplies industry. The development of this network has been accompanied by public policies and regulation that made possible knowledge transference from the NOC to domestic suppliers and the building of a network of universities.

However, the report stresses some shortcomings in public policy approach to the sector. First, national content policy seems to have been exaggerated and heads on to failing to become an important instrument towards to become a major obstacle to the development of the oil and gas business. Second, the paper argues that oil and gas procurement policy has not been linked to innovation policy and that this may be its most important shortcoming.

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