Grupo de Ciencia, Tecnología y Sociedad (CSIC)
Working Paper 02-20

New Socio-Political Environments and the Dynamics of European Public Research Systems

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Social Change and Public Research Systems

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Abstract

The performance of science and technology is being challenged by new socio-political environments. The changes in science policy are influenced by a more systemic view of the understanding on how science and technology evolve. The concept of risk society is mediating the links between science and society. Comparative analyses cast doubts about the possibilities of European institutions to cope with the challenges of the new environment.

Key words: science policy, systemic nature, risk society, social evaluation, public research, evolution, research contexts, institutions, programmes, assessment.

Introduction

It is becoming universally recognised that science and technology are instruments of increasing strategic value for the attainment of wealth in societies and for enabling them to compete in a global world. The world thrives from playing the big game of the economy by progressively moving from the production orientation of the industrial society to the services targeted society based on the application of innovation strategies to the systems of commercial organisation and on the efficiency of 'speculative' capitalism.

[1] This paper is based on the work and previous experience of the author and develops some results from the project 'European Comparison of Public Research Systems (EUPSR)', funded by the European Commission TSER programme (contract SOE1-CT96-1036), co-ordinated by J. Senker (SPRU). The author is solely responsible for the work presented in this paper. The support of the EC is gratefully acknowledged as well as that of the Spanish National R&D Plan (SEC97-1382). A preliminary version was presented in the Lisbon Workshop (5-6 June 2000) of the EUROPOLIS project funded by the STRATA Programme.

There are therefore relevant changes in the economic context that may influence the performance of science and technology. But this transition from a production to a services society is not the only one taking place at this turn of the century. Other important social changes are occurring in the developed world. One important feature of this social development can be assimilated to the concept of *risk society* as proposed and developed by Ulrich Beck. As stated by Beck, 'just as modernisation dissolved the structure of feudal society in the nineteenth century and produced the industrial society, modernisation today is dissolving industrial society and another modernity is coming into being.' [2]

For Beck the transition is, within the industrial society, from modernisation to 'reflexive modernisation.' While in classical industrial society the 'logic' of wealth production dominates the 'logic' of risk production, in the risk society, this relationship is reversed. In my opinion, the transition from a production based economy to a service based one is not leaving out the need for a 'reflexive modernisation' since the service based society is strongly relying on science and technology (the services society is also referred as a knowledge based society). Reflexive modernisation is meant and treated by Beck to extend scepticism to the foundations and hazards of scientific work.

These very important social and economic changes are placing the science and technology performers at all levels (political, scientific, technical, technological, and industrial) in front of new environment(s) which is(are) posing challenges to several domains of the science and technology realm.

This paper is not addressed to build a theory about the concept of new social environments but rather to use it as a heuristic for identifying the socio-political and economic circumstances which are influencing the role and activities of the Public Systems of Research (PSR). Drawing from the experience of the author in the case of Spain and the differences that are evolving in comparative studies at European level, the paper presents an assessment on how PSR are reacting to and placed in front of the challenges of the new future.

This essay analyses the impacts of these changes on science policy, and on the scientific and technical communities, and how institutions and programmes are adapting to these new environments(s), under the influence of European S&T policy. Some case studies are used to advance in this direction of analysis and thought.

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[2] Ulrich Beck, Risk Society. Towards a New Modernity, Preface (translated from German by M. Ritter, London, Thousand Oaks, New Delhi: Sage Publications, 1992), 10.

New trends in science policy

The framework for analysis of science policy actions and instruments has evolved from a linear model of the relationships between knowledge production and its transformation into, and/or its interactions with technology, to a systemic concept (the so-called 'systems of innovation'). By the same token, a new social contract between science and society is being suggested whereby science loses a part of its traditional autonomy in response to new social demands. This implies a revision of the myth of unfettered research dealt with by Sarewitz. [3]

Vannevar Bush once wrote that basic research - the investigation of natural phenomena (also called fundamental, pure, and curiosity-driven research) - and its practical benefits 'accrue to society through an apparently unrelated process.' [4] Because the motivation for research is not the resolution of practical problems, researchers must be shielded from political, economic and social pressures and restricted by nothing but their own abilities and imaginations.

This is no longer true. Research in the fields of electronics, life sciences and technologies or biomedicine is not carried out in isolation from society, neither is it independent from the influence of political, historical and economic milieus. Scientists do prefer working in fields that are closely linked to political and economic priorities. The tight link between the production of knowledge in some of the above mentioned areas of research and its application is strongly influencing the drive of knowledge pursuit as well as the rules to obtain funds and to gain public recognition.

As regards the production of knowledge, the notion that a new mode of production has implanted itself and that its nature should be fully recognised has gained much acceptance in academic circles thanks to the work of Gibbons et al. [5] The production of knowledge in accordance with the new 'mode' or 'mode 2' in Gibbons´ terminology is shaped by socio-economic and institutional change and is cognitively multidisciplinary and interdisciplinary. Interdisciplinary efforts are indeed required for the issues which are the object of research to be articulated, the research teams to be

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[3] Daniel Sarewitz, Frontiers of Illusion. Science, Technology and the Politics of Progress (Philadelphia: Temple University Press, 1996), 31–50.
[4] Vannevar Bush, Science, the Endless Frontier, reprint, (Washington, D.C.: National Science Foundation, 1960).
[5] Michael Gibbons et al., The new production of knowledge. The dynamics of science and research in contemporary societies (London, Thousand Oaks, New Delhi: Sage Publications, 1994).

organised, and the results of those activities to be disseminated and evaluated so as to answer the requirements of a global economy and society.

But is it easier to organise research groups under multidisciplinary, than under interdisciplinary approaches. To this effect two options could be considered: one would be to gather individuals who themselves work across disciplines. Such a group can give results that are close to those of a multidisciplinary organisation. The second organisational option would mean that researchers accept to collaborate with each other and to represent the knowledge of the others. However, this model of interdisciplinary co-operation requires considerable investment of time and commitment and is therefore difficult to achieve with a reasonable degree of satisfaction and benefit.

The argument of science as the 'endless frontier' has been unfolding the political and economic dialogue to support the increasing efforts in science and technology from the public sector, this is the 'myth of infinite benefit.' [6] The promise as held by Vannevar Bush that more research 'would mean more jobs, higher wages, shorter hours, more abundant crops, more leisure for recreation, for study, for learning how to live...', as cited by Sarewitz went uncontradicted in periods of economic prosperity and wealth (the United States was its paradigm during the first twenty years after the Second World War as it was the major economic power sorting out the post war period with its industrial base intact). [7] However, these arguments were denied by concrete realities under periods of economic crisis and recession (for example, the crisis of the seventies led to negative changes in the social well-being indicators regarding employment, wages, leisure and gap between the wealthy and the poor).

R&D and economic wealth: which is the driving force ?

On the light of the previous discussion, this question becomes crucial, particularly if there is also an increasing demand for 'accountability' of the science and technology activities.

While it seems clear that the overall investment in research and development yields a healthy rate of financial return, the question remains whether investment in R&D is the motor of economic wealth the driver of the impulse to R&D investment and activities. This question of the hen and egg type is not easy to respond and may likeky be dependent on socio-political circumstances and cultural forces. The so-called

[6] Sarewitz, Frontiers of Illusion, op.cit. note 3, 18.

'European paradox' argues against the power of science for promoting technological development. The case of Spain, an extreme in the R&D context of the OECD world, points out even more strongly in the same direction. While its economy has been able to grow and to step forward in catching up richer economies, empirical evidence indicates that efforts in R&D activities and their outcomes do not seem to be direct influential factors in such positive economic trends. [8-9-10] Indirect effects such as an increase in the education and skills of the Spanish human resources may be invoked as a counter argument.

This situation contrasts with the evolution in the United States. Economists, like Paula Stephan among others, have elaborated on the 'economics of science'. During the Clinton Administration the budget for R&D activities and programmes have grown significantly in the United States. It could be read that the proposal for 2000 fiscal year R&D budget is perhaps 'the strongest and most balanced basic research programme in the Administration history.'[11] Two main arguments seemed to underline the proposed increases (2,800 millions USA dollars): one, to balance the science budget, and the second to represent a strong commitment to academic research.[12] Meanwhile, EC main policies have been dominated by a monetarist view, and the science and technology policies failed in carrying out a coordinated effort. It is nonetheless true that the less developed countries from EC have done important efforts to reach convergence in economy and R&D efforts. However, the results are still poor as 15EC is trailing the United States, and Japan, with respect to research, development and innovation.

Social evaluation. Risk society and critical issues

Another relevant aspect on the issue of 'accountability' of science and technology thrives from the increasing awareness of developed societies of living in a risk society. Reflexivity has been excluded from the social and political interaction

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[7] Ibid., 17.
[8] Emilio Muñoz, María Jesús Santesmases and Juan Espinosa de los Monteros, 'Organisational detours for building research systems. The case of Spain and Portugal, an endless story?', EASST 98 General Conference: Cultures of Science and Technology, Europe and the Global Context’ (1–3 October 1998).
[9] Emilio Muñoz et al., 'Changing structure, organisation and nature of public research systems. Their dynamics in the cases of Spain and Portugal.' (Madrid: Instituto de Estudios Sociales Avanzados, CSIC, 1999).
[10] Emilio Muñoz, Juan Espinosa de los Monteros, V. Díaz, 'Innovation Policy in Spain, Technology, Innovation and Economy: National and regional influences', The CONVERGE Project Workshop, Strasbourg, 7–8 January 2000, http://www.iesam.csic.es/doctrab/dt-0003.pdf .
[11] Science, 287, 11 February 2000, News Focus, 952-955.
[12] Science, 287, 28 January 2000, Clinton Seeks "Major lift" in US. Research Programs, A. Lawler, 558.

between experts and social groups over modern risks because the systematic assumption of realism in science, as declared for instance by Lash and Wynne in his introduction to Ulrich Beck's book. [13]

The idealised model of the risk system and the related evaluations are based on the opinion of the scientists who rely essentially on laboratory knowledge. This model has been criticised by social scientists, who consider that this model contains a naive model of society. Some directions of modern sociology of science, namely the constructivistic view, also question the physical assumptions of that model.

The imposition of bounding premises has led to the polarisation of the debate around, as stressed by Lash and Wynne, 'the realist distraction concerning the truth value of scientific propositions, and polemic about the alleged irrationality of the social anti-S&T discourse and corruption of scientists and regulatory institution.' [14]

This situation has been illustrated by a series of negative contemporary examples like the debate in Great Britain about the health effects of herbicides, the mad-cow crisis in the UK or the contamination of feed by dioxins in Belgium. The battleground for this conflictual situation is once more the issue of accountability, a contention that I support and have referred to as a problem of the 'ethics of responsibility'.[15-16-17]

Several interpretations do exist to give account of this situation in the classical position of the scientific community and its leading speakers. One is that the scientifically illiterate public is used by extremists (religious right or environmental left) to give support to political agendas that run against the promotion of science and technology. Another is that 'the press is distorting and misrepresenting the character and attributes of the research system to a credulous and scandal mongering public and thereby turning the tide of public opinion against science and scientists.' A third stems in the intent of the humanists and social scientists, as part of the scientific community moved by the postmodernist view, to place natural scientists under the same denial of modernity.

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[13] Beck, Risk Society, op.cit. note 2, 4

[14] Ibid., 5

[15] Sarewitz, Frontiers of Illusion, op.cit. note 3, 51–69.

[16] Emilio Muñoz, 'Ética de la investigación y el desarrollo', Seguridad Nuclear, 5, IV Trimester 1997, 9–15.

[17] Emilio Muñoz, 'Los cultivos transgénicos y su relación con bienes comunes', in M. Palacios (ed.), Bioética 2000 (Gijón: Sociedad Internacional de Bioética; Oviedo: Ediciones Nobel, 2000), 376.

Main trends in the social evaluation of technologies

The social evaluation of technologies is put into practice as being a useful exercise. From a more technical perspective, it should be stressed that an approach to the new orientations of science policy cannot rest on distinctions between extremes: between the work which scientists carry out and that which is produced or collected by non-scientists: between that which, in the context appropriate to science is recognised as a matter for unfettered research, to be judged only by experts or peers, and research by objectives in which politicians and society at large intervene to make their opinions known and to decide upon the expediency of what is to be done. The path to be followed seeks to extend the ranks of the 'nobility' of Science, not by 'enabling' more scientists but rather by trying to ensure that the whole community of social actors is represented in the decision-making bodies and in the political forums, that is by making decision making more 'democratic'. If the principles of national security and economic competitivity - dominant in the pact whereby public support has been given to science and technology in the second half of the twentieth century - lose this protagonism, giving place to objectives of social welfare and the citizens quality of life, public involvement in deciding on the financing of science and technology becomes justified as a means of recovering a legacy which science has, perhaps, been forfeiting. Some concepts of theoretical and empirical value like the 'risk society' and 'public understanding of science' are relevant to endorse the needs for an increasing social evaluation of the progress of science and technology.

The concept of *risk society* as developed by U.Beck attempts to escape from the wider tendency towards timidity or complacent ethnocentrism. Quoting Lash and Wynne, 'reflexive modernisation confronts and tries to accommodate the essential tension between human indeterminacy and the inevitable tendency to make objective and to naturalise our institutional and cultural productions', leaving aside extremes of post-modernist views that imply the abandonment of scientific-instrumental modes or the inflation of power that modernism grants to them. [18]

The relations between science, truth and Enlightenment are seen by Beck as a 'sort of pedagogy of scientific rationality' which may be changed by discussion of self-produced threats. [19] Science can change itself by placing the production of objective

[18] Beck, Risk Society, op.cit. note 2, 6
[19] Ibid., 155–182.

constraints and 'unforeseeable scale effects' of techno-scientific actions at the centre of attention. Principles like that of 'bio-safety' are embodied in that current of thought.

Science studies

Science studies have evolved as one of the main cognitive and practical instruments in technology assessment exercises.

Practitioners of science studies are playing an increasingly important role in mediating the relationship between science (and technology) and society. They qualify differently depending on the European country and the main stream of their research trajectory. In France, those who identify themselves as sociologists of innovation predominate (one highly renowned unit is the *Centre de Sociologie de l'Innovation at the École des Mines de Paris*) or as economists of the innovation (i.e. BETA at the University of Strasbourg).

In both Great Britain and the United States, such scholars are coming to play a key role in debates about the public perception of science - related risks. An important part of their research has been associated to analyse the way in which old and new structures formal and informal, within the 'public sphere' shape the development of biotechnology. [20] The European Union has given strong support to this type of activities by funding the Task Group on Public Perceptions of Biotechnology (TGPPB) linked to the European Federation of Biotechnology (EFB) or important projects such as the European Community Concerted Action 'Biotechnology and the European Public'. This last project was aimed to map the public dimensions of a new technology (modern biotechnology defined according to the particular representations of biotechnology in the public sphere) [21]. There is a convergent argument towards the existence of a great degree of complexity of public response to biotechnology in Western Europe. The reasons underlying the diversity of public discourses about biotechnology are also diverse. The conclusions of the study 'Biotechnology and the European public' stress the fact that the complexity of public representations of biotechnology in Europe does not imply that they reflect a chaotic situation. Some orderliness was found that may stem from the historical processes by which industrialised societies have dealt with the

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[20] J. Durant, M. W. Bauer and G. Gaskell (eds.), Biotechnology in the Public Sphere. A European Sourcebook, (London: Science Museum, 1998); there is a reference on pp. 4 and 12 to J. Habermas, The Transformation of the Public Sphere (London: Polity Press 1990).
[21] Ibid., 217.

challenges posed by new technologies. This gives, in my opinion, support to the argument that biotechnology (and related fields) may be a good instrument for analysing the evolution of institutions and programmes to face new challenges and new environments for the development of science and technology.

Another case of this situation was the ignition of the so called 'science wars'. The backlash against 'social constructivists', who claim that science is much the product of a continuous dialogue between scientists as it is of their processes and protocols of experimentation, started in USA when their influence transcended from the academic world to the wider society and this appeared to influence decisions on science policy. The debate was triggered by Alan Sokal, a physicist at New York University, who brought the issue to wide public attention with a hoax he published in the summer of 1996 in the journal *Social Text,* to show the lack of rigour that may be found under some banners of constructivism and postmodernism. [22]

However, as the well known scientific journal Nature wrote '... would be wrong to tar all of science studies with the same dismissive brush, or to perceive them as wholly irrelevant to scientific progress.' [23]

This conflict has propagated to Western Europe, though the reactions to the fighting have been diverse depending on the countries and/or institutions. The European Union seems to have welcomed the debate and has attempted to incorporate the social, ethical and legal implications of the development of science and technology in general, and in particular that of strategic technologies like energy, information technologies and biotechnologies - into its political agenda and in R&D programmes. [24] Moreover, some institutions, like the flagship European Molecular Biology Laboratory (EMBL), have reacted positively to this trend. EMBL created a Science and Society Office in 1998, with the aim of increasing communication on both sides, science and society, not through a paternalistic 'education of the public' but just as much by making scientists aware of the ways their own work has implications or imprints itself in people's minds out in society. An anthropologist, H. Stefansson, is heading this new Office. [25]

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[22] Alan Sokal, 'Transgressing the Boundaries. Toward a Transformative Hermeneutics of Quantum Gravity', Social Text (Spring/Summer 1996), 217–252.

[23] Editorial Entitled 'Science wars and the need for respect and rigour', Nature, 30 January 1997, 385, 373.

[24] Preliminary evidence from the analysis of the funds allocated in the first calls of Framework Programme Fifth suggests that there are difficulties in the implementation of this policy. This situation is now under revision.

[25] EMBL, Annual Report, (1998), 195–197: EMBL Scientific Programme 2001–2005, 137–139.

Analysis of the structure, evolution and dynamics of research systems in Europe

In summary, the development of science and technology activities faces a new environment which is characterised by an increasing demand for economic and social accountability, new ways in the forms of organisation to produce knowledge, a changed relationship between public and private. Technologies related to life sciences-biotechnology and related fields are topical cases for analysing in a specific manner those challenges presented by the new environments.

In this context, the comparative study of the organisational and institutional arrangements of the research and development systems in Europe is not an easy task owing to the great differences existing between European countries with respect to culture and historical dependence on R&D for socio-economic wealth and international relevance.

The possibility to carry out these studies thanks to the funding of the European Commission through the Framework Programme and its specific programmes is providing grounds for the development of the analytical tool of comparative analysis in the domain of science and technology policies. Moreover, some European countries, namely France, likely driven by this European movement have been undertaking comparative studies at a global level in order to learn from others for redesigning the organisation and programming activities of their respective R&D systems. [26]

I have been involved in several of these projects what together with my previous experience in the management and analysis of Spanish R&D institutions and programmes provides me with some background to contribute to that type of analysis. In addition, I also researching and assessing the socio-economic, legal and ethical aspects of the promotion of life sciences and their biotechnological and medical implications both at European and Spanish levels.

In the following, I will present a summary of the main results derived from that experience, in particular from an EC-funded study of the public research sector (PSR) in the light of the economic and social trends that have been discussed in the preceeding sections.

[26] Commissariat Général du Plan, Recherche et innovation: la France dans la compétition mondiale (Paris: La Documentation Française, 1999).

The European comparison of Public Research Systems

The study was performed from 1997 to 1999 under the Targeted Socio-Economic Research Programme. [27]

The study aimed to compare the changing organisation and structure of public sector research in 12 European countries . It developed a methodology to examine how national policies affect researchers at bench level. The development of a methodology was an important objective with a view to the second main purpose of the project - how to check the relationship between top-down policies and bottom -up reaction of the research community to them- but also for the first goal -the comparison between public sector research. According to the traditional classification of the Manual of Frascati, there are three sectors at macro organisational level- Government, Higher Education and Business. In the project, the public sector research (PSR) was studied including government, non-universities research institutions and universities, and activities according to the new definition of the 'public sector'. This new definition was developed to reflect the heterogeneity of the institutions involved and the impact of recent changes to public policy for funding and controlling research. The definition based on criteria of funding, control and accessibility of results considers that 'public sector' covers institutions for which the major source of funds is public; and which are in public ownership or control (or have converted to private ownership since 1980), and which aim to disseminate their research. It also covers the organisations of officially recognised charities or foundations which raise the majority of their funds from the general public, and whose main activity is research.

The sample of countries involved in the study - Denmark, France, Germany, Hungary, Iceland, Ireland, Italy, Norway, Portugal, Spain, Sweden and the UK- have diverse characteristics and include: EU members and non-members, including one coping with the transition from a planned to market economy; large and small countries; developed, less developed and rapidly growing economies.

PSR systems expanded rapidly in every country, and this expansion was encouraged by OECD and European Community initiatives.

[27] This project was coordinated by Dr Jacqueline Senker (SPRU) for the overall project and by Drs P. Laredo (CSI, Ecole des Mines) and U. Schimanck (Max Planck Institute for the Study of Societies) for Work Package II. For the final report and additional information, contact J. Senker (SPRU, e-mail, j.m.senker@sussex.ac.uk). See also, EU Socio-Economic Research, Project Clusters: Systems of Innovation, Project Results (Luxembourg: Office for Publications of the European Communities), 105–123.

PSR is carried out in a diversity of organisations with three main sectors: a) universities, b) non-university research organisations for general or specific functions and c) government - laboratories to support policy formation and implementation. These organisations perform the following functions, with their relative importance indicated into brackets, changing over time:

i) the advancement of knowledge (universities +++; non-university research organisations ++; government laboratories ±).

ii) the support of policy formation and implementation (non-university research organisations +; government laboratories +++).

iii) the support of public welfare like health, environment, public safety, etc. (universities ++; non-university research organisations, ++; government laboratories, ++).

iv) the support of economic development including technology transfer (universities, ++; non-university research organisations, ++; government laboratories, +++).

v) The development of programmes to build up and support prestige activities and capabilities in frontier science (universities +++; non-university research organisations, ++; government laboratories, ±).

There is a marked change in most countries in the distribution of research among different sectors of PSR with an increasing proportion of research taking place in universities and a decreasing role for research institutes (the trend is particularly evident in the cases of France and Spain). Governments in every country have put growing emphasis on all sectors of PSR supporting innovation, undertaking 'relevant' research and engaging in technology transfer. The level of autonomy for academic researchers differs between institutions and countries but the self-governance of researchers (autonomy and unfettered research) seems to be eroded by demands for ‘relevance’ and by the growing proportion of research funds being allocated to research priorities determined by government.

Government funding for PSR has remained static in most countries in recent years and the institutions which are part of the PSR have, therefore, been encouraged to look for new sources of funds. Additional resources have been provided by the EC´s Framework Programmes and Structural Funds, by charitable foundations in some countries and by industry. There is now a considerable diversity of funding arrangements for PSR. Within this diversity, two main approaches do emerge and, within any country, two approaches may run in parallel. These approaches are the model in which research grants for university and non-university research organisations are allocated on the basis of competitive peer review. These competitive grants complement core funding which covers salaries, assumes that a proportion of the time of academic professors is dedicated to research and funds research infrastructure. The second approach is the block grant system that gives researchers in relevant universities, research institutes and government laboratories a degree of freedom in deciding on the internal allocation of funds. The 'block grant' system is slowly but steadily declining in favour of competitive applications for grants. There is also a growing role for regional agencies as funding sources of research in some larger countries.

The proliferation of funding organisations has led to weak co-ordination. Many countries are attempting to increase co-ordination over PSR system. Efforts focus on integrating the work of government laboratories or institutes that provide support for ministry functions into national and technology policy. Difficulties arise because the frictions between different departments in attempts to achieve co-ordination and between national and regional authorities in the allocation of funds for research.

The link of PSR with wider national economic needs has emerged as one of the main common goals. It has been approached with a variety of instruments: involvement of the industry in the policy-making process, promotion of mutual understanding between science and industry, technical support to industry, mechanisms for technology transfer. Technology transfer is very high on the agenda of most of the countries covered in the study. However, all the rhetoric about technology transfer does not ensure that the initiatives about transfer of technology are successful. There is a clear trend to push universities to undertake contract research for industry. All these tendencies are particularly problematic in southern countries as a possible reflection of the lack of indigenous firms with significant involvement in R&D.

Another common trend concerns the increase in research collaboration observed for most countries. Collaborations by the various sectors of PSR within countries as well as collaboration between countries have occurred. International collaboration in research is characterised by an important rise in inter-European collaborations and the importance of participation in EU R&D programmes to almost every country, independently of its size or state of development of its R&D system.

The drivers for change of PSR in the countries studied are many and of different nature. Budget constraints, political motive, international and EC influences, industrial needs and the emergence of new technologies are lying behind changes, reorganisations and adaptations of PSR systems in Europe. In some countries, with a strong political tradition and influence of the State, like France, decisions such as the one to develop energy independence or the attempts to reform the *Centre National de la Recherche Scientifique* (CNRS) have had or are having a strong impact, not only at internal level, but also on the development of PSR throughout Europe. The conflict between such political decisions and the actors involved in advice and decision-making due to their double condition of experts and practitioners scientists often influence the evolution of the R&D initiatives and PSR systems. For instance, in Portugal and Spain, decisions are strongly driven by the scientists themselves because many or the officials involved in decision-making lack awareness of the strategic significance of science and technology. In large developed countries, industry plays a large part in the dynamics of the PSR system. Public action may also influence the research agenda depending on positive or negative social attitudes towards technologies and their applications.

The emergence of new technologies and the development of research capabilities appear as the most important drivers of change in the PSR systems and their institutions and programmes. Programmes on information technologies, biotechnology and new materials had to compete with traditional fields under tight constraints on public spending and demanded the development of mechanisms to identify research priorities and to redistribute funds. The need to help industry to become more competitive in new technologies required the expansion of higher education, to train qualified manpower and research staff. The success or failure in these designs may explain the relative position of countries in their struggle for attaining economic wealth and convergence (the comparison of the cases of Ireland and Portugal provide interesting insights in this regard). Increased links between industry and PSR were necessary to enable industry to have access to knowledge about new technologies. New technologies enabled the development of more sophisticated scientific instruments, and widened the range of disciplines which required and used such equipment. Both these trends increased the cost of research, and may explain the evolution to increased links between sectors of PSR. The pervasiveness of the new technologies across disciplinary fields demanded methods to better co-ordinate the research activities of organisations responsible for public sector research. New technologies are characterised by their horizontal character and by interdisciplinary research skills as well as by a blurring of boundaries between basic and applied research and development. This situation may also apply to other areas and fields, but the process is driven by the new technologies, and creates the need for new organisational structures and funding arrangements, what can be referred as a 'new environments in the sense used in this essay.

But have institutions and their activities and programmes been able to respond to the new challenges ?

The progressive adaptation of the research community to the new environment. The case of human genetics

The second part of the European project referred to above purported to complement the analysis of the public sector research by a 'bottom-up' approach. The main goal was to develop 'a sound methodology for conducting cross national case studies of PSR in areas vital to public welfare and safety.' The frame supporting the work, as noted by Laredo, stems from the image drawn from science studies that 'research units or 'laboratories' are to science what firms are to economy: the basic units of production.' [28]

The study of the main units of production of science may provide clues to understanding the dynamics of an organisation or of a 'national system'.

The selection of the area of human genetics was based on a series of criteria that facilitated convergence: the general interest was fulfilled by the health sector; the 'mode 2' type of field was considered as a necessary requisite to take into account the problem oriented nature of the research field, the collaborations between actors with different disciplinary and institutional backgrounds, as well as the emergence of 'new' productive configurations.

What follows is my personal contribution to that report.

a) Reasons for choosing the field of human genetics

'The general features of human genetics make the field suitable for studying the dynamics of public sector research in response to the changes in its external environment. Firstly, genetics is the field of biological sciences which has witnessed one of the most revolutionary changes in the second half of the twentieth century. This

[28] Philippe Laredo, Uwe Schimank and Markus Winnes, An Approach to Public Sector Research Through its Research Collectives. Overview, Interim Report B (Paris: Armines CSI, Köln: Max-Planck-Institut für Gesellschaft), June 1999.

change has been driven by progress in knowledge about the structure of DNA, genetic codes, protein synthesis, regulatory mechanisms and by unprecedented technical advances, including new enzymes, PCR reaction, techniques for separation and identification and characterisation of macromolecules. New knowledge and technical advances result from an explosive growth of research in the area since the early 1980s, which uses multidisciplinary approaches based on classical biology, biochemistry, molecular biology, physical-chemistry, organic chemistry and thermodynamics.

- Genetics is at the core of the explosion of the so-called 'modern' biotechnology, the realm where biological sciences are becoming instrumental for economic developments in agriculture, industry and the service sector.
- The introduction of human aspects into genetics is revolutionising models of medical practice. New models are evolving which pay increased attention to primary care and preventive medicine. Genetics is playing and will play an even more central role as the genetic base for common diseases are identified.
- The organisation of research and education in the biomedical and medical curricula is undergoing deep modification under the influence of human genetics. Human genetics, and in particular genome sequencing, is incorporating 'big science' into the domain of life sciences.
- New sub-disciplines such as bio-informatics and new fields of applications like genomics (understanding the function of genes and using this knowledge as the basis for developing new pharmaceutical drugs and medical treatments) are emerging both in academia and industry.
- New medical services and new firms with diverse strategies (small knowledge-based firms and big multinationals based on mergers and outsourcing) result from the emergence and evolution of human genetics research.
- New and significant ethical and social issues are arising from developments in human genetics research, with implications for both new forms of medical treatment and for social applications e.g. employment, insurance.

Through this evolution, the field of human genetics now appears to be typical of the biomedical research realm. It not only provides a paradigm for the current organisation of biomedical research but it is also representative from the cognitive point of view. There has been a clear shift in medical research from the traditional descriptive-based studies of disease or from 'architectural' modes of treating disease (uses of surgical or therapeutic treatments which greatly alter the identities of human bodies) towards an approach based on molecular medicine to explore (and understand) disease mechanisms. The most optimistic visions see a happy marriage between clinical research and molecular medicine (i.e. a genetics based approach).

High priority has been given to life sciences and genetics research since the early 1980s, by both the EU and its Member States. The 'take off' of human genetics as a fast growing research area in government appropriations for research has coincided with important changes in national research policies. The changes include a shift from institutional funding with permanent posts towards temporary and competitive resource allocation. Secondly, mechanisms of quality control and evaluation have been introduced or strengthened. In addition, the special emphasis placed on the social and economic relevance of research privileges human genetic research because of its essential role in transforming and advancing public health care. Thus, human genetic research is particularly well suited for studying the effects of public sector research policy because its institutionalisation and growth largely took place during the new regime for national research policy.

Another general feature suggests that human genetics is a research area of central interest to the overall project, because it is frequently used as an example of the 'new mode of knowledge production' (Gibbons et al. 1994). In contrast with the traditional mode, characterised as disciplinary-based and academic-oriented, following the social norms and cognitive interests of a particular discipline which is relatively stable and hierarchically organised, the main elements of 'mode 2' are described as (1) trans-disciplinarity, (2) a 'context of application', which means a blurring of boundaries between basic and applied research and a problem or application-oriented organisation of research, and (3) heterogeneity and flexibility concerning the sites where and the organisational and financial arrangements under which research is performed. The debate about how relevant the 'mode 2' thesis is, to what extent it changes the 'social contract' between science and society and what this means for public research was therefore a second reason why human genetics was selected for the cases studies.

b) Some results and their relationships with the new research environments [29]

The prioritisation given to human genetics is a reflection of the more recent initiatives related to science and technology policies addressing issues of socio-economic relevance. The research units have been studied in a comparative analysis in six countries: Germany, Ireland, Norway, Spain, Sweden and the United Kingdom. All these countries established, or redirected their research agenda towards human genetics during the late 1980s or early 90s.

This field offers a clear example of the links between R&D policy and the shaping of a scientific organisation to adapt to the impact of a given policy. Resource allocation largely takes place on a competitive basis, most researchers are employed on temporary contracts or on a project by project basis and bulk of research activities is funded through competitive mechanisms.

The units involved in research on human genetics are trans-disciplinary and/or interdisciplinary and are located in a variety of institutional settings. This "locational" fragmentation seems to respond to some institutional drawbacks and to some specific needs of a field that represents a typical case of 'new mode of production of knowledge'. The research is problem-oriented and researchers look for the best suited setting for performing it, since human genetics is not recognised as independent medical discipline in either teaching or health care environments. The recruitment of new skills and technologies appears as a critical factor to the future success of the unit. Research collaboration fills gaps in skills, expertise and techniques, and is also vital for access to biological samples and patient histories.

Funds for research are provided by a diverse set of agencies: government and research councils, sectoral agencies with mission-oriented objectives, foundation and charities (especially in France, United Kingdom and Sweden) and, to different degrees, the European Union and the industry. Flexibility and ability to adapt are critical assets in this emerging, highly dynamic area of research where the flows of knowledge, techniques and applications are running over the traditional slow pace of academia and research institutions. This flexibility is reflected in the research and career planning, allowing more possibilities to open to trans-disciplinary research. International

[29] Jacqueline Senker et al., Final Report European Comparison of Public Research Systems (Brighton: SPRU, University of Sussex, 1999).

collaboration and demonstration of socio-economic relevance of the topics dealt with are other important pieces of identity and self-awareness of most research units and scientists.

A last, but no less important point in my opinion, concerns the level of awareness of the scientists on the existence of a social debate on the uses of human genetics (and other new biotechnologies), the repercussion on their activities in a "pro" or "con" manner, and their willingness to intervene in it. There were no common patterns in the reactions observed from the study - in the Spanish cases most of those interviewed recognised the importance of the issue, though a common articulation on how to deal with it was lacking. The institutions have attempted to approach it by the establishment of ethical committees whose evaluation is still waiting a serious analysis.

A personal assessment of the capability of institutions, organisations and programmes to adapt to the new environments

a) The universities

There is a general convergence about the idea that the university may play a growing role in performing research under the new environment/s.

Many arguments can be put forward in this direction. The new budget orientations of President Clinton Administration as outlined above point out clearly to the need to foster the intensity and relevance of research in the university. The same argument follows from the strategies adopted by the big US pharmaceutical firms involved in biotechnological research and development. Their Presidents and CEOs have claimed that universities must take the flag of the development of basic research in life sciences in order to be able to reduce their efforts in this line of activity. The so-called Dedicated to Biotechnology Firms (DBFs) - small firms which produce new knowledge and have in preparation the launching of a new, fundamental product - are no longer so much praised by the big companies. They prefer to put their interest in the acquisition of basic knowledge, essentially developed through interdisciplinary research going from molecular biology and gene sequencing to cell biology and bio-informatics for identification of protein functions (proteomics) and development of cell engineering. The strengthening of the university is a clear result of the TSER-funded project I have been outlining. However, these results have also shown that although most, if not all, of the university systems do accomodate to the characteristics of the humboldtian university, there are differences between the countries as a consequence of path-dependence and level of educational and socio-economic development.

An important question in view of these considerations is as follows: would so different universities at national and regional level be able to fulfil the complex roles requested to them? These roles can be summarised as follows: i) to perform high quality research (excellence); ii) to carry it out through new interdisciplinary and multidisciplinary approaches; and iii) to increase the effective links with industry.

I have doubts concerning the possibility that the universities, taken as a whole, could comply with the challenges they have to face. I foresee the following problems.

- Most, if not all, European countries are not satisfied with their respective university system. The systems are under scrutiny, but there is not a well defined drive for them.
- The classical humboldtian university is able to perform research, and research of high quality, but this research has been based on a fragmented structure: schools and departments. This traditional organisation must be a hurdle for the production of knowledge according to 'mode 2'.
- The conflict between the university as a fabric of knowledge and as an instrument for the formation of professionals remains unsettled (research *versus* training is a constant problem for the university staff in relation with rewards and socio-economic recognition). [30]
- The links with industry have been considered and are considered of increasing interest for the universities, but their implementation is causing difficulties with respect to direction and management.

A typical illustration is provided by the Spanish university. In the quarterly Bulletin of the *Spanish Society for Biochemistry and Molecular Biology* (SEBBM), a

[30] In the UK, there is a debate about a possible division between these two tasks and the subsequent attribution of one of each to different universities. In Germany, there seems to exist a general DISsatisfaction about the role of universities in providing professional skills to their students. In Spain, the great expansion of the university world (increase in number of universities, students, graduates and professors) presents advantages and drawbacks. During the preparation of this paper, a report on Spanish universities entitled Informe 2000 authored by Prof. J. M. Bricall has appeared, adding to what is likely to become a hot debate.

debate has recently emerged on the cost and relevance of research for Spanish universities. [31]

An article in the 1999 October issue by the Vice-chancellor for Economy and Organisation of the University of Barcelona (one of the historical largest Spanish universities, highly ranked by its research activities) expressed criticisms about the involvement of universities in research activities. The argument was essentially economic by indicating that the Spanish universities receive from research contracts only 10% as overheads for the general expenses, while in Great Britain this percentage amounts to 45%. This article has prompted the reaction of Prof. A. Rodriguez Navarro (2000), a full professor of the Polytechnic University of Madrid who has been chairing for several years the National Committee for the Evaluation of the Research Activity of professors from universities and researchers from CSIC. The counter-arguments of Prof. Rodriguez Navarro are essentially three: i) analysis of the differences between outputs and inputs of Spanish universities with respect to those academic institutions of the most advanced countries; ii) the deviation to vested interests (increase in salaries of professors) of the norm that was established in the Reform University Law of 1983 to foster contracts between universities and private institutions; iii) the lack of interest for research in Spain and consequently in the main research institution - the university. According to the author, only 7,000 university professors from a total of 40,000 can be qualified as professional researchers.

b) Non-university research institutions and government laboratories

This (sub) sector of the PSR offers the most different landscape across Europe, as well as vis-à-vis the United States. France and Spain are in one extreme by sharing a common structure in this (sub) sector of the R&D domain. The structure is quite different from that of the other European countries. Both have multidisciplinary research organisations with a set of institutes performing basic and applied research: *Centre National de la Recherche Scientifique* (CNRS) in France, *Consejo Superior de Investigaciones Científicas* (CSIC) in Spain. [32] The Spanish and French government

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[31] Alonso Rodriguez Navarro, 'La Investigación enriquece a las universidades', Boletín SEBBM, nº 127, (Febrero), 4-5.

[32] It is worth noting that the name of the Spanish organisation after its official translation to English, Spanish Council for Scientific Research, may be misleading for international comparisons. It is not a

laboratories (sub) sector is completed by a series of sectoral laboratories under the jurisdiction of the ministries with responsibilities for various sectors, namely agriculture, fisheries, public works, energy, environment (climatology), and mining and natural resources.

This situation is gaining far-reaching complexity with the introduction of the regional dimension in the establishment of new technological (or R&D) laboratories or for managing the previous established government laboratories, a situation which is particularly relevant in the case of Spain, though this trend is probably going to expand to other European countries. The panorama adds complexity with the creation of public/private organisations that are acting as interfaces between the research domain and the industrial world to provide the latest with technical services.

Germany and Italy do have an hybrid, although extremely different, situation with some central, multidisciplinar organisation (Max Planck, *Fraunhofer* in Germany, *Consiglio Nazionale delle Ricerche* (CNR) in Italy) and government laboratories.

Among the big European countries, the United Kingdom possesses the most university-based organisation of the R&D landscape. Sectoral councils provide funds to the university research and to some specific laboratories whereas there is a specific grant system to finance research at the universities under a competitive basis.

The small European countries do have a mix of situations going from ones with a system resembling the one of the United Kingdom (Sweden must be the example) to others with a set of government laboratories (with a public/private statute, like in Portugal).

Under this extremely heterogeneous landscape, it is very difficult to make an assessment of the situation and of the capability of the existing structures and organisations to cope with new environments. A practical rationale from my point of view lies in an assessment of the problems faced by institutions like the CNRS and CSIC because of their features.

One way to approach the issue is to ask the following question: which are the main problems faced by organisations like CNRS and CSIC in the changing environments ? In my opinion, these are mainly three: i) the relationships with the university; ii) the ability to modify the patterns of research imposed by the scientists themselves from their autonomy and self-compliance in order to comply with 'mode 2';

Council in Anglo-Saxon terms as it is not funding extramural research. Its functions are like those of a National Centre for Research like the CNRS.

and iii) acceptance by the scientific personnel of changing their civil servant statute to a contract-based system.

I am rather sceptical about the capability of this type of organisations to adapt to changes. The French Minister for Education, Science and Research has ignited a debate in the CNRS by treating to reinforce the role of universities in front of CNRS. [33] In Spain, CSIC researchers have been looking to the relationships with universities keeping in mind the foe/friend dilemma.

The current dominant stream of liberalism is leaving scientists even greater freedom than before to respond and adapt at the individual or group level to changing environments (international drive for basic science; business interests for applied research). Therefore, the big organisations are having difficulties to co-ordinate or influence the scientific trajectory of their researchers. The organisations or institutions are, at their best, providing with an adequate "micro-milieu" for those adaptations to take place satisfactorily.

The introduction of a contractual career is not an easy task for those research institutions governed by an administrative rule. The process will be controlled by the resistance, and not by the resilience, of the personnel.

In this context, it seems appropriate to refer to the promises of renewal and openness spelled out by the new Director of the Pasteur Institute, Philippe Kourilsky. Since it was founded in 1888 by Louis Pasteur, the institute has gained a world wide reputation in biomedical research, and its scientists won eight Nobel Prizes during the past century. But there have been long-standing debates, many of which have revolved around just how hard basic scientists should be trying to make their research payoff in medical applications. The institute is run by a private foundation partly supported by the French government and its statutes put a clear emphasis on microbiology and public health. Kourilsky has said that the lack of co-operation between basic and applied research has created an ‘intolerable’ gap. Kourilsky wants to divert 30% of individual laboratory funds to create a common pool of money for inter-laboratory collaboration projects. He also intends to limit the post of laboratory director to 12 years, through a four-yearly review. The Kourilsky's plan also intends to bring young blood to the institute by the creation of smaller laboratories steered by young researchers for a five-

[33] While this paper was in preparation, the French Minister for Education, C. Allègre, was dismissed by the Prime Minister, L. Jospin.

year period. This is a move to lure back scientists who have sought refuge abroad from the rigid and hierarchical structure that is still ruling French research.

The reforms of the plan are reminiscent of those proposed by the Minister Cl. Allègre to modernise French research. During the last two years, Allègre has tried to increase mobility between research agencies like CNRS, INSERM (the biomedical research government institution) and universities, and to recruit young sciencistists. These efforts have engendered the protest of the scientific community -1000 scientists and members of scientific trade unions marched on the streets of Paris in January 2000 in protest at the Minister's plans. [34]

c) Business

The business sector is a crucial actor in shaping the organisation and performance of the research community at present times by obvious reasons. It appears to me that the behaviour and influence of the business sector may differ depending on the country, size and type of firms and on their ownership.

[34] See footnote 32.