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Science, Technology and Innovation Policy: New governance schemes in Europe, in France and at regional level

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Science and innovation policies are at the core of economic development nowadays, at the level of nations, and for multi-national entities like European Union and sub-national actors like regional authorities as well. In the specialised literature, the concept of National System of Innovation (NSI) has been developed for a long time now [Freeman 1987 & 1995, Lundvall 1998, Nelson 1993)], at crossroad of economics of innovation and policy studies. The concept of NSI has two faces, namely (i) the description of the specificities of actors and relationships between actors contributing to the creation and diffusion of new knowledge and its economic application in a given country; (ii) the set of policies and specific instruments implemented by government and other public authorities in order to improve the efficiency of such knowledge creation and to translate it into economic development. In an increasingly globalised and complex world, nations are no more (if they ever were) the unique scene of the game. Therefore, beside NSI, other concepts have been developed like Regional Innovation Systems, [Braczyk, Cooke, Heidenreich 1998)], Learning regions [Florida 1995], Clusters [Porter, 1998], etc., and more generally multi-level governance of science and innovation. In addition, innovation processes are influenced (and, increasingly, research agendas designed) by the strategies of non-public organisations, like large firms and NGOs, leading to the concept of multi-actor space. French specialists of NSI, like Amable, Barré, Boyer [1997], have insisted on the institutional dimension. And the French case indeed is a good illustration of the importance of national context for innovation systems.

Our aim here is to describe the French system of innovation and its evolution within Europe and in comparison with the other developed areas of the world. The specificities of a traditionally centralised and interventionist state (characterised by the "Colbertist" tradition presented in part **2.**) are interesting to consider, since the corresponding NSI has now to adapt to new rules in terms of *liberalisation* and *decentralisation*. In both dimensions, the new context of European interrelatedness and regulation plays a significant role: strong national policy (project-oriented) is no more permitted and/or efficient; sub-national and supra-national entities join their forces to counterweight the traditional power of the nation state.

If France is relatively specific in Europe, it can also be considered as a model in the sense that it is not the only centralised country. UK, for instance, has a more liberal economy, but a less decentralised territorial organisation. Certain British regions are presently looking at foreign models in order to develop their own science and innovation system (and resist the huge polarisation power of the *Golden Triangle* around London, Oxford and Cambridge), and the French recent decentralisation scheme is a better case to contemplate than traditional federalist setting of Germany or Austria. The weaknesses of the French NSI illustrate also very well some of the European problems, for instance the seemingly difficult link between science and innovation that will be one of the central issue addressed in this paper. By comparing with other areas of the world we will be able to analyse the European science/technology paradox (part **3.**). But before entering the analysis of the seemingly inefficient interface between research and innovation, we want to underline the urgent need to improve the European system of innovation (part **1.**).

1. The necessity to base European economy on knowledge and its implications

Industrialised countries are increasingly confronted to adaptation problems in the context of the globalised economy. The question is not new, but many advanced countries, particularly in Europe, have recently experienced important changes in the volume and the nature of the process of "offshoring" industrial and tertiary activities towards emerging economies: Eastern Europe, the Maghreb area, China, India, etc. The global amount of production and employment concerned by that phenomenon has dramatically increased in a few years. The perception of the challenge and the fears about the future are reflected in the media, diffused in the society and gave rise to political debates. It is by now a big political issue within countries like France or Germany, where traditional industrial activities are clearly endangered by the growing competition from lower-salary countries and even by catching-up countries that are now able to supply well-trained engineers and efficient services.

At the EU level, the issue is not so directly addressed but it is implicit in the challenging project of transforming Europe in a leading "knowledge-based society" [European Commission 2000]: for retaining their current living standard, European countries cannot compete in traditional sectors and must therefore specialise in innovative services or science-based industries. But one of the present problems in European policies is the possible contradictions between several objectives. The new concept of European Research Area (ERA), which is a central element of the strategy for overcoming the perceived European lag on the way towards the future knowledge-based society, will be implemented by a better coordination of national S&T policies (and national educational/training systems), but also by the networking of regional centres of excellence. In order to increase the global efficiency of the European innovation system and avoid dispersion of efforts, the selection of "critical mass" clusters is a clear prerequisite of the policy. We can therefore anticipate a concentration of knowledge, innovation and economic development on a limited number of competitive territories. Such a result will be in contradiction with other objectives of the EU, like cohesion, equity, and regional convergence. Many large towns and innovation districts in Europe will certainly escape the negative consequences of globalisation by reconverting their activities to the new economy, but many other areas will just lose their traditional activities.

The European Commission feels concerned by significant disparities in the allocations of funding for research distribution of facilities between regions. In order to compensate the trend towards clustering scientific excellence (see map of regions in Appendix1), some solutions are proposed [European Commission 2001], but contradictions are unavoidable between science, technology and innovation policy on the one hand and cohesion and regional policies on the other hand [Héraud, 2003]. In a sense, European regional policy tends to become an instrument of innovation policy [Héraud, Elouardighi, Kahn, 2004], for instance by using structural funds to build the networks of excellence.

A new form of competition among territories is developed through the European policy focusing on "networks of excellence". Globally, the new rationale of research policy tends to be a multi-level governance mechanism between EU, member states and sub-national entities, in a context of complex competition. Even in a country like France, with a long-standing tradition of central state planning of public investments, an increasing part of the funding of science, education, training and technology transfer is subject of negotiation between all levels of public governance (state regions, cities).

2. The end of the *Colbertist* tradition in France

From the early development of the "royal manufactures" by Colbert in the 17th century to the high tech government-driven development after World War II, France has always exhibited an interventionist model of development. Its modern form is called *Technological Colbertism.* It is characterised by the following features [see F. Chesnais *in* Nelson, 1993]:

- Pervasive state involvement can be observed in the production of general scientific knowledge, but often of technology as well, through specific "mission-oriented" public organisms (applied public research organisations and agencies)[1], and by subsidising national "champion" firms. Public "large programmes" are also part of classical state interventionism: in 1990 five "*programmes de développement technologique*" (electro-nuclear, space, civil aeronautics, telecommunication, electronics-computers) consumed about 50% of the total civil budget of the state. Last but not least, the military technologies played a significant role in the national system of innovation.
- Organisation and funding of the largest part of basic research are implemented through a special institution, the CNRS, distinct from higher education organisations. The higher education itself is composed of universities on the one hand, and *"Grandes Ecoles"* producing elite engineers, industrial managers, political and administrative personnel on the other hand. It is important to underline that the latter prestigious institution is not traditionally research-oriented.

This stereotyped image of the French system is no more relevant as Mustar and Laredo [2002] have showed:

a) The major role of large programmes has almost vanished during the 90s, through privatisation and overall decrease. Public funding is now limited to internal expenditures of

1 Most of them have been created after World War II as building blocks of the NSI. They perform research in fields where, in other countries, university, private sector or NGOs are typically active. Among the major organisms: CEA (civil and military nuclear technologies, but also materials, microelectronics etc.), CNES (space), INRA (agricultural research), CEMAGREF (agricultural machinery), INRIA (artificial intelligence), INSERM (health), BRGM (mining, geology), IFP (petroleum and gas), CSTB (building), IFREMER (marine and fisheries research), ADEME (energy conservation, environment technologies), etc.

the public research organisms. A typical "bottom up" policy instrument like Research Tax Credit has now a larger budget than the technological programmes monitored top down. We must add that military expenses have considerably diminished and have less technological spillovers on the civil sector, as a consequence of the new policy principles (buying "on the shelves" instead of developing generic technology upstream).

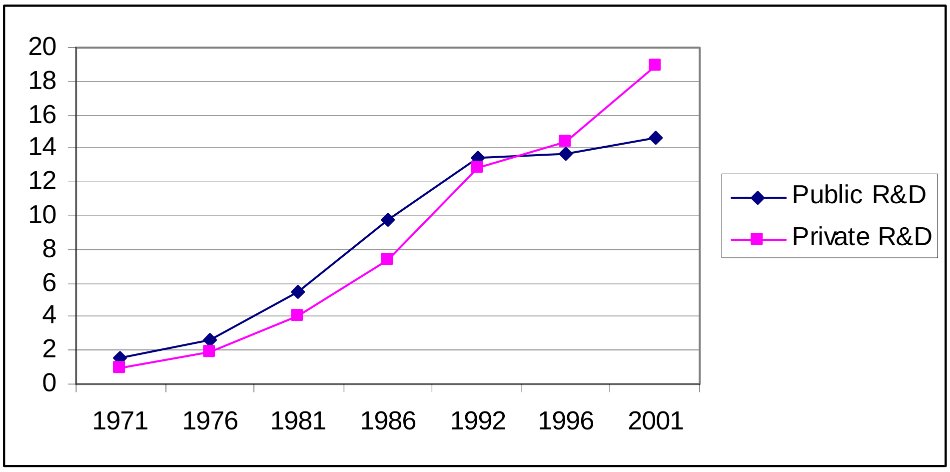
b) The basic research is no more focused on CNRS. The present French system is characterised by the "hybridization" of CNRS and universities, CNRS becoming progressively a research support agency more concerned with the structures than with projects and making contributions to universities in the form of human potential. At the same time, *Grandes Ecoles* are increasingly involved in research.

c) The convergence of "mission-oriented" research organisms and the academic world is evident: nowadays, the public research institutes like INRA (in agro-food technologies) have developed mixed research units with universities (following the same model than CNRS) and university labs are increasingly involved in co-operative research with industrial actors.

d) There is a growing role of new public participants in research policy: EU and regions. Both have entered the research and innovation scene in the early 80s. For the regions, the French devolution process started with the "decentralisation" Act in 1982. For the EU, the turning point is the first RTD Framework Programme in 1984. Regions were typically asked to contribute to university buildings and to innovation support of SMEs through State-regions planning contracts (*Contrats de Plan Etat-Région*). The EU framework programmes have introduced a new model of governance involving universities, firms, local and central administrations and co-funding schemes in R&D consortia.

Some basic statistics show the rapid evolution of the French system away from the Colbertist model. Firstly, the share of R&D expenditure financed and performed by the public sector relatively to that of industry has dramatically diminished during the 90s.

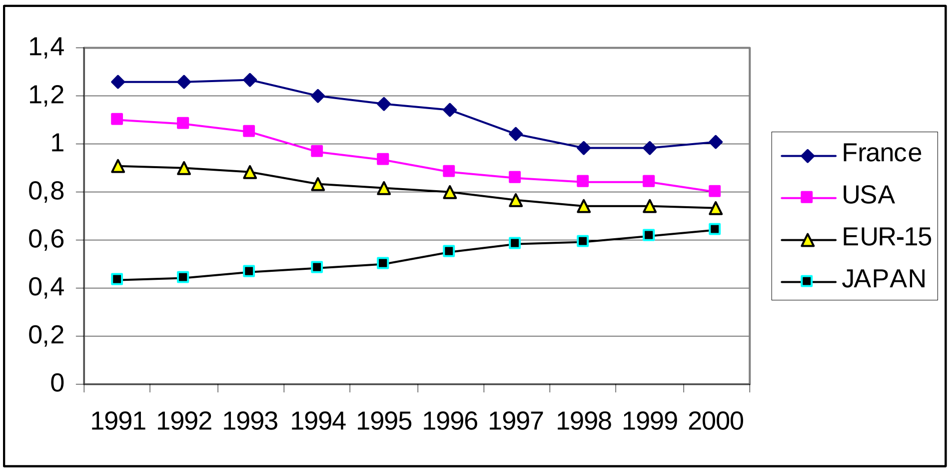
Figure 1
Compared evolution of public and private research in France
(current G€)



<u>Source</u>: OST (2004)

Relatively to GDP, the R&D public funding has diminished and French data look now closer to the international standard.

Figure 2
Public R&D budget (% of GDP)



Source : *Third European Report on S&T indicators* (EC, 2003) and OST(2004)

State subsidies and orders are now less focused on a limited number of large firms (national champions), and SMEs benefit from general and specific innovation policies, with a significant part of the public funding. The national agency ANVAR is now specialised in supporting them, instead of transferring results of public research to the large firms, which was its first assignment in the 80s. The Research Tax Credit system is now largely used by SMEs. As a result, the number of smaller firms involved in research has considerably increased. In 1999, the share of business R&D of firms with less than 500 employees is 21% - a higher level than Germany (15%), USA (19%) and Japan (7%), and close to the EU average (22%)[2].

The military R&D expenses accounted to 0,5% of the GDP in 1990 and 0,2% in 2000. As a share of the total public R&D expenses, they went down from 35,6% to 17,3%. In terms of international comparisons, military R&D is still above EU average in France (in 1998: 11% of total R&D instead of 6,8%) but far from the share of USA (17,5%)[3].

The share of university in total R&D has increased. Specialised research organisms are no more central, and France is presently not very divergent from the average of EU at the end of the millennium as Table 1 shows. USA and Japan are characterised by quite higher levels of private contributions (in performance, but not so much in funding for USA). Japan is the closest to France in terms of balance between public organisms and universities.

[2] *Third European Report on Science & Technology indicators* [2003], p. 135.
[3] OST [2002]

Table 1
International comparison of R&D performance (execution) by type of organisations (1998)

	FRANCE	EU-15	USA	JAPAN
"Mission-oriented" public organ.	20,9%	18,2%	10,9%	13,8%
University	17,1%*	20,1%	14,0%	13,6%
Firms	62,0%	61,7%	75,2%	72,7%
Total	100%	100%	100%	100%
Volume (G€)	27,0	134,3	214,3	84,1

* University + CNRS
Source: OST [2002]

The end of the Colbertist tradition in France has some positive aspects: diffusion of research in larger circles of the society, more flexible and "bottom-up" approach, decentralisation and inclusion of new actors – leading to more democracy, and maybe more efficiency, of the national system. But the transformation is not fully achieved and is also inducing some problems. A typical indicator of the centralisation of the French innovation system is the number of researchers concentrated in the region around Paris (Ile de France). In 2001 the proportion was still 36% for public R&D, and 48% for the private sector! There are some industrial and technological clusters outside this area, like Toulouse in aerospace and a major science park near Nice (Sophia-Antipolis), but the only region exhibiting a complete regional innovation system is Rhône-Alpes with the urban areas of Lyon and Grenoble hosting a coherent network of large and smaller firms, universities and research centres, active regional and local governance structures, and a high tech district in nanotechnologies (Minatech) that used existing infrastructures and public competencies but appears to a large extent as the fruit of a bottom up networking process.

As a whole, the country is still far from a perfect "knowledge-based society". The patent statistics indicate a relative decline in (private and public) technological creativity; production and export data show a relative de-specialisation of the national economy in the most innovative and science-based sectors; the participation in lifelong learning programmes is one of the lowest in Europe, etc. Such indicators are the sign of (at least) transition problems. The centralised system of the after-war period, which worked very well and allowed France to catch up rapidly, has not yet been replaced by a new model of development and the country is now incurring an increasing lag, behind the most dynamic systems of Northern America, East Asia and even Europe. In fact, the structural problems of France are symptomatic of the situation of a large part of the EU as we will see.

3. The science and technology paradox

In most of European countries, there is a paradoxical situation in the science and technology system. Europe is not lagging behind USA in science production, but it is quite less efficient in technological and commercial innovations.

a) Scientific outcomes

Concerning science, although USA appears leading if scientific results are measured by highly visible outcomes such as Nobel prizes, by using more comprehensive bibliometrical statistics (on the basis of ISI data) the world's share of the European publications is larger and slightly increasing. The only clear inferiority is in the "quality" of publications, as measured by citations indexes. That observation leads to a similar diagnosis than the counting of Nobel prize winners: excellence in research is often American, but not necessarily the global volume of research.

Let us illustrate the point with basic data. Considering the evolution of scientific production within the Triad, we observe that, in global terms, Europe is not falling behind the other leading areas of the world.

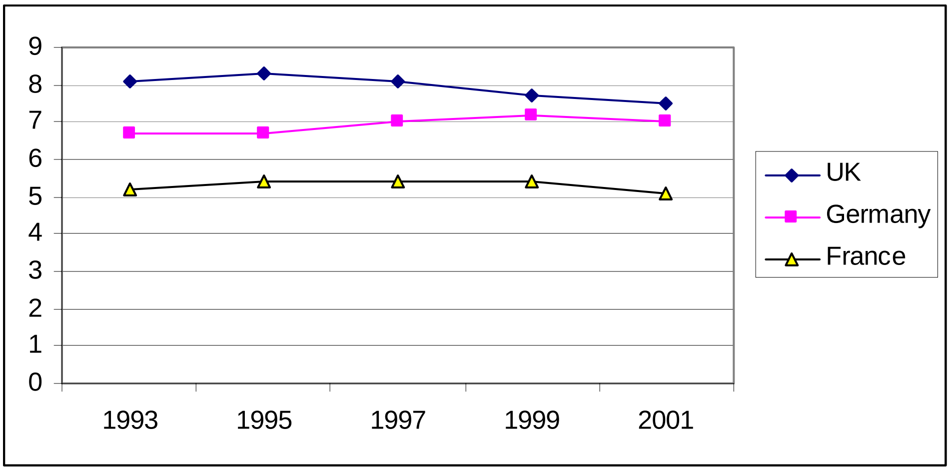
Table 2
Shares of world scientific publications (%) among the Triad

	1996	2001
EUR-15	33,3	33,4
USA	31,9	28,5
JAPAN	8,5	9,0

Source: OST [2004]

We can just notice that, in the recent years, UK and France started to decline. But their lower contributions are compensated by the resistance of Germany and progresses in some other EU-countries (Spain, for instance, starting from a low level, has considerably increased its share).

Figure 3
Shares of world scientific publications (%) for the three main European countries



Source: OST [2004]

Europe is winning the scientific competition in an increasing number of fields, as seen in the table of Appendix 2. Another way to look at the data is to consider that the (almost) complete leadership of USA gained in the middle of the twentieth Century is now giving away some fields to Europe (and also, very recently to the area "Asia-Pacific").

If we consider the criterion « quality of science », measured in terms of citation indexes, the image of Europe is different. This is probably a part of the solution of the European paradox, *i.e.* explaining the discrepancy between innovation indexes and gross scientific production.

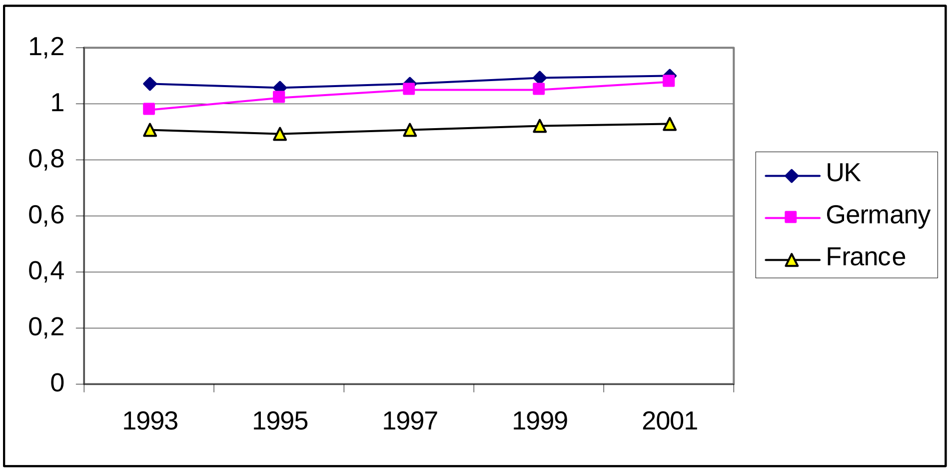
Table 3
Index of publication impact among the Triad

	1996	2001
EUR-15	0,96	1,00
USA	1,44	1,48
JAPAN	0,82	0,84

Source: OST [2004]

In comparison with British and German colleagues French researchers must improve their "professionalism". This situation has certainly something to do with the relative weakness of the university system in France (because of the traditional supremacy of the *Grandes Ecoles* and the brain drain they produce among the most brilliant students).

Figure 4
Index of publication impact for the three main European countries



Source: OST [2004]

b) Technological outcomes

The core of the European paradox is the poor outcomes in technology. Concerning applied science, technological development and innovation, the current indicators are patent statistics. We can consider them in one of the two major patent systems: the European (EPAT) or the American (USPAT). Table 4 demonstrates the superiority of the American inventors (and/or the power of the patent applicants): the US applicants have a larger part of their own patent system (48.7%) than the Europeans (42.3%) – Europe being restricted to EC with 15 members; and they apply more in Europe (32.2% of EPAT) than the Europeans apply in the American system (17.6% of USPAT).

Table 4
Shares of US and European patents in 2001

%	USPAT	EUPAT
EUR-15	17.6	42.3
USA	48.7	32.2

Source: OST [2004]

Wherever considering patent applications in EPAT or USPAT, the share of European applicants is declining. Table 5 shows the situation in the EPAT system. We observe a particular decline of France.

Table 5
Evolution of the shares of European patents
(annual growth 1992-2001, in %)

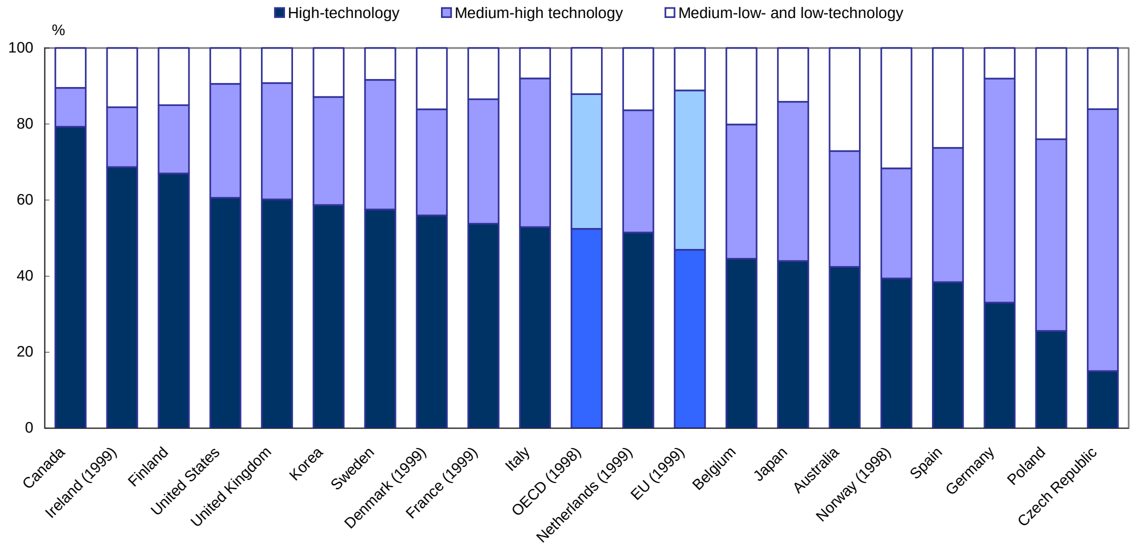
USA	JAPAN	EUR-15	GERMANY	UK	FRANCE
+1.6	-3.1	-0.6	-0.6	-1.8	-2.9

Source: *Third European Report on Science & Technology Indicators* [2003]

By using patent statistics leads, one gets a pessimistic vision of the European capacity of translating science into technological innovation. But it does not mean that European industry is systematically less creative. The real point is about leading sectors and science-based activities. The following examples cast light on the specificity of European (and French) situation.

In terms of R&D performance, European industry is still leading for chemical products or automobiles. It is comparable to the United States or Japan in electrical products and electronics or in pharmaceuticals. Europe is performing quite less research than USA in biotechnologies, semi-conductors or software and less than Japan in hardware. In France, car manufacturers are doing a lot more R&D than the computer sector. The difference is that innovation in car manufacturing does not lead as systematically to patenting than in biotechnology. The science and innovation statistics reflect in fact the specialization of the American economy in science-based activity. In comparison, Europe’s economy appears specialized in medium technology. On the other hand, the European scientific activities are not as systematically associated with economic applications. On the following figure, the relative specialization of Europe in medium technology as compared to USA can be observed. For this aspect, Germany appears clearly as the European paradigm. In fact, France, like UK and northern Europe, is closer to the US model.

Figure 5
Share of sectors in the global R&D expenses for each country



Source: OECD and *Third European Report on Science & Technology Indicators* [2003]

European enterprises benefit directly from a good level of education of the population and indirectly from the existence of good academic research, but not in the way American champions apply discoveries in life science, new materials or computer science. This situation has certainly some relationship with university-firms partnerships, with public defense R&D programs, and other specificities of the US system of innovation.

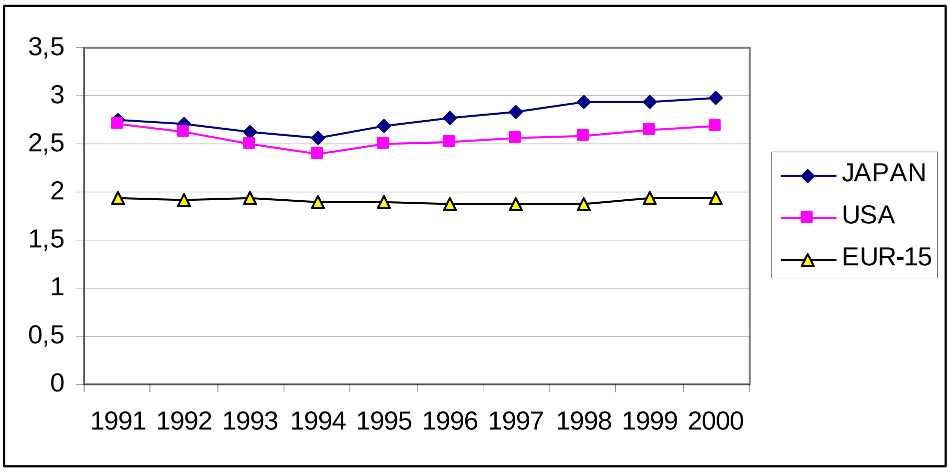
In France, the university system is not designed to fulfill the same function and the set of public research institutions has no more the possibility to be involved in large national technology programs (the classical French *grands programmes* of the 70s and 80s). The contribution of the French private sector is relatively concentrated. Five sectors carry out 57% of private R&D: automobile, communication equipment, pharmaceuticals, space industry, medical instruments. It is worthwhile noting that the same sectors benefit from a huge part of the public support (70%), but the global amount of public funding is decreasing in the long run.

4. Conclusion in terms of research policy

During about 10 centuries, Europe was the model and centre of diffusion of science and technological innovation. Important progresses in human wealth and health have been associated to that development in knowledge and culture. War technologies are also part of the landscape. Totalitarianism and war in the 20th Century Europe were also a major cause of the sudden decline of European supremacy during that century, in favour of America to a large extent. The challenge of Year 2000 (Lisbon Summit commitment and European Research Area implementation) is to re-establish Europe as a leading knowledge-based society. A concrete commitment was fixed: the famous 3% GDP level of R&D activities.

Looking at the data (Figure 6), the "EUR-15" Europe has not followed the two other poles of the Triad in the turn of the mid-90s.

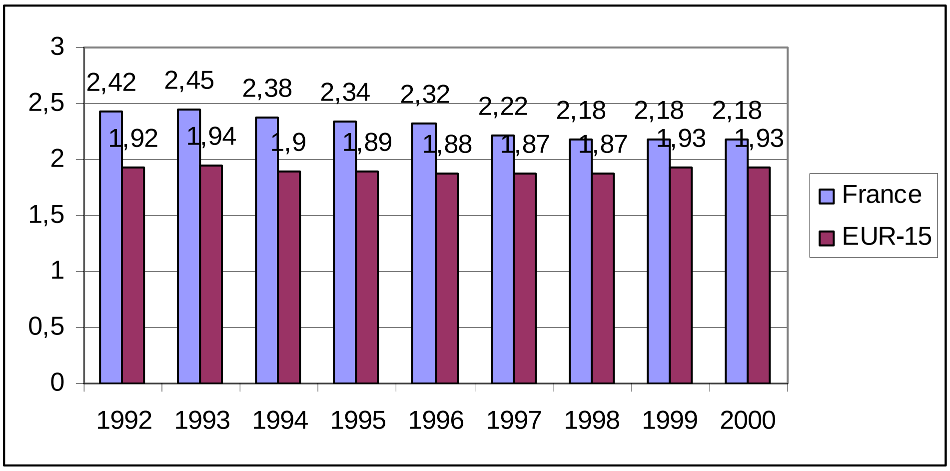
Figure 6
R&D intensity (% GDP) in the Triad



Source : *Third European Report on S&T indicators* (EC, 2003)

Although still being one of the leading European countries (research intensity above the EU average), France has decreased its efforts, as can be seen on Figure 7. The country was not moving towards the 3% level now set by EC as a target - and recent data estimations do not give any hint that it went in the right direction after 2000.

Figure 7
R&D intensity (% GDP) in France and in the EU



Source: OST [2004]

That statistical evidence confirms the difficulty for France to find an alternative model of science and technology development after the rapid fall down of the modern Colbertism set up after World War 2. European (and regional) governance is progressively replacing national governance but certainly not with the same philosophy. The new rules of the globalised economy have challenged other national systems as well. The case of Japan is also interesting to consider. In spite of the financial and economic crisis, Japan succeeded to increase its research intensity (and has reached the European target!). It is not certain that France could rapidly fulfil the collective European commitment even if political will were really present. Financing significantly more research requires probably, in the present macroeconomic situation and given the Maastricht criteria, a level of resources that is not available in the national economy (for private and even more for public actors). The problem is that, if a country like France does not invest quickly in science and innovation, and gets thus returns from competitive advantages, a sort of "poverty trap" could squeeze it in a situation where it will be no more possible to catch up.

References

Amable B., Barré R., Boyer R. [1997], *Les systèmes d'innovation à l'ère de la globalisation*, Paris, Economica.

Braczyk H-J., Cooke P., Heidenreich,M. (eds.) [1998], *Regional innovation systems. The role of governances in a globalized world*, London, UCL Press.

European Commission [2000], *Towards a European Research Area*, Jan. 18, Brussels, COM(2000)6.

European Commission [2001], *The regional dimension of the European research area,* Luxembourg, COM 549 final.

European Commission [2003], *Third European Report on Science and Technology Indicators,* DG Research, Brussels.

Freeman C. [1987], *Technology policy and economic performance : Lessons from Japan*, London Pinter Publ.

Freeman C. [1995], « The national system of innovation in historical perspective », *Cambridge Journal of Economics*, vol. 19, N°1 (5-24).

Florida R. [1995], "Toward the learning region", *Futures*, 27, (527-536).

Héraud J-A. [2003], "Regional innovation systems and European research policy: Convergence or misunderstanding?", *European Planning Studies*, 11(1) (41-56).

Héraud J-A., Elouardighi J., Kahn R. [2004], "Une relecture de la politique régionale européenne et du rôle des collectivités : l'exemple des politiques de recherche et d'innovation », 15ème Colloque de l'ASRDLF, Brussels, 1-3 Sept. (http:/www.ulb.ac.be/soco/asrdlf/papiers.html)

Lundvall B-A. [1992], *National systems of innovation: An analytical framework*, London, Pinter Publ.

Mustar Ph., Larédo Ph. [2002], "Innovation and research policy in France (1980-2000) or the disappearance of the Cobertist state", *Research Policy*, 31 (55-72).

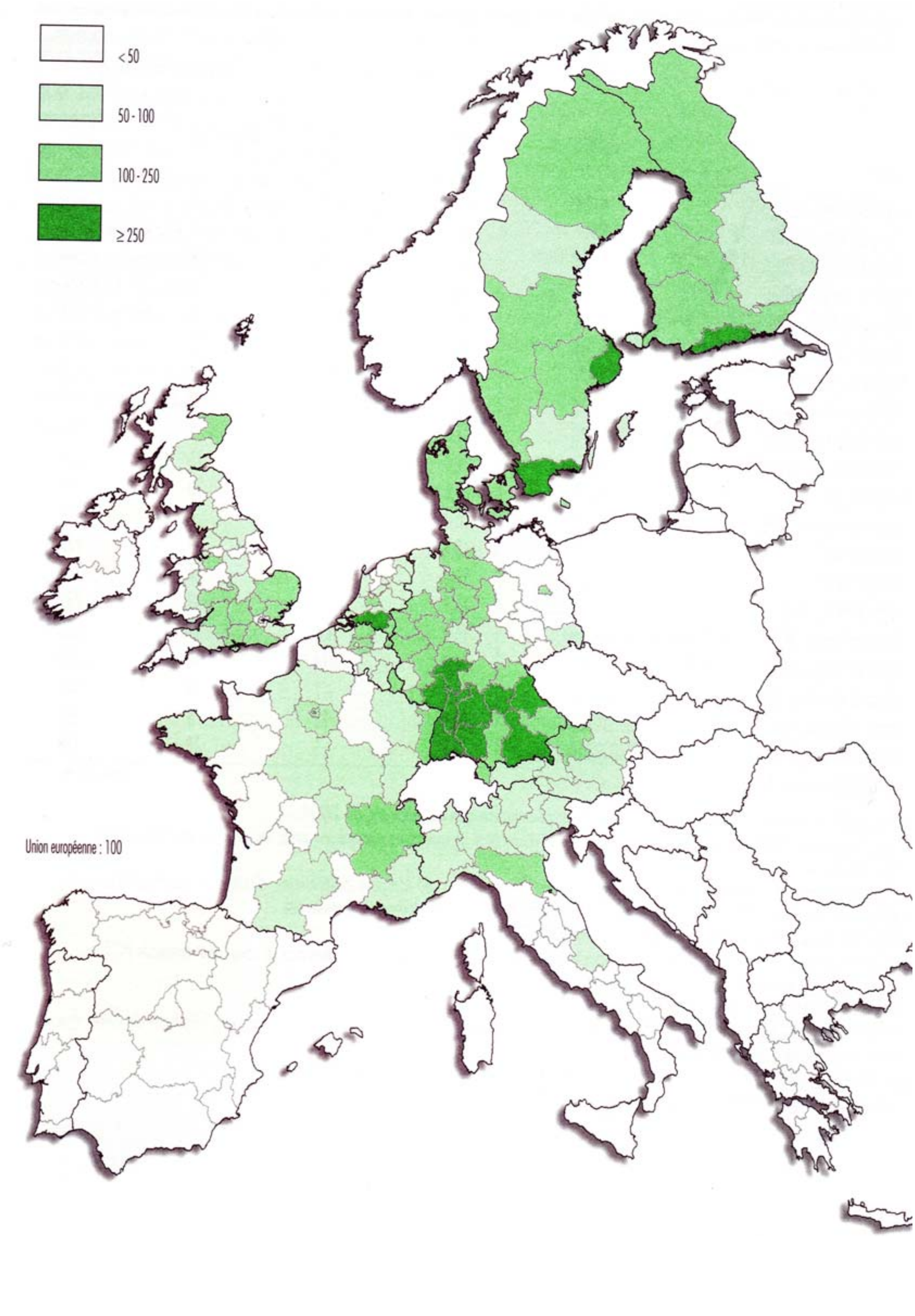
Nelson R. R. (ed.) (1993), *National innovation systems: A comparative analysis*, New York, Oxford University Press.

OST[2002, 2004], *Indicateurs de sciences et de technologies*, Rapport de l'Observatoire des Sciences et des Techniques, Paris: Economica.

Porter M. E. [1998], "Clusters and the new economics of competition", *Harvard Business Review*, Nov-Dec. (77-90)

Appendix 1

Technological density in European regions (2001)



Number of European patents per inhabitant (European average is 100)
Source: OST (2004)

Appendix 2

Scientific leadership by discipline: comparison within the Triad

Who is first place in publications in 2500 of the world's leading journals?

	1981	1983	1985	1987	1989	1991	1993	1995	1997	1999	2001
Agricultural Science	USA	USA	USA	USA	USA	USA	*EU*	*EU*	*EU*	*EU*	*EU*
Biology & BioChem	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Chemistry	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	USA	*EU*	*EU*	*EU*
Clinical Medicine	USA	USA	USA	USA	USA	USA	USA	*EU*	*EU*	*EU*	*EU*
Computer Science	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Ecology & Enviroment	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Engineering	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	EU
Geoscience	USA	USA	USA	USA	USA	USA	USA	USA	USA	EU	EU
Immunology	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Materials Science	USA	USA	USA	USA	USA	USA	*EU*	*EU*	**AP**	**AP**	**AP**
Math	USA	USA	USA	USA	USA	USA	USA	*EU*	*EU*	*EU*	*EU*
Microbiology	USA	USA	USA	USA	USA	USA	*EU*	*EU*	*EU*	*EU*	*EU*
Molecular Bio & Genetics	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Multidisciplinary	*EU*	*EU*	USA	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*
Neuroscience	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Pharmacology	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*
Physics	USA	*EU*	USA	USA	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*	*EU*
Plant & Animal Science	USA	USA	USA	USA	USA	USA	USA	*EU*	*EU*	*EU*	*EU*
Psych & Psychiatry	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
Space Science	USA	USA	USA	USA	USA	USA	USA	USA	*EU*	USA	*EU*
No. Led by US	17	16	17	17	16	16	13	11	10	9	7
No. Led by EU	3	4	3	3	4	4	7	9	9	10	12

(AP = Asia-Pacific)

Source : Institute for Scientific Information, Philadelphia