Research and innovation: How can the American model be used to contribute to the French debate?

by the French-American Foundation, Paris

Introduction

Since the recent protest movement by researchers and against a background of growing international competition, France has been giving thought to a reform of its research and innovation system so that it will be better equipped to meet the new challenges that it must face. A great deal of discussion is currently under way between stakeholders whose interests sometimes differ, but whose co-operation is the essential component of a competitive strategy aimed at creating synergies and leverage effects.

At the same time as France is rethinking how its research system is organised and operates, the US model is growing stronger and is seen as a "reference". This is why understanding the mechanisms and drivers of the scientific and technological sector in the United States can make a relevant contribution to the French debate. To this end, the 2004/2005 cycle of conferences devoted to the US research and innovation system, which was organised by the Association Nationale de Recherche Technique and the French-American Foundation - France, provides some interesting points of comparison that can be taken into account in an effort to "rebuild" the French research system. Among others, Corning Incorporated, a US company established in 1851, which is the world leader in manufacturing substrates for liquid crystal screens, is an excellent example of the opportunities for co-operation between France and the United States in the field of R&D at both the academic and the industrial level, in particular through its facility based in Fontainebleau.

The issues addressed in these conferences primarily concerned the role of universities and the promotion of excellence in US research, US scientific policy and the links between public and private research in the United States. The analysis of these issues contributes to a better knowledge of the organisation of the "US model", which is notable for the undoubted excellence of its scientific and technological results - appreciably superior to those achieved in France and even in Europe.

The discussions between French and US specialists proved to be extremely rich and relevant, thanks to the contribution made by such gifted speakers as Charles Wessner, Director, Technology and Innovation (The National Academies); Christine Bénard, Director of Research at the CNRS and Advisor for Science and Technology at the French Embassy to the United States; Robert Lowe, Professor at the Tepper School of Business, Carnegie Mellon University; Arthur Bienenstock, Dean of Research at Stanford University and former deputy director of the White House Office of Science and Technology Policy; Jim Turner, House Science Committee; Bradley Knox, Small Business Committee, House of Representatives; Mark Stanley, NIST; Kathleen Kingscott of IBM; Joseph Bordogna, Deputy Director, Chief Operating Officer (National Science Foundation); Jean-François Minster, former director of INSU-CNRS and former CEO of IFREMER; Lina Echeverria, CEO of Corning SAS; and Graham Mitchell, Director of the Program in Entrepreneurship, Lehigh University, Pennsylvania, and former Assistant Secretary of Commerce for Technology Policy.

Understanding how universities fit into the research system in the United States can provide a basis for analysing how the French university system, the effectiveness of which is currently being questioned, might approach a reform of the way it operates.

US universities are key research and development actors. Their central position is not really due to their financial contribution to R&D, but rather to mechanisms that place them at the heart of the system and drive them to seek excellence. For example, the fundamental role played by private companies and the federal government in funding US R&D creates a climate of intense competition among universities, since this funding is granted on the basis of projects that each of them submits. This competition is one of the factors that explains the quality and dynamism of US research.

Furthermore, the fact that the United States does not have a system of "grandes écoles" distinct from universities, as in the French education model, explains the close relationship between universities and production sectors in the US, where companies automatically turn towards universities - not to mention the fact that the vast majority of corporate managers themselves attended these universities.

Lastly, the role of federal institutions in creating and maintaining the network of outside infrastructure and the enormous scale of the financial resources invested are also assets for US universities. In 2004, the federal government's contribution to R&D funding amounted to $127 billion, and the 2005 budget was $132 billion. Research funding is primarily allocated by the Department of Defence (DOD), the National Aeronautics and Space Administration (NASA), the National Institute of Health (NIH) and the National Science Foundation (NSF). These funds are granted in equal proportions to public and private institutions, despite the fact that there are fewer of the latter, whence an imbalance. However, in addition to the funding received from federal agencies, US academic research is also based on funding from local states, industries, foundations and its own resources.

The guaranteed transparency of the procedure for selecting the projects to be funded and the considerable degree of control exercised within the universities themselves (since boards of trustees have final responsibility for the choice of projects) are both positive mechanisms that are key factors behind the achievements of US research.

In addition, the interaction of the scientific and industrial sectors, through technology transfers and the creation of start-ups by universities, is essential to understanding the growing share of university funding provided by US companies.

Technology transfer is one aspect of a policy aimed at enabling firms to branch out in their regional growth strategy and is a significant driver of economic development. Since the Bayh Dole Act was passed in 1980, US universities have had intellectual property rights over all federally funded projects and any resulting discoveries patented can be licensed to companies. In fact, this Act encourages university research in the field of technology transfer, the marketing of scientific discoveries and lasting co-operation between researchers and companies in this field, even though these positive effects are offset by the risk attaching to heavy investment in patents and licences for technologies that will not necessarily be developed successfully, as in the case of *Novartis-Berkeley.*

Start-ups enable universities to play a growing role in the local economy because of their strategic location near university campuses and the funding granted by federal, regional and even local institutions. Their success rate, which is much higher than that of start-ups in general, therefore raises the issue of the appropriate management of the public funds provided to support these initiatives.

US universities have always provided an interface between research and companies. The most recent institutional changes and trends in the industrial sector have therefore strengthened these traditional ties, while acting as a catalyst for the establishment of new university structures.

The promotion of excellence in research: the experience of the National Science Foundation (NSF)

Created in 1950 at a time of post-war reconstruction in response to President Roosevelt's desire to give government a stronger role in research and education, the National Science Foundation (NSF) is now seen as a model for the promotion of research and innovation.

This independent organisation, one of the aims of which is to support scientific and technological progress in the fields of health, development and national defence, was largely based on the ideas contained in Vannevar Bush's book Science: The Endless Frontier, which already at that time argued that the future of science was contingent upon high-quality education and that scientific research was a valuable asset.

The NSF has been a model for many countries and is based on fundamental values such as respect for different opinions, the participation of civil society, teamwork and dedication on the part of all concerned. Its strategic policies are aimed at integrating "intellectual capital", research, education, exchanges and co-operation. Its objectives are based on "human capital", ideas (scientific and technological discoveries, innovation, imagination), tools and resources (laboratories, infrastructure, facilities) and excellence (leadership, management, organisation and entrepreneurship).

The National Science Foundation works in co-operation with other federal agencies, such as the National Science and Technology Council (NSTC), which sets goals for federal government investment in the scientific field. The NSF is responsible for evaluating key programmes such as the GPRA (Government Performance and Results Act) and the PMA (President's Management Agenda) with the assistance of unpaid volunteer experts and auditors, showing a constant concern to promote access to education and research. The idea is to meet the President's expectations by developing criteria for evaluating the government's performance in the field of R&D so as to increase its effectiveness at different levels: administration, management, strategic guidance of personnel, improvement of the financial rate of return, growing use of technologies, etc.

Promising projects are selected by review committees on the basis of merit (scientific interest, impact at various levels). Every year the Foundation receives over 40 000 proposals and on average awards some 10 000 research grants. Currently, the focus is on nanotechnologies, engineering, biocomplexity in the environment, social and human dynamics and mathematical sciences.

In this way the National Science Foundation makes it possible to develop synergies and promote excellence in research and education through flexible and transparent operating procedures.

Science policy in the United States: The first level of strategic guidance of research

One of the basic assumptions in the field of research consists of recognising that there is an element of the unknown since no one can foresee the inventions and discoveries that will be made by the scientific community.

In the United States, 68% of federal funding of basic research goes to universities and other higher education institutions and 10% to research laboratories managed by universities.

Federal funding of research in the US is characterised first and foremost by its openness to innovation and is provided by agencies as diverse as the Department of Defence, the Department of Energy, the Department of Health and Human Services, NASA and the NSF. Each of these institutions has specific priorities and different objectives (energy, the environment, economic development, etc.), which means that there must be co-ordination at national level, even though this is complex. This strategic guidance is ensured by two agencies, i.e. the OMB (Office of Management and Budget) and the OSTP (Office of Science and Technology Policy).

The OSTP plays an advisory role to the President on science and technology policy and co-ordinates activities between the various federal agencies. The main scope of its activity is the budget, science and technology researchers, information technology and nanotechnologies, government-university relations, the major directions of research, initiatives in the field of education and research, nuclear energy, biomedicine, the physical sciences and engineering.

An analysis of the demographic challenges facing the US science and technology sectors shows that the late 1990s were characterised by a massive reliance on skilled immigration to offset the internal shortages caused by the ageing of the population. The positive discrimination programmes initiated by the federal government have also made it possible to increase the participation of women and ethnic minorities in the science and technology sectors, despite longstanding scepticism in this regard.

Strategic guidance and planning at the federal level are essential both for basic and applied research. The challenges are ongoing, particularly in the field of nanotechnologies, which explains the scale of private investment, as in the case of IBM - Stanford University.

There are two main differences between France and the United States in the field of science: firstly, the compartmentalisation of research and education in France following the separation between the CNRS and universities, and secondly the importance given to basic research, bearing in mind that the strategic guidance prevailing in the United States involves co-ordination rather than centralisation.

Public-private research: US strengths and French shortcomings

For nearly 25 years, the United States has been building up its research and innovation system by relying mainly on public-private networking. Against a background of growing international competition, emphasis is being placed on expanding financial resources in order to maintain a leadership that thus far remains unchallenged. What lessons should France draw from this example? A study of the evolution of the US innovation ecosystem enables us to understand the assets and the challenges faced, for purposes of a comparison with France, and to break with the main myths prevailing in this sector in the United States.

The US innovation ecosystem is, above all, a dynamic model that responds to the expectations and motivations of the different players in the science and technology sector. Its strengths are based on the substantial amount of R&D expenditures, solid legislation in the field of patent protection and large venture capital markets. In addition, US cultural norms such as the promotion of entrepreneurship and considerable tolerance of failure (which is viewed as a learning process enabling people to make a fresh start) are other features that need to be taken into account.

However, besides these assets, there are also numerous challenges to be met if the US is to maintain its innovative capacity, such as a drastic reduction in the supply of venture capital, especially since the end of the Internet bubble; a widening trade deficit (currently $650 billion); international competition in the high-tech sector (from Sweden, Finland, Japan, South Korea, etc.); and a historically low level of federal funding for R&D.

In this somewhat unpromising general situation, France is still a contender and is not that badly placed. Its innovative capacity in terms of technologies, products and new industries is greater than that of its European neighbours, in particular because of the range of its technological and industrial expertise in strategic sectors such as the pharmaceutical industry, civil aviation, the space industry and nuclear energy. France also has high-quality human resources and excellent infrastructure networks. Its policies in the field of innovation include interesting measures such as co-operation between the public and private sectors; growing mobility among researchers; initiatives to promote the dissemination of technologies, funding of projects and growing Internet access; the promotion of entrepreneurship through the creation of start-ups, the development of competition, etc.

In addition, France has increased its R&D spending and has reached the objective of 3% of GDP set by the Lisbon Declaration, the main challenge being to promote change by creating new incentives for investment in the field of science.

The failure of many countries to maintain R&D levels will ultimately jeopardize the competitiveness of the European Union. The fact is that sustainable economic development, both in France and elsewhere, requires significant investments in new technologies and the creation of new businesses. The solution proposed by the Beffa Report is to create a National Innovation Agency that would identify the key programmes for industrial development in priority sectors such as energy, transport, health care, nanotechnologies and information and communication technologies. This initiative proposes public investment targeting large-scale scientific projects capable of developing industrial and sectoral specialisation in France.

However, the Beffa Report does not propose any measures to support the small and medium sized businesses that might become the large corporations of tomorrow (like Microsoft). In the United States, on the other hand, the SBIR (Small Business Innovation Research Program) created in 1982 requires federal agencies with budgets in excess of $100 million to participate in funding grants for innovative companies.

Some of the common myths about innovation in the US include the supposed “rationality” of the system (whereas it is characterised by some degree of flexibility), the overly large budget devoted to defence and research and theories about “perfect markets” that do not take into account the fact that there is an information asymmetry.

The dynamics of public-private partnerships and the legislative environment of innovation in the United States are based primarily on the role of universities and the support provided to small and medium sized enterprises.

Although it is true that US universities spend between $30 and $35 billion each year on R&D, the enormous increase in the size of budgets is above all a post-World War II development. Then again, the legislation passed in the fields of patent protection (Bayh-Dole Act) and competition (Antitrust Policy) played a fundamental role in the development of co-operative ventures and partnerships, removing the separation between universities and businesses that had existed until then.

Similarly, the creation of the Small Business Administration has contributed greatly to the increase in the number of loans granted to small and medium-sized businesses to promote entrepreneurship (in particular through the key role of women) and the flow of private capital into small businesses.

The Advanced Technology Program established in the 1980s is a genuine model subsequently adopted in many OECD countries. The objective is to provide financing to companies with high technology risks in their initial phases of development, i.e. the first three years for a SME and the first five years for a large company. In all, $4.3 billion are provided each year for this initiative, 66.6% of which goes to small and medium-sized enterprises. Joint financing with a company is also possible and projects are evaluated on the basis of their scientific and technological merits. The results are encouraging and show that, in 86% of cases, the financing provided accelerates technological development, increases the competitiveness of the companies funded, promotes co-operation and makes it possible to reduce production costs while at the same time creating opportunities in sectors in which investment is becoming scarce because of the high risks involved.

Lastly, the growing need for flexibility, both in the United States and Europe, and the faster pace of innovation require large industrial companies in science and technology (such as IMS, Morgan Stanley, etc.) to play an active role in meeting the new challenges in this sector.

Applied research in France and the United States: Differing relations with R&D actors? The example of a specific company.

Corning Incorporated has a long tradition of innovation stemming from its continuous R&D activity. Its research activities have long been conducted on several continents, with its two largest laboratories located 1) in the United States (Corning NY) and 2) in Europe (Fontainebleau - France). This conference provides an opportunity to make a general presentation of a method of managing innovation that straddles two cultures and, more specifically, to present the differing ways of interacting with R&D players outside the company, public laboratories and universities.

The company, created in 1851, today has some 25 000 employees and a turnover of roughly $4 billion. Traditionally a glass manufacturer (of “specialty” glass, i.e. neither container glass nor flat glass), the company has now broadly diversified into other materials, such as crystalline materials and polymers.

Corning Optical Communications supplies the telecommunications industries with products such as cable and fibre optics for optical telecommunications networks.

Corning Technologies develops a wide range of products and technological solutions in advanced materials markets, such as substrates for flat screens, ceramic substrates for automotive catalytic converters and filters, very high-precision lenses for manufacturing computer chips, products and technologies for life-science laboratories, optical-ophthalmic products (special optical glass for projector lenses and mineral and organic corrective lenses) and special materials (unique glass products for targeted markets such as aerospace, aeronautics and astronomy).

Corning's tradition of innovation is reflected in the history of its discoveries and its contributions to technology and manufacturing processes. Its culture is geared to transforming science into technology with a view to providing consumer products and applications with a competitive advantage and a certain exclusivity stemming from the complexity and well established intellectual ownership of the products and the processes developed.

To this end, the company manages its portfolio of projects in the light of a basic "formula" for selecting projects so as to maximise the chances of developing a product that will have an optimum and lasting competitive advantage. The "formula" is in fact based on the technological barrier associated with the trademarked product.

The first step is to find an area in which the company's in-depth knowledge and expertise in a technical and scientific field can be matched with a clearly identified critical need on the part of a customer. The subsequent project must result in a component that is the "keystone" of a system with features that are difficult to realise. Strategic control over the product life-cycle is ensured by highly specific processes (know-how) and very careful management of intellectual property (some 300 patents filed yearly).

An important aspect of this strategy is the management of research staff. The professionalism required is obtained by ensuring the continuity of staff over time. Many careers - in fact the vast majority - are devoted entirely to innovation in R&D in the fields of materials and processes. In order to ensure diversity, the building up of experience and the possibility of advancement in this context, three parallel "ladders" have been identified, with the possibility of crossing over between them in the course of a career:

- the technical-scientific ladder, up to the level of research "Fellow";
- the project management ladder, up to the level of Programme Manager.
- the operational ladder, up to the level of Director of Research.

The three top levels of these ladders are equivalent in terms of pay and prerogatives. A research director may manage a research unit of over 150 people, while a research fellow may have no direct hierarchical relationship. In general, fellows have over 20 active patents to their credit and more than 100 publications recognised as being of general interest, together with their other achievements. It is clear that the separate functions of operational director of research and programme manager give rise to a strictly compartmentalised organisation of operations.

In terms of relations and co operation with public laboratories, differences can be seen between the approach taken by the R&D team in the United States and the European laboratory. The contracts and relations established in the United States are geared more to the concept of long-term monitoring of progress in basic fields and areas of expertise, in a fundamental perspective. The terms of the co operation refer to general discipline and the work is monitored multi-annually and does not necessarily target a specific, clearly identified problem in a given time frame. The purpose of these relations is to maintain contact and keep informed of the state of the art in a few selected fields, with laboratory directors in person often acting as consultants.

In Europe, on the other hand, the approach is generally more targeted and in fact more limited in time. Although co-operation is established on the basis of the need to understand fundamental issues, projects are generally chosen in order to respond to a clearly identified problem. As a result, relations often do not last any longer than the individual contracts [specific contracts, graduate degrees, dissertations - generally written under CIFRE (conventions industrielles de formation pour la recherche, or industrial research training agreements) - and post-doctoral work]. Consequently, there is a higher "turnover" of the public laboratories with which our European organisation is in contact.

The current trend is to shift co-operation in Europe towards a model that is closer to the practice in CORNING US, through co-operation programmes with major European laboratories that are more lasting and more targeted towards fundamental and general areas of expertise.