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The French system of innovation in the oil industry some lessons about the role of public policies and sectoral patterns of technological change in innovation networking

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Abstract

The central issue in this paper is to show the importance of public policies and sectoral patterns of technological change for institutional interaction in National Systems of Innovation (NSI), from the illustrative case study of French oil industry. This case is a relevant example of the French style of public policy, more well known as Colbertism. In the oil industry, Colbertism has demonstrated a greater ability to overcome some of its main challenges related to a weaker diffusion propensity and to a excessive concentration of R&D funds in some strategic sectors. The study of this industry demonstrates that sectoral patterns of technological change are very important to explain institutional interaction. Differences in the degree of appropriability between up and downstream of the oil industry had a great influence in this interaction and in public policies effectiveness. However, the technological diffusion success was not only due to some favorable technological factor but also to the nature of decision making, which was the outcome of a cooperative process.

1. Introduction

Even if we recognize that firms are the main protagonists of the innovation process, there is also an increasing interest in the importance of National Systems of Innovation (NSI) in this process (Freeman, 1988, 1992b; Lundvall, 1988; Lundvall, 1992; Nelson, 1988, 1993). Innovation, and more generally technical change, in this perspective is also the outcome of an interaction between agents that are not always of the same institutional nature, who work in cooperation and/or complementarily much of the time inside national borders.

Finding a clear definition of NSI in the literature is a difficult issue. It is understood as a set of different institutions such as business firms, R&D and training centers and government agencies which cooperate and even in certain circumstances compete within organized markets (Lundvall, 1988). [1] These institutions interact in the innovation process. Government policies and institutions have an important role in the formation, and even more in operating innovation systems; but of what kind? NSI are the result of a cumulative learning process, more likely to happen within national economies where the cultural dimension and peculiar institutional trajectories are of great importance.

Public policies and institutions are important to

[1] Lundvall (1992, p.52) introduces this concept to show that under certain circumstances markets are not impersonal: "The simple answer is that most markets are not pure and characterized by anonymous relationships between buyers and sellers. Most markets involve an element of mutual exchange of qualitative information, and sometimes by direct cooperation between users and producers, in the process of innovation."

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understand the collective learning inside national frontiers. Our central hypothesis is that public policy plays a determinant role in the constitution of innovation systems, specially when the private sector is not strong enough to take the lead. Cooperation among industry is not natural, even within national borders. Government policy can create favorable conditions for this cooperation by playing an active role, and, by creating the missing links in the system. The French pattern of public intervention, usually called Colbertism, is quite illustrative of this issue. This pattern corresponds to a certain kind of labor division between the public and the private sector and to certain institutional arrangements of dual form for elite education and training (Chesnais, 1993). However, this model shows a particular internal diversity due to historical features and to sectoral technological trajectories.

A national style of public policy may have important differences at sectoral level. In this article we try to show that the oil industry is a special configuration of French NSI and the specific style of the Colbertist model. Sectoral specific features were important for the institutional set-up, and for interactive learning between innovating institutions. Thus, our main issue is to show that NSI have a certain degree of diversity modulated by sectoral patterns of technological change. These patterns, or technological regimes, can be interpreted as different processes of technological learning according to sectoral specificities. They depend on the interaction of a series of factors – opportunities of innovation, appropriability and users – which vary according to sectors. They are determinant in the way innovation systems are constituted and interrelate, as in the way that public policies are implemented. However they are not the sole factors generating sectoral variety. Much of this specific evolution is explained by historical events.

One of the main challenges for the Colbertist model in the French oil industry was the lack of sizable national production opportunities, particularly after Algerian independence. This apparent obstacle could have created technology transfer problems from public R&D to the productive sector. However, the IFP (Institut Français du Pétrole), the public R&D and training center, found important ways to diffuse its technological knowledge to firms through special institutional arrangements which grew up through a learning process.

Public policies were determinant in the French oil industry to create leading innovative institutions and to shape cooperation and coordination between public R&D centers and firms. We show that policy varies according to technological trajectories' differences, within the oil industry, between downstream (refinery, distribution and petrochemicals) and upstream (exploration, drilling and oil and gas extraction).

2. Public policies and NSI variety

Much has been said about the importance of national cultural specificities for NSI constitution and functioning (for example Johnson, 1992, p. 39). The common cultural origins make easier the somewhat qualitative interaction that occurs inside organized markets. Alongside national legal systems, national government policies and national institutional frameworks are the frequent explanations for diversity among countries' NSI.

There are significant differences among countries, according to the national style of public policy. Some countries like France developed a 'mission-oriented' or 'vertically oriented' style of public policy, which confers great importance to State intervention in some strategic industries (Ergas, 1987; Chesnais, 1993). However, it is difficult to define accurately what is in fact a style of public policy.

Mission-oriented countries' R&D efforts are depicted as leaning heavily on State military programs. The most important single feature of this country style of public policy is concentration (Ergas, 1987). However, this general attribute attached to some countries, mostly the US, UK and France, overlooks some important differences in country styles. The US follows a quite different pattern of public policy from that of France. In the latter, direct participation of the State through planning and public enterprises is an important distinguishing dimension, while the American government is much more reluctant to assume production and to promote explicitly national and sectoral planning.

Thus, military and strategic industry concentration of public funds does not seem to be the single and the most important dimension of the French style of technology policy. From our point of view, another extremely important feature is the explicit State participation at all levels of economic and social life. In fact, this pattern concerns preferentially industrial and technological laggard countries with catching-up oriented public policies.

After the end of the Second World War in France, catching-up oriented public policies focused firstly on institutional set-up. This kind of intervention led to the creation of public laboratories and public firms with the purpose of filling in the missing links of NSI, normally taken on by private firms. In fact, this was a response of the public administration to the weakness of the private sector, which was not able to foster the creation of industrial firms with the capability to take the lead in the innovation process.

The role of that kind of public policy in NSI technological dynamics is relevant to assess. Actually, most of the current writings criticize the State-centered style of policies because it tries to replace firms by public institutions with few results in terms of diffusion (Bell and Pavitt, 1992).

There is great doubt concerning the real cooperation aptitudes that exist between public R&D and the productive sector, especially when public research is of a more applied nature, and when private firms play a dominant role in the productive sector. We find the two following critiques directed towards the labor division between public and private sectors in the innovation process.

1. The division of labor between public R&D and the productive sector explicitly assumes a linear model of innovation. Public policies based on the simplest linear model are very much criticized by innovation studies, which emphasize the interactive nature of the innovation process (David, 1993). Since firms are the principal protagonists of this process, the technology created in public laboratories would have difficulties in finding adopters in the productive sector. In fact, great institutional differences would make the technology transfer quite difficult. Implicitly or explicitly, authors state that this kind of labor division only works if public or semi-public institutions are in charge of basic research because of the importance of non-market rationality for this activity. Only public institutions or government-funded institutions are able to realize much of the basic research (Pavitt, 1992).
2. The second critique is supported by the fact that firms hardly externalize industrial research (Teece, 1988). The main arguments of this thesis are as follows:
   - 2.1. transaction and contract costs are very high because of uncertainty associated with R&D outcomes;
   - 2.2. tacitness, specificity and cumulativity of technology hampers the transfer of technological knowledge; [2]
   - 2.3. continuous and close cooperation between R&D, production and marketing activities is necessary to lead to innovation.

These two theses have a common feature. They point to important difficulties for inter-institutional technological transfer, especially when it is done within a well-established linear labor division frame.

The literature on NSI is aware of this point. Thus, the emphasis is centered in promoting policies and institutions mostly concerned with basic formal education, training, basic research, normative control, and diffusion to small and medium firms (OCDE, 1992; Dalum et al., 1992; Patel and Pavitt, 1993). In this context, the role of governmental action is quite indirect. [3] Firms and markedly private firms still are the main protagonists of innovation.

However, State-created sectoral institutions and incentive mechanisms can increase the cooperation between firms and other institutions important to NSI. Freeman (1988, 1992b), analyzing the Japanese case, shows how the MITI created sectoral institutions (engineering research associations) to increase

[2] "Le maintien de structures propres durables de R&D apparaît pour la firme comme le seul moyen d'accumuler et de controler ce type d'actifs et de concevoir des techniques adaptées à ses propres spécificités" (Weinstein, 1992, p. 82).

[3] This role is almost limited in some instances to education and training: "the national education and training system is of central importance for the innovation system ... The most important and obvious way public policy can strengthen the capability to learn and to innovate is through investing in education and training, and through continuously renewing the form and the content of these activities" (Dalum et al., 1992, p. 302). Nevertheless the same authors recognize the necessity of the coordination of other policy instruments in sectoral policies: "In our interpretation, the existence of such 'industrial complexes' may form an important point of departure for formulation of a specific kind of technology policy program, which aims at coordinating education and training efforts, R&D efforts and technological service with the interactive learning taking place inside the industrial complex" (ibid., p. 309).

cooperation. First, in the 1950s and 1960s ERAs were important in making cooperation easier between small suppliers and government laboratories. During the 1980s these kinds of institutions went through a real boom in new technologies, with a strong participation of large firms. European R&D programs such as BRITE and Esprit have the same purpose in the formation of firm networks (OCDE, 1992).

Therefore, the questions concerning the role of the State-centered innovation model are the following:

1. how can public R&D diffuse to the productive sector, especially in a open economy;
2. how can public policies improve innovative partnership in NSI?

We can show that the French style of public policy, applied to the oil industry, has faced these challenges, creating original institutional arrangements to make innovation interaction more easy. However, first we shall see that NSI have important internal differences according to sector specificity.

3. Sectoral variety inside NSI

If public policies can explain important differences between countries, we may observe also that sectoral technological regimes have significant influence on NSI internal diversity. NSI can have internal varieties depending on sectoral patterns of technological change. Nelson and Rosenberg (1993) mention that networks belonging to NSI are not the same in all industries or technologies. In fact, specificities of sectoral technological regimes greatly influence the shape of institutional set-up. Some of those institutions are sector-specific, such as firms, but also training and R&D centers, and governmental agencies. Thus, features of sectoral patterns of technological change may significantly influence the nature of innovative interaction that occurs between these institutions. The context of technology may have a great impact in institutional trajectories and in the interacting learning process of NSI, forging sectoral subsystems.

In order to understand more accurately the NSI-specific institutional set-up and the interaction dynamics, as for the oil industry in France, we need to incorporate some elements of industrial analysis about technological development. The direction and the speed of sectoral patterns of technological change, or technological regimes, are related to the innovation opportunities, the degree of appropriability, and patterns of demand (Pavitt, 1984; Winter, 1984; Dosi, 1988).

Technological opportunity is very much linked to the technology life cycle and seems to be an important factor in explaining the intensity of interaction between institutions. Core technologies of a new paradigm are pervasive by excellence. A wide range of other sectors incorporates them in innovations. A MERIT study demonstrates the importance of core technologies in firm interaction (Freeman, 1992a). This study shows a great increase in the number and in the variety of modes of technological cooperation – joint ventures, research corporations, joint R&D, technological exchange agreements, direct investment, customer–supplier relations and one-direction technology flow – during the 1980s for information technology, biotechnology and new materials. The main reason for this process is the need for firms to share risks in order to open new markets through the introduction of new products.

Patterns of demand often concern the user–producer relationship, well studied by Lundvall (1992). Firms' relation in the productive chain is an important space for interactive learning and cooperative research. However, the influence of this kind of relationship in firm propensity to formally cooperate in technological agreements seems to vary according to the national context. In Japan the user–producer relationship is responsible for most agreements (80%) while in Europe only for 15% (Dodgson, 1993).

Sectoral and even intra-sectoral differences in the degree of appropriability are also important factors that can explain the nature and the intensity of technological interaction between institutions. Cooperation seems more easy when the kind of research carried out is hardly kept proprietary or is generic (Nelson, 1988). In contrast, more effective are the means of appropriation and spontaneous or policy-created interaction becomes more difficult, as we will see for the French oil industry.

In the oil industry, we can find great differences of appropriation regimes according to position in the productive chain. In upstream activities, which concern geological prospects, drilling and production, the degree of appropriability is weak, mostly because of the interactive nature of the innovative process between users (oil companies) and producers (oil supplies firms), and also due to the strength of users related to producers. The strategy of oil companies, which are large concentrated and diversified firms, is to increase competition between suppliers in order to reduce their bargaining power. These firms have large R&D facilities and specific knowledge to make considerable efforts in upstream technologies, while most of the time they are not involved in the production of these facilities.

Notwithstanding this, the downstream part of the productive chain – refining, transport and distribution – demonstrates a somewhat different situation. The technology generated by oil companies is kept proprietary, especially product innovations, because of its importance to market segmentation strategy. Thus, oil companies internalize most R&D efforts in that domain and have a low propensity to cooperate.

We are aware that technological trajectories are not the single reason for NSI sectoral variety. This variety can originate in vertically oriented government policies. Some sectors like agriculture and energy, where the government is more inclined to intervene because of national security matters, usually present subsystems in a great number of countries. Some countries are also more likely to generate sectoral varieties because they have vertically oriented industrial policies. French NSI are a clear illustration of this matter. [4]

4. The diffusion challenge of the Colbertist model

The French government established a new interventionist style of industrial policy in some sectors considered strategic to the country's development, notably since the end of the Second World War, with the liberation and the installation of the provisional government led by General De Gaulle. This new model of industrial but also of science and technology policy, was called 'Colbertism' (Papon, 1978; Salomon, 1986; Cohen, 1992). The role of government, in this model, is very wide and consists not only in regulating but also in introducing new public actors and coordination mechanisms with the specific purpose of building up and strengthening industrial 'filières' in these sectors. This kind of policy involves important public R&D funds. Besides, the government intervenes in the supply side by creating large sector-oriented firms, which are prime contractors, and associated public R&D centers in charge of basic, but mostly applied, research. The private sector acts in a complementary fashion through equipment and parts suppliers, and engineering services firms. The articulation between these institutions takes place within large technological programs, whose aim is to pursue a catching-up strategy. In fact, since the private sector is mostly laggard, government policy fills up the empty space by introducing new public actors that are more capable of undertaking and organizing innovation. The most significant examples are the nuclear, telecommunications, computing, railway, aerospace, weapons, coal, steel and of course oil industries. This model was a success in some sectors and programs, such as Airbus, Ariane, TGV and the PWR nuclear program. But sometimes, as some critics suggested, it resulted in 'white elephants': Concorde, Plan Calcul, and Superphenix are the most famous cases.

Assessing the French industrial policy experience, Salomon (1986) assigns to French technological programs a military rationality (*la logique de l'arsenal*). This rationality was too narrow and oriented towards national technological independence, without clear market preoccupation. It was, in this sense, little prepared for increasing competition in a global world market. [5]

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[4] "The French national systems of innovation consist to a large extent of a set of vertically structured and fairly strongly compartmentalized *sectoral subsystems* often working for public markets and invariably involving *alliance* between state and public and/or private business enterprises belonging to the *oligopolistic* core of French industry" (Chesnais, 1993, p. 192).

[5] When De Gaulle left the government at the end of the 1960s, an important shift in French policy took place. The nationalist technology choice was abandoned for a more realistic vision which tried to incorporate competitive aspects. Thus the graphite gas program was abandoned for the PWR technology which was nationalized. In telecommunications French technology was also partially abandoned and foreign switching technology was adopted (Puiseux, 1977; Cohen, 1992).

Although French industrial policy was successful in some sectors, this model of government intervention lacked any inter-sectoral diffusion dynamism and concentrated excessively national R&D efforts in a few strategic sectors. Therefore, 47.8% of industrial R&D efforts were allotted to only three sectors (aerospace, telecommunications and computers) which amounted to just 6% of industrial production in 1987 (Barré and Papon, 1993). The source of this distortion seems to be the concentration of public resources in large-scale programs oriented to a few sectors. Nevertheless, this critique does not apply to the oil industry in France. This industry while representing 3.8% of industry R&D expenses was responsible for 9% of industrial product for the same year (Boy de la Tour, 1989).

5. The Colbertist model in the oil industry

The French oil industry is a good example of NSI internal diversity. Even if we find some similarities with the national pattern (Colbertism), the oil industry has built up institutions and interaction mechanisms that are in some sense quite specific in the national spectrum of sectoral policies. The specific features of Colbertism in the oil industry are a complex combination of different kinds of factors, some of a more technological kind such as great profitability and low level of technological intensity; [6] others have their roots in the historical evolution of this industry in France.

These characteristics were important factors for the success of the French oil industry. The great profitability of the oil business has allowed the State to obtain important tax revenues from the commercialization of fuels. These revenues did not even require the existence of an oil industry in the country, but only that of an oil market. Very early it allowed the government to fund industrial and technological projects, as we shall see. Otherwise, low technological intensity in the oil industry has allowed the Colbertist model a greater degree of success.

The main institutions of the French oil industry were almost completely the result of government will. The awareness in government spheres about the importance of oil for the French economy originates in the First World War, in the specific conditions of the battle of Verdun, when most troop logistics had to be made by road, because of railroad interruption by the advance of German troops. The dramatic circumstances of this battle entailed awareness of the necessity to build a public policy for oil (Giraud and Boy de la Tour, 1987). At the end of the war the government created a special agency in the ministry of the industry destined to take care of national issues related to oil, which was later to become the Dhyca (Direction des Hydrocarbures).

Government intervention occurred in two stages. The first stage took place between the two world wars. The main concern of government circles in this period was to build a downstream industry (refinery, transportation and storage facilities). This was made possible by the promulgation of the 1928 oil law which obliged the main oil companies with commercialized oil products in the country to install refinery and storage facilities. France also obtained, after the Armistice, the German shares of the Turkish Petroleum Company, later Iraq Petroleum Company. With these shares, the government created the CFP (Compagnie Française des Pétroles) with the task of covering part of the crude oil needs of the country (up to 40% in the 1930s). This institutional set-up was efficient in initializing the creation of the downstream industry. However, France was cruelly lacking in an upstream industry (oil exploration and extraction). The activities of the CFP upstream were reduced to a capital participation in the Iraqi fields in a business controlled by the Anglo-Saxon compa-

[6] Oil is clearly a mature industry. In general terms, this industry has had much more technological intensity in the past than at present. Therefore, in the interwar years this industry had higher technological intensity, measuring employment of scientists and engineers per thousands of production workers, alongside the chemical industry in the United States (Mowery, 1981, quoted in Mowery and Rosenberg, 1993). More 123recent data show a decreasing R&D intensity. OECD production data show that reported R&D expenses decreased from 1.2% in 1970 to 0.6% in 1980. However, production data in the oil industry are not a good indicator of value added. Oil shocks during the 1970s can explain partially the decline of the ratio. More recent data of 1992 show that in the USA the fuel industry had an R&D expenses to sales rate of 0.8% and R&D expenses per employee rate of $4120. The latter ranks the fuel American industry in the eleventh position among 18 industries (Business Week, 1993).

nies. The French company didn't have any upstream production experience. Thus, the CFP had a reduced interest in investing in France or in the colonial empire. Just before and during the Second World War the government took initiatives to create some institutions in order to promote an upstream oil industry on French territory: the RAP (Régie Autonome des Pétroles) in 1939 and the SNPA (Société Nationale des Pétroles d'Aquitaine) in 1941.

At the end of the Second World War, the second stage started. The government created the BRP (Bureau des Recherches Pétrolières) in 1945. These new institutions, specially the BRP but also the RAP and the SNPA, were key in building up an upstream industry. The main historical steps on the exploration side were the 1951 discovery of the Lacq natural gas field in the southwest of France, the discovery of oil in Algeria in 1956, and in Gabon in 1957.

However, the most important peculiarity of the French institutional set-up was the creation of the IFP (Institut Français du Pétrole), in 1944, during the De Gaulle provisional government. This R&D and training center for the hydrocarbon sector was really an important institutional innovation for the oil industry in postwar public policies. It added to the widespread interest in having national companies a greater concern for building an industry based upon a national technological capability. This public policy inspired by Colbertism led to the creation not only of the IFP but also of a French oil supplies industry.

Since its creation, the IFP acquired a very important dimension. In the sixties it employed 1600 persons, and about 1800 in 1992. Its budget amounted to 1600 millions francs for 1992. The Institute's most important activity is R&D, which absorbs almost 80% of its revenues. The R&D effort is mostly directed to applied fields upstream (geology, drilling, production systems) and downstream (refinery and petrochemicals). The Institute also conducts R&D in other fields such as alternative energy sources and engines.

The education and training function of the IFP must be underlined. The Ecole Nationale des Pétroles et des Moteurs, belonging to the Institute, is responsible for graduate and postgraduate education and for continued education and training courses for oil industry workers. As we mentioned before the French education system is characterized by a dual form. In the oil industry the 'Grandes Ecoles' are still responsible for the education of high level management, while graduate and postgraduate education for intermediate levels is taken on by the IFP. The importance of the Institute's education function shows the weakness of the French university system, especially in transfer sciences.

Fuel tax has been an important instrument to finance government institutions with productive functions and remains until now an important means of financing sectoral R&D. A special fuel tax contributes 65% of the IFP's finance. The government also created the FSH (Fonds de Soutien aux Hydrocarbures), a special fund to develop the oil industry. This fund financed BRP and RAP activities during their start-up period, and is now mainly used to finance sectoral R&D efforts.

In 1966, the BRP and RAP were merged and the Elf holding was created. In 1976, this holding became the Société Nationale Elf Aquitaine (SNEA). The Elf group received substantial resources from the FSH until the beginning of the 1970s, which allowed it to become an important oil group (Chatain, 1983).

The French oil supplies industry appears to a large extent to be the result of the upstream shift. Most of the firms were created or developed during the Algerian oil boom and after, with the North Sea oil boom. IFP and government-funded projects played an important role in the formation of this industry, as we will see in the next section.

The most important specific feature of the French system of innovation in the oil industry when compared to other sectoral experiences is surely its relative openness to competition. Contrary to railways and electricity, there was no State monopoly. Also, there were no large State programs that guaranteed the demand for the industry. The French oil firms had to compete from the beginning with well-established foreign oil companies in the internal market. [7] This characteristic becomes even more profound with Algerian independence in 1962. This date is really an

[7] This competition was never complete since the French government used to concede a refinery capacity to each company. However it existed more effectively at the distribution level.

important turning point in the development of the French oil industry. Since that period it had to expand mostly outside national borders. The internationalization of the French oil industry happened almost simultaneously with the emergence of offshore production at international level. [8]

Offshore represents an important technological discontinuity for oil industry evolution (Cook, 1985; Bell and Oldham, 1988). This discontinuity was at the same time a challenge and an opportunity for the infant French industry. It created the conditions for the French system of innovation in the oil industry to realize a catching-up process (Soete, 1985; Perez and Soete, 1988). The established technological capability of French firms in the oil industry along with a clever policy turned towards innovation allowed it to seize this window of opportunity. Effectively, the presence of the IFP, the emergence of Elf at the side of Total–CFP as large oil companies and of the French oil supplies industry created the conditions to take advantage of being a newcomer in an emerging technology. During the 1960s, the Dhyca which controlled the FSH created special committees to manage government R&D funds for pioneering projects in offshore technology. As we shall see, R&D funding was an efficient mechanism to increase interaction between institutions in this industry.

Because of its relative success in this leapfrogging strategy, French oil firms now occupy a leading position in the international oil industry. French oil companies come after the American and British (Table 1), and the French oil supplies industry is second after the United States and ties with the British in world ranking (Valentin and Trouvé, 1993).

The following features explain the success of the French NSI in the oil industry:
1. the innovation strategies of the oil companies, IFP and oil supplies industry;
2. the success of the diffusion of IFP technology generation to the industry;
3. the key role played by coordination mechanisms to organize interaction in the innovation process.

This article only explores the second and the third features, because our main concern is in innovation networking inside NSI. [9] From this perspective, the main challenge to the French oil innovation system was to allow technological diffusion from public R&D execution, centered on the IFP, into the productive sector, and to promote interaction between firms.

Table 1
First 20 oil companies by sales and profits in 1992 (francs)

Firm	Country	Sales Billions	Profits Millions
Exxon	United States	548.7	25,281
Royal Dutch-Shell	Netherlands, United Kingdom	524.3	28,662
British Petroleum	United Kingdom	313.8	−4,282
Mobil	United States	309.1	4,568
ENI	Italy	213.9	−4,065
Elf-Aquitaine	France	200.5	6,177
Chevron	United States	200.1	8,315
Texaco	United States	196.7	3,773
Total	France	136.6	2,847
Amoco	United States	135.3	−392
Pedevesa	Venezuela	113.2	1,791
Pemex	Mexico	112.8	5,676
Nippon Oil	Japan	105.2	1,319
Repsol	Spain	98.6	3,720
Atlantic Richfield	United States	95.7	3,720
Petrofina	Belgium	92.5	763
USX	United States	85.7	−9,677
Idemitsu Kosan	Japan	83.0	100
Sangiong	Korea	77.4	832
Petrobras	Brazil	77.3	15

Source: Institut Français du Pétrole (IFP), L'Expansion, 1993.

6. Diffusion mechanisms of public R&D

Even as a public R&D center, the IFP focuses its effort on applied research and development. The nature of the oil industry technological regime explains much of this feature. Technological change is

[8] The emergence of the offshore industry happened during the 1950s in the Gulf of Mexico. Important firms such as MacDermott and Zapata were created then and developed the initial drilling and production systems (Cook, 1985). However, water depths were very shallow, between 10 and 50 meters. The offshore expansion in the 1960s and 1970s required drilling in water depths of over 100 meters.

[9] The first feature is analyzed specifically in Furtado (1994). This report studies the trajectory of eleven French oil supplies firms along with two French oil companies.

Table 2
Patents granted in USA: 1988–1992 annual average

Institution	No. of patents
Thomson	237
Rhône-Poulenc	219
Elf-Aquitaine	198
Alcatel Alsthom	186
Saint-Gobain	97
L'Oreal	86
IFP	69
Pechiney	59
Bull	57

Source: Business Week (1993) and Institut Français du Pétrole (IFP).

more the concern of engineers than of scientists. Other sectors' radical innovations – i.e. information technology, new materials, chemistry and mechanics – entail big technological improvements (Walker, 1986). The role of the IFP is to interact with all these fields, more specifically with chemistry and geology. Thus, its position differs from the usual basic research-oriented public institution. We have good reasons to think that the applied research and development context worsens the interaction difficulties between public research and the productive sector. The technological transfer would not be so easy because of appropriation risks from competitors. In addition, firms are not so inclined to externalize R&D due to contractual problems and difficulties of transferring tacit knowledge (Section 2).

Because of its orientation to applied fields, patenting is a crucial feature of the Institute. The number of patents granted by the US government is used as a good indicator of technological strength. If we compare the IFP with large French firms we find that in the 1988–1992 period it ranked in seventh position (Table 2). Only Elf-Aquitaine had a better position for the oil industry, but the importance of its pharmaceutical subsidiary (Sanofi) explains much of the group's technological strength.

However, patenting is much more a downstream than an upstream activity. The IFP as the most important R&D center in France and one of the leaders in the world oil industry gives us a remarkable illustration. Therefore, refinery and petrochemical process and products were responsible for 60% of patent deposits in France from 1986 to 1990, while only 32% were upstream-related. The proportion in the Institute R&D budget was the reverse: 41.9% were destined to the upstream while 33.5% to the downstream (Furtado, 1994). The greater propensity to patent in the downstream industry shows that technological knowledge generated there is much more codified and hence more easily appropriated by industrial property rights. Effectively, downstream activities are close to chemistry's technological trajectory. In the upstream industry, where technological knowledge is of a much more tacit nature, secrecy and technological know-how are important means of appropriation.

Differences in technological trajectories within the oil industry have as great importance for the diffusion process of public R&D as for interaction and cooperation between firms. The IFP generated a double diffusion mechanism to face the oil industry's internal technological diversity. Of course, these mechanisms resulted from institutional learning and evolution through time.

In the downstream industry, the IFP functions much more like a business research institution which tries to sell its own refining and petrochemical processes to a great variety of buyers. The domestic market is not large enough to legitimate the R&D effort of the Institute in this field. Moreover, IFP technology sales to other countries do not represent a competitive challenge for French oil companies (Elf and Total), that do not base their market advantage in this kind of technology. Therefore, out of 960 industrial processes contracts realized since the creation of the IFP until 1992, only 72 were in France. In fact, France comes in second place after the USA (97) and very close to Japan (71) in the national ranking.

To sell its own technology, the IFP has around the world its own agencies for its marketing activity. The Institute also realizes complementary basic, and in some cases, detailed engineering activities. Engineering services are an important source of income for the Institute, much more than patent licensing. However, these activities are also cost consuming. [10]

[10] These activities, called 'valorization' increased their participation in IFP expenses from 12% in the beginning of the 1980s to 17% in 1992.

Engineering activities' revenues almost overlay the cost but are unable to pay all the R&D costs of the downstream area.

Upstream technology development and industrialization is rather the outcome of the interaction between users (oil companies) and producers (oil supplies firms). The IFP has tried to associate with this two kinds of firms to guarantee the demand for its own technology. Historically, almost 80% of Institute projects involved some kind of collaboration with firms. Since the 1960s, there have also been multilateral research contracts, which are consultation and coordination mechanisms between the public R&D center and the productive sector.

As a professional R&D and training center, the IFP was in a favorable position to consolidate this rather interactive mechanism with firms. Collective contracts were the guarantee of an involvement of firms with the Institute's R&D effort, but they were also a means for the industry to follow the Institute's R&D activities.

In the upstream industry, the cooperation between the IFP and the two French companies is very intense. These are important research partners for the Institute. This interaction is due to their same public and national origin, although the two French companies possess great autonomy for their technological decisions. However, the main behavior of these firms is to purchase most of the technology outside, from oil supplies firms. The French oil companies were responsible for the creation of some of these firms, which started and developed relying on their procurement policies.

Thus, oil supplies firms are the main partners in upstream technological development. However, the IFP had some difficulties in finding interlocutors on the side of this industry, especially when diffusion dealt with relevant innovations. It is in this framework that the Institute created its own 'spin-off' firms. The most illustrative cases are Technip, a downstream and upstream engineering firm, and Coflexip, a flexible pipe producer and installer. The IFP subsidiaries were gathered in an industrial holding called ISIS (Internationale des Services Industriels et Scientifiques). In 1992, this holding gathered 11 firms with sales totaling 10 billion francs and 7700 employees. The ISIS group represented almost 20% of the production of the French oil supply industry. The 'spin-off' firms are responsible for an important share of IFP joint R&D effort in the upstream industry. The Institute has an important associated research program with Coflexip for the development of flexible pipe technology. This kind of cooperation also happens in the fields of geo-engineering and drilling for upstream technologies and in the field of catalyst for downstream technologies.

7. Cooperation and coordination mechanisms

The French government had a leading and direct role in the institutional set-up of the oil industry system of innovation. The pillars of this policy are the Dhyca, the two French oil companies and the IFP. The Dhyca is not simply a traditional regulatory agency. It is also very active in the R&D field. Its contribution was to promote the institutional mechanism which played an important role in planning public and private R&D efforts. The collective consultative mechanism that functioned mostly as a bottom-up decision mechanism is greatly responsible for government planning and coordination capacity. However, these institutional arrangements have gone through an important learning process which allowed it to adapt to a new environment and to improve its efficiency.

We have mentioned that the IFP, as a professional research institute, makes its own decisions in agreement with all the important institutions of the industry. The Dhyca initiatives were of the same kind. Therefore decision making in the oil sector functions quite differently from the usual top-down Colbertist model.

In effect, in the oil industry there is no unique State-owned prime contractor with a firmly established technological objective in a large program. It is much more a mix of institutions with multiple and changing objectives. The lack of substantial hydrocarbon resources in French territory explains much of the nature of Dhyca programs. The main purpose of the sectoral policies implemented by the Dhyca was to prepare the French oil industry to compete in a changing and diversified environment.

The French industry had to find the means to survive in a competitive environment. These conditions were created through the launch of technologi-

Table 3
Working groups and institutions represented in the COPREP/CEP&M 1994–1998 plan

Working groups	Institutions represented
3G techniques	Elf, IFP, CGG, Total
Drilling	Forasol, Geoservices, Total, Sedco Forex, Sagem, PSO, IFP, Elf
Maritime works research	IFREMER, Elf, EPTM, BOS, Solmarine, Bureau Veritas, Doris Engineering, Sofresid, CLAROM, TPG, Total
Production systems in earth and sea	TPG, Doris Engineering, Sofresid, Elf, IFP, Total, BOS
Polyphasic transport and offshore production	Total, ECA, EVE, IFP, Nomad, Elf, TPG, Coflexip, MBH, Doris Engineering
Maritime works	Coflexip, EPTM, Beicip Franslab, Cybernetix, IFREMER, Elf, Bureau Veritas, ITP, Total, BOS, Stolt Comex Seaway
Gas technologies	Technip, Cedigaz, BOS, GdF, IFP, Total, Elf, Sofregaz

Source: CEP&M and COPREP (1993).

cal programs with the purpose of shifting the infant French industry from onshore to offshore. The most important program was launched upstream. The government created special committees to coordinate these efforts. After the second oil shock, similar initiatives were extended downstream with however a lesser degree of success. In these committees, the most important French firms participated at the side of the Dhyca and IFP.

7.1. COPREP and CEP&M: interacting upstream

In 1962, the independence of Algeria represented a great challenge for the French oil industry future. The response to that challenge was to launch a technological program that would allow French oil to make a leap over the main competitors.

The CEM (Comité d'Etudes Maritimes), created in 1963, was set up to develop French oil technology for deep waters. Its permanent members were the IFP, Elf and Total. For that task the Committee received important funds from the FSH to finance 50% of the development, testing and manufacturing of industrial projects. [11]

The Marine Program, elaborated by the IFP in the beginning of the 1960s, was the guidepost for CEM project financing. The main purpose of this program was to improve offshore drilling and production from water depths of 100 to 1000 meters. This program financed a wide range of technological developments and industrialization such as geophysical marine devices, marine drilling, marine production systems and a wide range of submarine services such as diving, welding, pipeline installation, etc.

The advance acquired by the French offshore technology over its competitors was decisive when the 1970s oil boom took place, especially in the North Sea. France then acquired an important competitive advantage over other European countries to design and build exploration and production facilities in the worst climatic conditions of the North Sea. [12]

In the 1970s, the CEM split and became COPREP (Comité de Programmes d'Exploration et Production) for the exploration field and CEP&M (Comité d'Etudes Petrolières Maritimes) for drilling and production facilities. The composition of these committees changed. New institutions of the French supplies industry were admitted as full members. In fact, the preponderant presence of the IFP gave way to a more cooperative pattern of interaction.

In the beginning of the 1980s, a new institutional change happened with the merging of COPREP and CEP&M. The purpose of this change was to replace the concerted programs, the most important of which was the Marine Program, by a general plan. This new institutional arrangement is still operating now. Three 4-year plans have already been launched (1984–1988, 1989–1993, 1994–1998). An important feature of this new arrangement is a wider participation of representative actors of the oil industry.

[11] In the beginning of the sixties this proportion was 100% but it decreased progressively to 50% in 1974.

[12] Elf and Total were in charge to build Ekofisk in the beginning of the 1970s, then the northern production system in North Sea.

The sectoral upstream plan elaborated by COPREP and CEP&M functions much like a collective decision making-system. It is not only an allocation mechanism for public but also for private R&D funds. The construction of the plan is a collective task. The most active Institutions – R&D centers, oil and gas companies, oil supplies firms, almost all of French origin – are represented in technological groups. The Committee's ability to integrate, alongside 'national champions', other institutions like small and medium firms, was decisive to improve interaction between innovators. [13] The institutional composition of the technical groups in the latest plan is shown in Table 3.

The plan is the outcome of an interactive process between technological groups and a strategic group. The strategic group has representatives from the IFP, the oil companies and the most important oil supplies firms. The main task of technological areas is to define priorities and the amounts of required resources. Then a pyramidal and interactive decision-making process allows the building of a set of articulated sectoral priorities associated with R&D expenses.

The budget plan amounts to almost four times more than the public funds allocated by the FSH. The plan involves annual expenses around 1200 million francs (Table 4). Thus, half of this amount is 50% FSH-funded projects and the other half consists of the industry's own coordinated effort. Outside the plan, 600 million francs are spent in confidential and strategic non-shared firm R&D effort. Therefore, the plan coordinates almost two thirds of the upstream R&D effort.

The first purpose of the plan is to improve the R&D national effort in the upstream industry, where

Table 4
Distribution of R&D efforts for 1994–1998 CEP&M/COPREP plan

Field	Budget (millions of francs/year)
3G technologies	580
Drilling	90–110
Exploitation	395–435
Gas	90–150
Total amount	1155–1275

Source: CEP&M and COPREP (1993).

the lower degree of appropriability does not induce firms, especially suppliers, to assume high levels of technological risks. Almost a third of French R&D effort is brought about through FSH direct support. [14]

The second purpose of the plan is to encourage collaboration between the innovative institutions. The plan was successful in orienting collective decision making in R&D efforts. There is a great degree of adhesion between plan projection and actual expenses. In fact, the lesser degree of upstream technology appropriability seems to be an important factor in explaining why collective decision making works. However, this feature is less linked to weaker mean of appropriation, making technology more reproducible by competitors, than to the fact that technology generation is a collective process involving different kinds of institutions. Effectively, upstream oil technology mostly concerns product innovation of the oil supplies industry. Technology is appropriated, as for other specialized suppliers, "by firm specific skills reflected in continuous improvements in product design and in the ability to respond sensitively and quickly to users' needs" (Pavitt, 1984, p. 359). In the oil industry, specific user needs issues, such as adapting a design to specific geological or weather conditions for example, but also the necessity of sharing risks in high-cost projects makes user–producer interaction necessary. Thus, one important feature of specialized suppliers' technology generation is user involvement, since user–producer interaction is clearly a decisive means to innovate in the upstream industry.

[13] The medium and small innovating firms are also more sensitive to government support in their decision to innovate but also to user support because of the interdependence of investment. "Technology programs aiming at supporting the emerging industrial complexes may, as suggested..., put a special emphasis on involving the most dynamic small and medium sized enterprises in interactive learning, rather than fostering a few 'national champions'. The smaller dynamic firms are very active in terms of product innovation and they are also more dependent on government support in these activities than big firms" (Dalum et al., 1992, p. 310).

[14] The financial support of the FSH to projects is risk sharing. Thus, they require reimbursement only when the project is commercially successful and is limited to 150% of the lent funds.

With the purpose of understanding more accurately the level and the kind of institutional interaction, we analyzed a sample of 72 successful R&D projects realized in the COPREP and CEP&M during the first two plans. We separated projects into three categories: those with vertical cooperation (institutions of different kinds); horizontal cooperation (only one kind of institution); and single institution projects. The horizontal and vertical cooperation projects are not mutually exclusive. Thus, a project can be at same time vertical and horizontal. However, the collaboration and non-collaboration categories are mutually exclusive. We also separated the type of project by the kind of institution: oil companies (O); oil supplies firms (S); and R&D centers (I). Finally, technologies were separated in two groups: 3G technologies that concern geology, geophysics and oil fields; and the rest, i.e. drilling, exploitation and gas technologies.

As a whole, non-cooperative projects are more frequent than cooperative projects, 38 against 34 (Table 5). This feature, however, is much more frequent for drilling, exploitation and gas technologies than for 3G technologies.

In 3G technologies, horizontal cooperation is much more usual among users (oil companies) than among suppliers (oil supplies firms); public R&D centers are determinant, and to a lesser extent oil companies, in vertical cooperation projects. Thus paradoxically, suppliers are in the second plan for horizontal and vertical cooperation related to oil companies and R&D centers, in spite of more frequent cooperative projects in 3G technologies. Only three out of six projects of the main supplier firm in this field involve cooperation.

The situation is almost the same in the other upstream technologies. There are a much greater number of projects and supplier firms involved. There are also a larger number of users and R&D centers. However, a large number of institutions do not increase the propensity to cooperate. Out of 57 projects, 35 do not involve any kind of cooperation, mostly suppliers projects. This feature indicates that supplier firms have a lower propensity to cooperate than other categories of institutions. On the other hand, public R&D centers are systematically present in vertical cooperation. Another important feature is that horizontal cooperation mostly occurs within vertical cooperation. Thus, out of 14 cases of suppliers of horizontal cooperation, nine are also of a vertical nature. This fact tends to show that vertical cooperation acts as a catalyst to horizontal cooperation and, therefore, that mainly public R&D plays this role.

An outstanding observation is that user–producer cooperation (O/S or O/S/I) is not very frequent: less than 10% of all projects. Horizontal cooperation is more frequent. This feature indicates a certain degree of specialization of user and supplier firms in their R&D efforts. For some specific technologies, we find users more frequently, especially those technologies (geology and drilling) linked to important competitive advantages. Otherwise, oil companies often decide to invest in technologies where suppliers' capabilities are lacking.

Problems of innovation secrecy between user and producers can also explain this lower collaboration intensity. Oil companies usually consider that most of the upstream technologies are not proprietary. Thus, they are much more inclined to share this knowledge and R&D efforts with other firms. Generally, oil firms' competitive strategy upstream is to maintain in the same market niche several competing suppliers. Supplier firms do not have the same perspective since they consider upstream technology to be strategic in their competitive advantages. Therefore, suppliers have a greater propensity to make

Table 5
Forms of cooperation of COPREP/CEP&M projects: plans 1984–1988 and 1989–1993

	Vertical cooperation				Horizontal cooperation			No cooperation			Total
	O/S	O/I	I/S	I/O/S	S/S	O/O	I/I	S	I	O	
3G	1	6	4	1	1	5	1	3			15
Drilling/exploitation/gas	1	5	7	4	14	4	2	31	2	2	57
Total projects	2	11	11	5	15	9	3	34	2	2	72

Source: author's elaboration based on COPREP and CEP&M (1988) and CEP&M and COPREP (1993).

vertical cooperation only when public R&D centers are involved.

Horizontal cooperation is the more frequent form of cooperation between firms. However, in the same sense as before, this kind of cooperation is more frequent between users (9 out of 20 projects) than with suppliers (15 out of 54 projects). In fact, the two French oil companies do cooperate in a great variety of projects.

As a whole, horizontal or vertical cooperation projects involve relatively more users than producers. Therefore, suppliers restrain cooperation much more than users, in order to guarantee the appropriation of the outcome of their technological efforts. Public R&D centers, especially the IFP, are the key institutions to make cooperation happen. Their decisive technological capability associated with important public R&D funds foster cooperation. Some other institutes such as the IFREMER (French Marine Research Institute) are determinant in some specific fields. Public research institutes are present in all cooperating projects with oil companies and in 7 out of 10 suppliers.

Analyzing this sample of COPREP and CEP&M projects, we have good reasons to think that cooperative research is not the main feature of the sectoral plan in spite of the public will, and it is not the most important means to innovate and interact in the upstream industry. The most important interaction outcome is the planned prospective effort that allows sectoral institutions to build a common vision of the future and consequently to plan an R&D division of labor. Therefore, public policy acts to increase synergy between institutions much more by coordination than by cooperation.

In fact, means of appropriation have important consequences for public policies oriented to R&D. When these means are weak as for upstream technologies, firms become less inclined to invest in an activity which has an uncertain rate of return. Therefore, public incentive can have a greater importance in a firm's decision to invest in technology generation. This explains why public funding through the FSH is so important to upstream firms' R&D efforts. In addition, the committees, which are responsible for the sectoral planning, allow a more coordinated decision-making process. However, firms have less incentive to cooperate by this kind of funding. Oil supplies firms, which consider upstream technologies as proprietary, have a weaker propensity, even with an incentive mechanism, to cooperate.

7.2. COPRU and GSM: interacting downstream

The second oil shock created new technological challenges for the oil industry. The French government created the COPRU (Comité de Programmes Raffinage-Utilisation) and the GSM (Groupement Scientifique des Moteurs) in the beginning of the eighties in order to face these challenges. They especially concerned the refining industry, i.e. the increase of the demand of light fuels, enforced environment specifications, and new requirements to process more heavy crude oil. The GSM is a much more creative answer by the IFP to the decreasing importance of the oil industry in the national economy during the 1980s. This initiative consisted in establishing a stronger cooperation with the two big French car-makers based upon a long Institute education and R&D tradition in engine technology.

The COPRU became mainly a consultation mechanism with the national firms of the IFP downstream research effort. The two French oil companies, the national gas company (GdF) and the two main carmakers (Renault and Peugeot-Citroën) participate in this Committee. The participation of the two carmakers is due to a special concern about increased intersectoral firm interaction in fuel–motor technology. Periodically, the IFP presents its own downstream R&D projects to the Committee to receive suggestions and to be approved before review by the administrative board of the Institute. This Committee played a central role informing firms about the IFP's R&D efforts. [15] However, industrial firms do not coordinate their own R&D efforts through this institutional mechanism. Thus, unlike the previous case, the COPRU does not act as a planning instrument for sectoral R&D effort. The Committee has almost no revenue to fund projects. In spite of these limitations the Committee was instrumental in some cases in

[15] IFP represents 42% of all R&D downstream expenditures (Direction des Hydrocarbures, 1993).

allowing collaborative research between institutions, such as for a heavy oil conversion project, an alliance between IFP, Total and Elf, and for the fuel–motor upgrading between Elf and Renault.

The GSM acts as a complementary mechanism. In fact, the IFP is spending increasing amounts of resources in engine research. The contribution of this group is to allow a better interaction between the IFP research effort and car-makers. The GSM faced several coordination problems when this group started its activity due to conflicts between the French car-makers. For this reason, the IFP took on almost all the R&D effort of the group and held the coordination activity. The way to integrate its own R&D effort in the national context was to fine-tune a labor division with car groups. Thus, the IFP has concentrated its own efforts in basic research fundamentally towards a better knowledge of motor functioning and in structuring a testing facilities network for engine suppliers. As in the preceding case, the role of such a group is to discuss the IFP R&D effort with the most important French firms. The results in coordination or cooperation of sectoral R&D efforts are even poorer than in previous cases. However, the IFP initiative greatly reinforced French technological capability in the engine industry. Thus, the Institute played an important role in basic research and organized an engine-testing network, strengthening some of the missing links of the French NSI.

These two cases show that in spite of the government will, appropriability matters are very important, hindering cooperation and interaction downstream. The oil and car industries consist of large firms, which carry out substantial R&D efforts. The preservation of the large French firm's appropriability interests was the only way for public research to interact with industrial firms. This process had also induced institutional learning by the construction of a consultation mechanism that progressively allowed some division of labor between public and firms' R&D.

In refinery–petrochemical technologies, the division of labor started almost with the IFP creation. This R&D center was a great generator of process technology taking on the task of technology marketing and diffusion. The oil companies, on their side, have concentrated their efforts in product technology (lubricants, additives, etc.), whereupon they can develop their marketing strategies. The COPRU only works as a cooperative mechanism when the main actors are aware of some technological discontinuity, in the case of deep conversion for instance.

In engine technology, the construction of labor division between public research and firms is a much more recent process. In spite of a certain tradition in education and research, the IFP became a full member of this club only during the 1980s. In this context, public R&D positioning in fields where French car firms used to be less present, like basic research, was the only way to match a certain labor division between public and firms' research. In this field there was much less appropriability concern and French car companies could by this means benefit from the important externality of better scientific support.

8. Conclusion

The French oil industry is a relevant case study for NSI in the two main aspects suggested in the beginning of this paper: the role of public policies and of sectoral patterns of technological change. The first question that we tried to answer was about the importance of sectoral technology regimes in NSI internal diversity. We called attention to the importance of degree of appropriability as a factor capable of encouraging or discouraging institutional interaction in the innovation process. The empirical study confirms our assumption about the crucial importance of the degree of appropriability in this matter. In effect, the oil industry presents an important technological heterogeneity, between upstream and downstream, with different firm strategies in each case. Thus, our study showed that in the upstream industry interaction and cooperation to some extent were much easier because the large user firms did not consider it proprietary technology. However, smaller supplier firms did not follow the same behavioral pattern. They were not so much inclined to cooperate as we illustrated analyzing the COPREP and CEP&M projects.

In the downstream industry we find a quite different situation. Cooperation and coordination between institutions were much weaker in spite of public efforts. Thus, they become increasingly difficult when industry is concentrated and technology concerns established core firm activities.

The second important question concerns the role of public agencies and policies in fostering the interaction between institutions in the innovation process. We assumed that this role could be much larger and more successful than normally suggested by innovation studies. The importance of public institutions such as the IFP allowed France to launch large technological programs that were fundamental for its industry, in order to acquire an important technological advance in the world market. However, the most important challenge to this pattern of public policy, better known as 'Colbertism', was to secure the diffusion process in open market conditions. This pattern is much better suited to operating in protected markets. Such a challenge was faced by important institutional innovations.

The IFP implemented special institutional mechanisms to guarantee its own technological diffusion. This involved increased firm participation in its own decision making process and the search for firm alliances for R&D projects. By these means the Institute was capable of including the industry in its own initiatives. However, the IFP also developed the strategy to create its own supplier 'spin-offs' when complementary capacity for its innovation was missing in the productive sector.

Alongside the IFP, government policies worked also to create special committees which allowed the improvement and the coordination of R&D efforts in the industry. The complex technological requirements of the oil industry ask for the engagement of a great variety of firms in a large array of technologies. The committees helped with some public funding to enhance R&D effort upstream, where means of appropriation are weaker. However, they worked more effectively to improve coordination than cooperation. In the upstream industry, where they were much more effective, they rather functioned as a planning instrument. Though the success of these government initiatives was granted by the lesser degree of appropriability, the cooperative nature of decision-making was an important success factor. Therefore, the French public policy pattern in the oil industry is much more a successful variety of 'Colbertism' because it did not repeat its main mistakes.

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