Impact of the French innovation and research policy on construction firms

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Abstract

For many years France has been characterised as a country where state intervention was needed to guarantee the wealth and the strength of the economy. Most of the funds dedicated to R&D focused on large programmes limited to specific sectors such as nuclear, space, aeronautics, telecommunications, and defence, and were mainly monopolised by large companies. Therefore SMEs were often ignored. However, this scheme has been challenged by the growing role of the European Union and French regions in national programmes. Under the new institutional framework public expenditures are not only devoted to R&D but also to innovation.

The construction industry is characterised by a high proportion of very small firms who do not have any internal R&D department. R&D in construction is also not organised as formally as in manufacturing companies. The level of R&D expenditures appears to be lower in construction than in any other industry. As a consequence the industry is not able to benefit from most public R&D programmes. However R&D is just one source of innovation and construction firms tend to use less formal way to innovate. The business activity has also a strong influence on the propensity to carry out R&D.

To illustrate how the construction industry has benefited from the French innovation and research policy, the paper will first characterise the evolution of the French national policy in the domain of research and innovation. Then, it will examine the role of Research, Development and Innovation (RDI) for construction companies and describe two public schemes aiming at supporting innovation within construction firms and the diffusion of low energy buildings. Finally, the analysis will present the role of RDI in the innovation strategy of a small sample of construction companies located in the Aquitaine region (South-West of France).

Keywords: Innovation, construction, R&D policy, RDI, SME.

1. Introduction

In 2008, France spent 41.7 billion Euros on R&D. When expressed in terms of GDP, it represented 2.14% (OST, 2010). It accounted for about 3.8% of world R&D expenditure. For many years France has been characterised as a Colbertist state. Most of the funds

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dedicated to R&D focused on large programmes limited to specific sectors such as nuclear, space, aeronautics, telecommunications, and defence (Mustar and Larédo, 2002). This public support was mainly monopolised by large companies. Firms employing less than 250 employees were frequently ignored. However this scheme has been challenged by the growing role of the European Union and French regions in national programmes. Under the new institutional framework public expenditures are not only devoted to R&D but also to innovation. Moreover SMEs are at the core of the innovation policy.

The French construction industry (building construction, installation and finishing and civil engineering) is characterised by a large number of SMEs employing less than 10 employees. Conversely firms employing more than 250 people are limited. They represent less than 0.1% of the firms of the industry whereas their contribution to the production reaches about 20%. These firms are usually not at the core of the national policy supporting R&D and innovation.

The construction industry has never been considered as strategic for French national independence. Thus it has not been able to benefit from the large programmes. However policies supporting the innovation capacities of SMEs do not target any sector and are more adapted to the specificities of the sector. Moreover public procurement can be a source of innovation and R&D in construction. For example large and complex buildings involving a network of actors are frequently leading participants to launch R&D to circumvent technical bottlenecks encountered during the course of the project.

The paper will first characterise the evolution of the French national policy in the domain of research and innovation. Then it will examine the role of R&D for construction companies and the importance of public funding. Finally the analysis will focus on the role of R&D in the innovation strategy of a small sample of construction companies located in the Aquitaine region.

2. Characteristics of innovation and research policy in France

According to Ergas terminology (1987), France technology policy was for a long time considered as « mission-oriented ». As in the United-States and the United-Kingdom, technology policy was linked to objectives of national sovereignty. The focus is on radical innovation (“big science is deployed to solve big problems”) and most public R&D is dedicated to the defence sector and key sector for international strategic leadership such as nuclear energy and telecommunications.

Mustar and Laredo (2002) confirmed this view and propose four traits to describe the French research system:

1. Most public research budget is directed towards a limited number of sectors which contribute to the objectives of national independence (nuclear, space, aeronautics, defence, telecommunications…);

2. Basic research is mainly done by CNRS (National Centre of Scientific Research). Universities mainly focus on teaching and are competing with French higher education institutions which train the “elites”;

3. Several public research institutes carry out research for the needs of several governmental departments;

4. A limited number of large companies monopolise most public support for research. However SMEs do not belong to this network and do not benefit from public funding.

These policies faced several limitations at the end of the eighties. It appeared that they yielded few direct benefits and crowded out a large share of commercial R&D. Only a small number of high-technology firms were the recipients of public subsidies. The spin-offs were limited. Traditional sectors such as construction did not benefit from the high level of public expenditures on R&D.

Ergas opposes “mission-oriented policies” to “diffusion-oriented policies” which aim at diffusing “*technological capabilities throughout the industrial structure, thus facilitating the ongoing and mainly incremental adaptation to change*” (p.192). Countries such as Germany, Switzerland, and Sweden tend to adopt “diffusion-oriented policies”.

During the 1990s several changes have affected French national policy. Large programmes have received less support. Partnerships between CNRS and universities have been reinforced and the research potential of universities has grown. Around 2000, there were about 14 000 researchers and research engineers at CNRS versus 45 000 teacher researchers at the universities (Mustar and Larédo, 2002). However, it was mainly the development of support for innovation and tax credits that modified the French innovation and research policy:

- The National Agency for the Valorisation of Research (ANVAR – now OSEO) was created to support innovative SMEs. It was organised on a regional basis. The agencies located everywhere in France, aid small firms not only through financial assistance, but also through technological advice. The main tool was a zero-rate loan that could cover up to 50% of the costs of the innovation project. The firms refunded the agency only in case of success and without paying any interest. Large firm were usually excluded from this procedure.

Research tax credits were introduced and contributed to the development of R&D activities in SMEs. In 1987, 3 500 applied to the scheme. In 2000, applicants exceeded 6 000. Several successive changes in the way to take into account R&D expenditures increased the number of beneficiaries by 147% between 2000 and 2007 (table 1 – OST, 2010). In 2008, the scheme was simplified and in 2010 about 18 000 firms asked for research tax credits (Froger, 2012).

Table 1: Research tax credits

	Research tax credits							
	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2007*	*Evolution 2007/2002 (%)*
Declarations	*6344*	*6253*	*5907*	*5833*	*6369*	*7400*	*9658*	*+64*
R&D expenditures declared	*10248*	*10712*	*11668*	*11300*	*11600*	*13500*	*15300*	*+31*
Beneficiaries	*3060*	*2810*	*2760*	*2757*	*4250*	*5430*	*6822*	*+147*
Volume in million €	*529*	*519*	*479*	*428*	*890*	*982*	*1687*	*+252*

OST (2010)

Moreover two new key players appeared in the French research landscape: the regions and Europe. With the Decentralisation Act (1982), the regions brought complementary resources which supplemented the investments of the State. Europe also provides supports for research and innovation through its successive Research Framework Programmes. The European budget has grown very fast from 678 million Euros (2.4% of its budget) in 1985 under the First Framework Programme (1984 – 1987) to 6.5 billion Euros (5% of its budget) in 2008 under the Seventh Framework Programme (2007 – 2013).

3. Construction, R&D and public financing

3.1 R&D and the construction sector

The economic literature shows a positive relationship between firm size and the likelihood of performing R&D. Several advantages are put forward to explain this relationship: "*the greater willingness of larger firms to incur risks associated with R&D, the greater access to finance by larger firms, the greater ability of larger firms to internalise R&D spillovers due to greater diversification, and the greater likelihood that larger firms will possess the complementary capabilities (e.g. marketing) necessary to exploit innovations*" (Cohen and Klepper, 1996, p. 936).

The construction industry is characterised by a high number of very small firms. In France in 2007, among the 369 100 firms of the industry, 339 900 (92.1%) employed less than 10 employees and contributed to 33.44% of the production (Commissariat Général au Développement Durable, 2010)[2]. Conversely the number of firms employing more than 250 people is limited. They were about 300 in 2007 representing less than 0.1% of the firms of the industry. Their contribution to the production reached 20.2%. This specificity and the nature of the innovation process within the industry explain why R&D expenditures are much lower than in other manufacturing sectors (table 2). Most innovations developed by contractors are made at the job site in the course of a construction project and they do not require a high amount of financial resources. Innovations are mainly project specific and they barely require R&D. Innovations are "*ad hoc responses to problems encountered in the*

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[2] The Commissariat Général au Développement Durable distinguishes three categories in its classification: building construction, installation and finishing and civil engineering.

course of a construction project that an innovating builder was engaged in. They were emphatically not "R&D projects" in any formal sense" (Slaughter 1993: 87). When they do some R&D, contractors collaborate usually with materials and/or equipment suppliers on specific projects. The resources dedicated to this activity are much smaller than those of their suppliers.

Table 2: Internal R&D expenditures of the private sector

	Internal R&D expenditures of the private sector					
	2002 (Billion €)	*2007 (Billion €)*	*Evolution 2007/2002 (%)*	*2002 (Billion €)*	*2007 (Billion €)*	*Evolution 2007/2002 (%)*
Manufacturing sector	***18.0***	***20.2***	***+ 12***	***82.3***	***81.5***	***- 1***
Aeronautics and space construction	*2.3*	*2.7*	*+15*	*10.7*	*10.8*	*+ 1*
Electric equipment	*4.6*	*4.3*	*- 6*	*21.0*	*17.4*	*- 18*
Pharmaceutical industry	*2.8*	*3.5*	*+ 27*	*12.8*	*14.3*	*+ 12*
Equipment goods	*1.7*	*2.2*	*+ 27*	*8.0*	*9.0*	*+ 12*
Transport	*3.2*	*3.7*	*+ 15*	*14.9*	*15.1*	*+ 1*
Chemistry	*2.2*	*2.4*	*+ 10*	*10.0*	*9.7*	*- 3*
Natural resources intensive industry	*0.6*	*0.7*	*+ 11*	*2.7*	*2.7*	*- 2*
Labour intensive industry	*0.5*	*0.6*	*+ 29*	*2.3*	*2.6*	*+ 14*
Non-manufacturing sector	***3.9***	***4.5***	***+ 18***	***17.7***	***18.3***	***+ 4***
Primary sector and energy	*0.9*	*0.9*	*+ 9*	*3.9*	*3.8*	*- 4*
Agro-food industry	*0.5*	*0.5*	*+ 5*	*2.3*	*2.1*	*- 7*
Construction	*0.1*	*0.1*	*+ 9*	*0.4*	*0.4*	*- 4*
Services in transport and telecommunication	*2.4*	*3.0*	*+ 24*	*11.1*	*12.1*	*+ 9*
Total	***21.8***	***24.8***	***+ 13***	***100***	***100***	***-***

OST (2010)

This situation was also typified by Pavitt (1984, p.356) who was the first to put ahead the existence of sectoral patterns of technical change. He categorised general contractors as "*suppliers dominated firms"*. Firms from this category devote few resources to R&D. They focus their innovative activities on processes. "*Most innovations come from suppliers of equipment and materials, although in some cases large customers and government-financed research and extension services also make a contribution*".

These elements are confirmed by the fourth Community Innovation Survey (SESSI 2006) which integrated for the first time firms from the French construction industry. One of the aims of this large study was to characterise innovation within the industry. 39.4% of the French construction firms, who were surveyed, declared that they were innovative between 2002 and 2004. These figures are lower than for manufacturing and service industries (46.2%).

The survey (table 3) also indicated that internal R&D is the main input for firms employing more than 250 people while smaller firms follow a different path. They rely either on training or on the acquisition of equipment. Thus focusing too much on R&D could be misleading since very small firms which are dominant in the industry innovate through different paths. Patel and Pavitt (1994, 543) drew similar conclusion: "*We have shown that when we treat technical change as synonymous with R&D activities in science-based industries, we are in danger of neglecting up to nearly 40% of what is going on in technical change, especially in non-electrical machinery and in small firms."*

Table 3: Input for innovation between 2002 and 2004 within innovative contractors (%)

	Internal R&D	*External R&D*	*Acquisition of equipment*	*Acquisition of external knowledge*	*Training*
10 - 49	*45,4*	*16,9*	*53,8*	*11,7*	*48.4*
50 - 249	*48,3*	*16,8*	*57,3*	*23,8*	*68.9*
250 and more	*69,1*	*31,0*	*47,3*	*22,6*	*53.6*
Total	*46,6*	*17,4*	*54,0*	*13,6*	*51.2*

Source : SESSI (2006) - http://www.insee.fr/sessi/enquetes/innov/cis4/EH.html

However this lack of R&D is also problematic since R&D raises the "absorptive capacity" of the firms (Cohen and Levinthal, 1990). This "*absorptive capacity*" is defined as the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities. It is a function of firm's prior knowledge. Thus R&D is also a way to take advantages of external knowledge and to use existing networks.

3.2 Public funding for R&D in construction

R&D expenditures of the construction industry are very limited compare with other sectors. In volume it is even the sector with the smallest budget dedicated to R&D. About 90 per cent of these expenditures are financed by internal resources (OST, 2010). This is confirmed by Tessier (2008) who indicated that only 16 per cent of firms from the construction industry have access to public funding (versus 36 per cent for manufacturing companies). Only large civil engineering companies operating at the international level were able to receive some public support.

Public funding to the sector mainly comes from OSEO, the public finance company supporting innovation. However all financial products and services developed and proposed by OSEO are not dedicated to the construction sector. This is not the case of "PREBAT" ("Programme de Recherche et d'Expérimentation sur l'énergie dans le BATiment" - "Research and experimental programme on energy in building") which aims at reducing energy consumptions in buildings.

3.2.1 The innovation aid schemed proposed by OSEO

Since its creation OSEO has developed a whole range of products and services in order to cover the needs of innovative SMEs. OSEO's activities are complementary with those developed by banks or venture funds. OSEO covers three lines of activities

- Supporting innovation and technology transfer (*OSEO innovation*)
- Financing investments and operation cycle, in partnership with banks and finance institutions (*OSEO financement*)
- Guaranteeing bank financing and equity investments (*OSEO garantie*)

The financial support brought by *OSEO Innovation* covers part of the expenditures dedicated to R&DI (Research and Development, Innovation). Innovation activities include the acquisition of technology, industrial design, trial production, feasibility studies and market tests and launch (OECD, 2005).

In 2009, 176 construction projects represented 4.08 per cent of all projects financed by OSEO through the "innovation aid" scheme (OSEO, 2010a). This aid contributed to the development of 131 innovative projects in the building sector (10.9 M€), 23 projects in civil engineering (2.4 M€) and 22 projects proposed by material suppliers (1.35 M€). However the borderline between construction and other industrial sectors is frequently very thin. For example, in the energy sector among the 156 projects financed in 2009 (16.6 M€), 38 (3.9M€) were dedicated to the building market (optimization of heating systems, software to monitor energy consumption – OSEO, 2010b).

Moreover OSEO focuses mainly on the smallest and youngest enterprises that experience greater difficulty in gaining ready access to financing. 33 projects (20%) were developed by SMEs with less than 3 years old. They received 2.68 M€. Firms with less than 20 employees (the majority in the construction industry) received 6.19 M€ for 88 projects.

Several of these projects are linked to sustainable construction which is a source of business opportunity. To reduce greenhouse gas emissions and energy consumption, new products and process are created. It concerns photovoltaic cells which are integrated to the envelop of the buildings, new construction systems based on products offering a smaller environmental impact, industrialisation of the construction process, development of Building Information Modelling. But the innovation aid scheme is not adapted to project-based activities and innovation developed during the course of a construction project.

3.2.2 The programme PREBAT

In 2007 "PREBAT" was launched by the government at the national level to spur sustainable construction. It was one of the measures taken to address climate change, to restore biodiversity and to limit environmental and health risks. The aim was threefold:

1. To anticipate the change of thermal regulation which would become very ambitious both for new and existing buildings;

2. To find solutions to technical and economical bottlenecks;

3. To develop experimental projects.

To reach these targets, several priorities were defined for the period 2007 – 2012. One of them was to lead the construction value-chain toward low energy buildings before the implementation of a new regulation in 2013, requiring that all new buildings (residential and offices) have to consume 50kwh/m²/year. Public and private clients who accepted either to construct low energy building or to renovate buildings to reduce drastically energy consumptions received financial supports. This was a stimulus to diffuse new technologies, new systems and new construction processes associated with low energy buildings.

The programme was financed by ADEME (the French Environment and Energy Management Agency) and French regional authorities. Public subsidies rose from 7.2 M€ in 2007 to 42.8 M€ in 2010. 11 Regions took part to the programme in 2007 and 20 in 2010. 1 025 projects were supported during this period. 65% of the projects concerned new buildings and 35% renovation projects.

The subsidies delivered by ADEME and the French regions covered on average about 10% of the construction costs. It represents approximately the additional investment costs linked to better energy performance**.**

The impact of the programme was considered as positive. 80% of the 241 clients surveyed (Euréval, 2012) had never built a low energy building before. About 75% (mainly households) considered that without financial subsidy the financial equilibrium of the project would have never been reached.

However the learning process appeared to be limited since most clients were in charge of just one project. According to the experts who evaluated the programme, clients would have needed three consecutive projects to learn about the process of constructing / renovating low energy buildings: at the first time, the client discovers the process and identifies the technical problems. During the second project, he starts to solve them. The third time he monitors most technical issues. However public authorities who were the main beneficiaries (they represent 36 per cent of the clients) considered that they learnt a lot and they developed new practices. The programme was a way to raise their competencies and to make them aware on the specificities of the future regulation and on some specific technical items (e.g.: blower-door tests, implementation of new material and equipment).

Similarly the learning impact was quite important within the design team. Moreover the programme raised the competencies of the contractors and installation and finishing companies. For example, to guaranty the energy performance of buildings, electricity and plumbing companies have to make box-out at the design stage and they are not allowed to drill on site.

4. Role and impact of R&D in construction: a regional survey

4.1 The context of the survey

In 2011, CSTB and a consultant company were commissioned by CREAHD (a regional institution promoting innovation in the construction industry and gathering firms, public and private research organisations and universities) to examine the innovation strategy of firms from the construction industry located in the Aquitaine Region. Firms were questioned about the organisation of their innovation process, the funding, the results of the innovation and the role and importance of R&D within the context of sustainable construction. Telephone interviews with general managers or executives (R&D, financial…) were carried out between June and September 2011.

Four groups of firms were targeted: 1/Designers and architects; 2/ Suppliers of material; 3/ Building companies; 4/ Civil engineering companies;

An electronic survey was first sent to 3280 firms representing the four aforementioned groups. 139 answered. Then in-depth interviews were carried out with nineteen companies representing each group. All the firms firstly answered to the electronic survey. CSTB was in charge of ten interviews. The following section will present the main results of these interviews. “A” and “B” represent the architect and the design office; “C” and “D” are the suppliers; “E”, “F” and “G” are the building companies. “H”, “I” and “J” are the civil engineering companies.

4.2 The role of R&D in the innovation strategy of construction companies

“A” and “B” were innovative but they did not really conduct R&D. According to both actors, innovation is pulled by the evolution of the regulatory environment (for example the thermal regulation is becoming more stringent) and the introduction of new equipment and products by suppliers. Innovations are usually developed with the partners of the building site. The suppliers are often the leaders but either the architect or the design office frequently coordinates the innovation process. The client who finances the project has also a key role to play. Indeed projects which are less financially constraint open more opportunities for innovation.

The two suppliers of material (“C” and “D”) belong to large international companies with R&D facilities. “C” employs 120 people and has three regional laboratory gathering 11 R&D engineers. These researchers have to identify the constraints of the building site, to develop solutions in order to strengthen the competitive advantage of the firm and to answer to the expectations of the client and to follow-up the construction project. When projects are very complex, the firm receives the support of the R&D unit of the group. “D” has no permanent budget for R&D. It develops research when its financial margins are better. Thus the research activity is not continuous. However the firm is still able to benefit from the exchange of best practices among the affiliates of the mother company.

The three building companies are typical example of the diversity of situations within the sector. “E” has less than 10 employees, “F” 53 and “G” is the subsidiary of one of the three major companies in France. “E” has no R&D department but the manager has developed a R&D project with both public and private research laboratory. This collaboration led to the creation a new product. The SME has also received the financial support of several local agencies promoting innovation since the product is closed to the market. However due to its limited financial and research capacities the innovation process is very long and the SME still lacks a commercial network to sell its innovation. “F” has three employees who work part time for the internal R&D department. The rest of the time they are involved in marketing activities which are complementary to their research work. It is a way to get feedbacks from the market. Thanks to this research activity, this contractor was able in the past to diversify its activity. It has developed several products and has become a supplier of the industry (in 2010, the turnover was 7.6 million and about 3 million was connected to the commercialisation of new products – the other part was linked to its traditional building activity). This SME regularly cooperates with a local engineering school for most of its research projects. Due to a bad experience with OSEO (the firm had to refund the public agency when its business activity was affected by the crisis), it prefers to innovate by using its internal resources. “G” has no internal R&D competencies. However it can benefit from the support of the central lab located around Paris and a regional design office. However the main source of innovation is the internal database gathering information on the internal innovation awards’ scheme. These awards are open to all affiliates (and employees) of this large company and concern all types of innovation. The aim is to prevent employees to re-invent the wheel and to promote the exchange of best practices between affiliates located in remote places. “G” has already been involved in several experimental projects launched at the national level to promote innovative processes in construction.

Among the three civil engineering companies, two are affiliates of large companies. Both have a R&D laboratory. For “H”, the aim is to keep the link between its research activity and the needs of the market. One of the key issues of this lab is to watch the evolution of the regulation and to anticipate market changes. This strategy allows “H” to sell new products before its competitors. “H” frequently cooperates with local engineering schools and suppliers. In the past it also received the financial support of OSEO for some products dedicated to the construction site. Head of units (e.g. marketing, finance) are frequently the main barrier to R&D. Indeed when the construction market has to face a crisis and when prices go down, they try to reduce R&D budgets. But since the company has developed a culture of innovation, most budgets are not diminished on the long run.

“I” has no permanent R&D lab but several engineers are mobilized for complex projects such as the high-speed train. Only internal resources are used to finance research projects. Most innovations come from suppliers of products and equipment. “H” and “I” consider that the public R&D funding is not adapted to the research activity connected to the construction site. Indeed the life cycle of a construction project is very short while most public supports are dedicated to new products with longer life cycle.

“J” is a SME with less than 20 employees. It has no R&D activity. The innovations developed by the manager concern the organization of the company.

5. Conclusion

The construction industry is frequently criticized for its limited capacity to invest in R&D. A basic statistical comparison between construction and all manufacturing industries turns at the disadvantage of the construction industry. However R&D in construction (e.g. contractors, architects) is not organised as formally as in manufacturing companies. Only large company can support a dedicated R&D department. Most development activity occurs on the building site. Moreover several activities which are at the core of the construction business are not classified as R&D by the Frascati Manual. For example, *"investigations of proposed engineering projects, using existing techniques to provide additional information before deciding on implementation, is not R&D…* » (Frascati Manual, 2002, p.30). Similarly "*the vast bulk of design work in an industrial area is geared towards production processes and as such is not classified as R&D, There are, however, some elements of design work which should be considered as R&D, These include plans and drawings aimed at defining procedures, technical specifications and operational features necessary to the conception, development and fabrication of new products and processes*." (Frascati Manual, 2002, p.44). Thus the project-based nature of the industry does not fit well with the official classifications.

R&D does not have to be considered as an end. It has just to be considered as a way to reach a better performance or to develop new product / process. The innovation model is not linear and can be considered as a chain-linked model (Kline and Rosenberg, 1986). Several innovations are due to feedbacks from the market. Moreover the flexibility of the construction process allows for adaptation and development of existing products.

Further research has to be developed to examine the complementary role of R&D in construction (the "absorptive capacity") and analyse the impact of training on innovation. Indeed training is considered by the smallest enterprises as the main input to innovation.

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