CAN PROJECT MANAGEMENT ORGANIZATION BE SUITABLE TO INCREASE THE EFFICIENCY OF PUBLIC RESEARCH LABS?

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ABSTRACT. The organization of public research labs plays a fundamental role to increase their efficiency and the production of scientific research more and more necessary to economic growth of countries. The paper presents the main organizational studies carried out on public research bodies in U.S.A. and Europe. After that this research analyzes the organization of the biggest public research body in Italy, showing the points of strength and weakness in comparison with other scientific structure. In particular the research shows as project management applied to public research bodies affects the organizational behaviour and research labs operate as *quasi-business firms* or hybrid research laboratories *with many characteristics of the business firm, except for the profit motive.* Moreover the matrix organisation in public research organization creates difficulties such as co-ordination problems, staff might be reluctant to accept constant change and prefer the organisational stability from membership of their own functional grouping; there may be a problem of defining the extent of the project manager's authority over staff from other departments and of gaining the support of other functional mangers; functional groups may tend to neglect their duties and responsibilities. There organizational problems reduce the efficiency of these structures and overall national system of innovation.

KEYWORDS: Organizational Theory, Matrix Structure, Public Research Laboratories, Project Management

INTRODUCTION

Scientific research is undoubtedly one of the most debated topics in the countries of the European Union. The core of the debate regards a European system of innovation made up of efficient research labs (Herbst 2004), capable of producing research and innovation, both of which are necessary to boost the economic growth of the whole European Union. Crow and Bozeman (1989) analyse and compare industry and government R&D laboratories, detecting lower efficiency rate and higher bureaucratisation in US government labs. Such criticism, which is rather widespread also in Europe, has led European governments to tackle the reorganisation of public research, generating extremely fierce debate, evaluations with international scope[1], as well as controversial and not always satisfactory solutions (Dresner 2002). Nevertheless, the changed political climate, a growing interest for innovation, public budget difficulties, as well as a greater need for accountability, have led governments in most countries to intervene in the reorganisation of PRBs. A thorough reorganisation of public research was carried out also in Italy, in two different stages over 4 years (1999 and 2003). The objective was to increase its efficiency and effectiveness. In consideration of the widely shared political objective of improving scientific research organizations in an industrialised country such as Italy, but above all in view of the necessity for the economic system of profiting from the results of scientific research, the purpose of this paper is to answer to the following question:

can project management organization be suitable to increase the production of scientific research and efficiency of public research labs?

Before to discuss this question, let us to provide a description of the main US and European scientific agencies and then sets out to analyse the recent organisational evolution of the most important Italian public research body, the National Research Council (CNR), investigating its strengths and weaknesses as well as the threats and opportunities of its new reorganisation and governance.

[1] The institution of evaluation committees with a heavy presence of scientists from different countries has become common practice but there is also a tendency to perform *ad hoc* evaluations carried out by *panels* of independent experts from foreign countries. See, for instance, the evaluation of the Research Council of Norway (Arnold, Kuhlman and van der Meulen 2001).

THE ORGANISATION OF PUBLIC RESEARCH BODIES (PRBS) IN THE U.S.A. AND IN EUROPE

The United States are often considered a leader country for scientific research production and innovation because of the organization of their national system of innovation. In fact, the universe of American research and development labs is extremely complex and includes around 700 federal labs that are financed directly by the US government, hundred of university research labs, and almost 14,000 industrial labs. There is also a number of labs that display hybrid characteristics and cannot be included in any of the above three categories. University labs are very often part of larger institutions with several different missions, some of which are not strictly academic. American national system of innovation has a well-established tradition in large research institutes, among which some of the most renowned are the Bell Labs, David Sarnoff, Lawrence Berkeley Labs, and Los Alamos National Laboratory. For instance, the Los Alamos National Laboratory, established in 1943, has 7,000 personnel from the University of California and over 3,500 researches hired from the Department of Energy. The structure of Los Alamos includes 10 *Directorates* and a total of around 50 divisions, programs, and offices. These US labs can be organised in research teams, led by a *principal investigator*[2], departments, divisions or branches, more or less ad hoc, based on the needs of the project, and other. Many laboratories are organized on more than one basis. University research labs, within American national system of innovation, are most often organised on a *principal investigator* model, whereas government labs are more commonly organized on the basis of department and principal investigator (Crow and Bozeman, 1998). Though they are often considered outstanding models of efficiency, US research labs are encumbered with bureaucracy.
Similarly to the US, in Europe there are several public organisations operating in the research field, among which the most important are the *Max Planck Gesellschaft* - MPG in Germany, the *Centre National de la Ricerche Scientifique* – CNRS in France, the *Consejo Superior de Investigaciones Científicas* - CSIC in Spain, and the *Consiglio Nazionale delle Ricerche* - CNR in Italy. All these bodies are divided into a large number of institutes and laboratories supported by a central administration and by scientific coordination structures (for instance, departments in the French case and a senate in the German model). They are characterised by the presence of researchers' democratic representation bodies, according to the typical model of the so-called professional bureaucracies. In the course of the last century within the field of public research this generated what Picard (1990) calls *république des savants*.

The structure of the *Max Planck Gesellschaft* in Germany is made up of central headquarters and of a wide scientific network. The headquarter deals with administrative activities as well as public relations and liaises with the Government in the negotiation of yearly public funds assigned to the research organisation. Its scientific network is made up of 80 institutes with a total of 12,000 personnel (3,200 of which are researchers) and 9,000 PhD students and associate researchers. Its scientific activities are grouped into three macro-areas: Biology and Medicine; Chemistry, Physics, and Technology; Humanities. Similarly to other major German research bodies (Fraunhofer Gesellschaft, Leibniz Gemeinschaft, and Helmholz Gemeinschaft), the *Max Planck Gesellschaft* is characterised by large- institutes, each subdivided into smaller research units focusing on specialised topics and/or new lines of research. The income of the Max-Planck is almost entirely made up of public financing (around 94%). The Federal Government and the Länder contribute to the financing of the institution in the amount of around 50% each. On the other hand, activities carried out on behalf of third parties generate a relatively small part of proceeds; in any case, the relationships with the industrial system as well as technology transfer are dealt with by an external affiliate company (Garching Innovation GmbH) and by

[2] A principal investigator (PI) is the lead scientist for a particular well-defined science project, such as an astronomical observing campaign, laboratory study or clinical trial. In the context of federal funding from agencies such as National Aeronautics and Space Administration (NASA) or the National Science Foundation (NSF), the PI is the person who takes direct responsibility for completion of a funded project, directing the research and reporting directly to the funding agency. For small projects (which might involve 1-5 people) the PI is typically the person who conceived of the investigation, but for larger projects (such as the construction of scientific spacecraft or observatories) the PI may be selected by a team to obtain the best strategic advantage for the project. In the context of a clinical trial a PI may be an academic working with grants from National Institutes of Health (NIH) or other funding agencies, or may be effectively a contractor for a pharmaceutical company working on testing the safety and efficacy of new medicines.

Fraunhofer-Gesellschaft.

On the contrary, the French model appears to be highly fragmented: the *Centre National de la Recherche Scientifique* is made up of 1,257 laboratories with around 26,000 personnel (11,000 of which are researchers), divided into 6 departments: Mathematics, physics, earth sciences, and astronomy; Chemistry; Life sciences; Humanities and social sciences; Environmental science and sustainable development; Engineering; and 2 National Institutes: National Institute for Nuclear and Particle Physics; National Institute for Earth Sciences and Astronomy. Its organization structure is based on the organisational concept of *unité mixte de recherche* (Larédo and Mustar 2004). These so-called mixed units are research groups of small-medium institutes located in university buildings or campuses, with which they have strong interactions in relation to the presence of university professors and researchers as well as for what concerns their involvement in 2nd and 3rd grade education. These units involve a total of 60,000 students, professors, and external researchers. 18 regional delegations deal with the management of all the laboratories and take care of building relationships with local subjects (local authorities, universities, etc.).

A solution that lies somewhere in between the German and the French model is that of the Spanish *Consejo Superior de Investigaciones Científicas*. It is made up of 94 institutes, 29 centres and another 20 organisational units. 149 groups with over 6,000 personnel (2,300 of which are researchers and 4,000 of which are young trainees) operate in these research units and there are 8 different scientific areas.

THE ORGANIZATION STRUCTURE OF THE NATIONAL RESEARCH COUNCIL IN ITALY

The Italian National Research Council (CNR) is similar to other research institutions in Europe; it is a public national body whose task is carrying out, promoting, spreading, and enhancing research activities aimed at the scientific, technologic, economic, and social development of Italy. Its activities are divided into macro-areas related to multi-disciplinary scientific and technologic research, concerning the following fields: biotechnologies, medicine, materials, environment and earth, information and communication, advanced production systems, law and socio-economic sciences, humanities and cultural heritage. The CNR operates throughout the whole of Italy thanks to a wide network of institutes, in order to facilitate a widespread circulation of its competences in every area of the nation and to foster collaborations with local institutions and businesses. From a financial point of view, its resources in the past came mainly from the Government, but now the institution also receives quite a large amount of funds from the market: at present 50% of its budget is self-financed (Coccia and Rolfo 2002); the adding up revenues came from studies and consultancies for external third parties, from agreements with businesses, as well as from contracts entered into with the European Union and other international bodies. The CNR operates on the basis of its own three-year activity plan (which can be updated yearly) that sets general guidelines and establishes objectives, priorities, and resources for the entire period, consistent with the National Research Program (Programma Nazionale per la Ricerca – PNR) and with European Union research programs. The *three-year plan* defines the necessary financial planning in order to carry out scientific activities and it also deals with personnel hiring requirements, indicating the number of people to be employed in each scientific area, the scheduling of selection and recruitment procedures, as well as forecasts about personnel distribution divided into large national areas. This plan and its yearly updates must be approved by the Italian Ministry of Education, University, and Research in order to become operational.

Table 1 provides a comparison among major European scientific institutions in terms of financial and human resources. If the average structure of research institutes is analysed (table 1, Main networks and resources), data concerning year 2002 (last available data) show that the German Max Planck Institute enjoys the highest financial resources as well as human resources and publication per researcher.

At the end of 1990s the debate around public research (and CNR) in Italy was focused on the modest economic impact of scientific activities. As small research institutes within Italian national system of innovation was considered a cause of scale diseconomies and high costs concerning the maintenance of the several institutes, Italian Government since 1999 decided to merger the existing 316 research

units divided into Institutes and Centres (the latter being research unit operating inside universities and in collaboration with them) into about 108 new institutes (Table 2). However due to the rules governing public activities (CNR personnel have the status of civil servant) it was impossible to concentrate physically the personnel that are now scattered in more than 200 places: in fact, every institute has a main lab (headquarters) and 2-6 decentralized research units.

The consequences were twofold: an increase in the administrative burden of the headquarters and a decrease in the autonomy of detached units. The territorial layout of the institutes turned out to be the source of managerial and organisational difficulties and in the short run it did not bring about any noticeable improvement in relation to scientific collaborations among labs, since separated units tried to maintain a part of their past autonomy. As a consequence, the 1999 reform was heavily criticised and a second reform was promoted by the new government in 2003.

Table 1: European research bodies

	CNR ITALY		*CNRS FRANCE*		*CSIC SPAIN*		*MPG GERMANY*	
	2001	*2002*	*2001*	*2002*	*2001*	*2002*	*2001*	*2002*
	RESOURCES OF EUROPEAN RESEARCH ORGANIZATIONS							
Researchers	3,693	3,610	11,643	11,643	2,259	2,713	3,116	3,509
Budget	793	814	2,457	2,533	404	562	1,261	1,253
Budget per researchers	214,672	225,485	211,028	217,556	178,840	207,151	404,685	357,082
	BENCHMARK AMONG EUROPEAN RESEARCH ORGANIZATIONS - 2001 PERIOD							
Publication per personnel	0.61	0.61	0.71	0.63	0.57	0.59	0.65	0.64
Publication per researcher	1.34	1.36	1.42	1.39	1.93	1.89	2.42	2.19

Source: CNR Data 2007

Table 2: Reorganisation of the CNR after its reform

	Old structure (1999)	*After Reform*
No. Institutes	200	104
No. Centres	116	----
Decentralized units	-----	143
Total	316	251

THE NEW ORGANIZATION STRUCTURE OF THE CNR

Legislative Decree 127/2003, which is inspired by the principles of *Project Management*[3], reorganises the scientific network of the CNR on the basis of 11 Departments that all the research institutes belong to. From the hierarchical point of view the organisational configuration based on projects has a matrix structure, involving the coexistence of a functional configuration (displaying vertical development) together with a number of resource teams coming from the various functions that cross the structure horizontally. The result is a organisation network, in which each resource involved in developing projects simultaneously is subjected to a double line of authority: hierarchical vertical authority, exerted by the manager of the functional area, and the Project Manager's authority, the latter being in charge of functional coordination along a line that crosses the organisation structure involved in projects horizontally. This type of structure is particularly suitable when several projects are managed simultaneously. The main reasons that lead an organisation to adopt Project Management techniques are de-

[3] *Project Management* manages projects through the interaction between organisational and interorganisational activities and it is used for projects with the following characteristics:
- complex and difficult;
- made up of several activities;
- with specific objectives;
- with set times and costs.

scribed in table 3.

Table 3: Reasons behind the use of Project Management and main advantages

Reasons that cause the method to be adopted	*Objectives and advantages of the method*
The time intercurring between the beginning of a project and its completion tends to become longer.	Usefulness not only for the contractor in order to meet the set quality standards and accomplishment deadlines but also for the principal in order to make sure that the project deadlines are met and to ascertain when payments are due.
The capitals put into the project, before its end results are used, tend to increase.	Providing documentation on the basis of which the project manager has a complete and clear overview of the actual development of the activity in relation to reference guideleines used to intervene in case of critical situations.
As the technology increases, the use of time and money becomes more and more rigid.	Increasing the awareness of the operational bodies.
The technology requires more and more specialised personnel.	Exposing difficult situations, facilitating the evaluation of the effects deriving from the choice of alternative solutions, and speeding up remedial interventions.
Organisation is the unavoidable counterpart of specialisation.	Making predictions on how the activity will be completed and on the basis of previous knowledge trying to avoid mistakes made before.
In case of larger investments of time and capital, the rigidity of the employment, the need for large and very specialised organisations, as well as *market performance* problems in an advanced technology situation demand more efficient control and planning.	Ensuring coherence between partial objectives and general objectives.
Need to take decisions (even abandoning the project) during the development of the project focusing in particular on risk management.	

Source: Fassero 2004

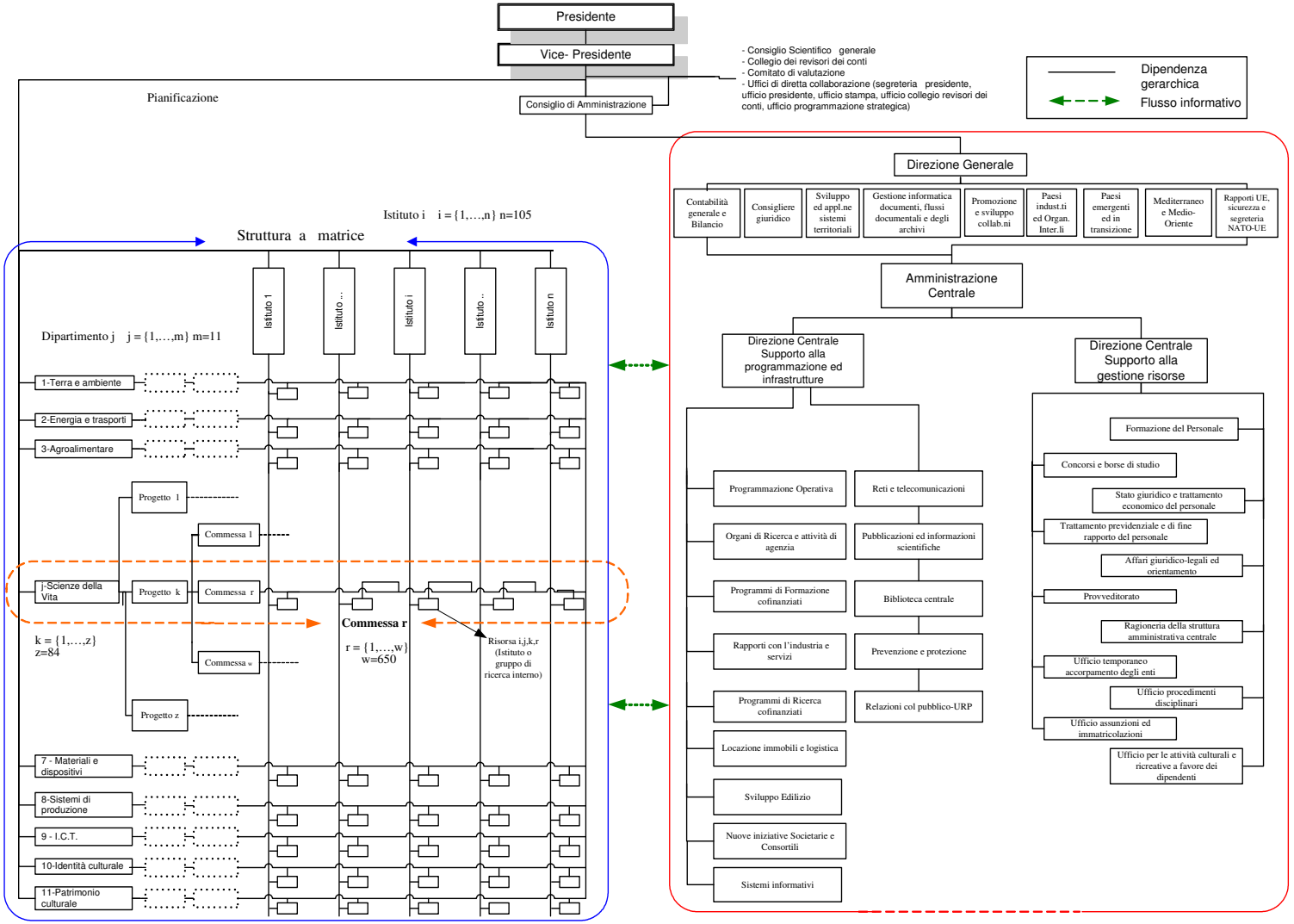

Figure 1*:* New Organization (matrix structure) of the CNR according to the reform of Legislative Decree 127/2003

In fact the new structure of the CNR, displayed in Figure 1, with the creation of 11 Departments is something different from project management principles. These new institutions, introduced by the 2003 reform, are permanent and must accomplish 85 research macro objectives (projects), which in turn include around 650 work packages (or research lines), coordinated by project managers in order to achieve the desired results also thanks to partnerships with external businesses and collaborations among different institutes and departments. Now, the CNR's new matrix structure includes, besides Institute Directors, three hierarchy levels such as Department Directors; Project Managers; Work Package Managers that have been creating co-ordination problems and conflicts between Institutes' directors and Departments' directors. Ideally, financing should be allocated "per project" on a competitive basis and no longer per "subject" (institute). This mechanism of funding is only on chart and is not applied. However, the reorganisation of the Research Council aimed at overcoming the overlap and replication of activities among its numerous institutes; as a consequence, this were true, there would be no internal competition whatsoever, since each objective would be tackled exclusively by one institute or research group. Moreover the continuous cut to CNR budget operated by different governments will allow in 2007 to pay salaries of the permanent staff and only a part of general costs.

The *Departments of the CNR's new organisation* are structures whose task is to coordinate the institutes belonging to the organisation in the process of expanding their knowledge and technology and to help the development of new generations of researchers and technical experts. They are grouped by projects and by specific interdisciplinary "thematic areas". In order to develop its projects, each department requires the contribution of a variety of institutes that, in turn, are usually involved in projects belonging to several different departments. Each department has a "hierarchic" type of power on its projects (but not on the institutes), since it assesses them, it ensures reciprocal coordination with other thematic areas, and it provides each project with overall resources and a *project concept* (expected times and results or objectives). Therefore, departments have the function of directing projects and checking on them. They appoint project managers, provide the necessary expertise, and approve projects' structural proposals put forward by project managers *(project-definition)*. They also take care of the relationship with other departments and with third parties involved in projects (also on an international level) and lastly they appoint project evaluation committees. Departments should be interfaces between the CNR's offer of scientific research and expertise (available and potential) and the demand of the Government, businesses and the public administration, in other words the research demand coming from the whole Italian economic system.

The *Institutes* are the organisational units that are connected with departments in which the research activities of the CNR are carried out and the scientific competences regarding the evolution and development of researches are organised, enhanced, and updated. The 11 scientific departments are: agriculture and food, energy and transport, cultural identity, ICT, production systems, molecular design, medicine, materials, life science, earth and environment, cultural heritage. The institutes play the role of representing the CNR's research supply and the evaluation criteria used to allocate resources in the future should be the following:

- ability to be selected within the *call for competencies* in relation to various projects defined by the departments and by other bodies external to the CNR;
- ability to attract brilliant talents with wide experience;
- ability to create alliances and networks with highly-qualified bodies (peer-to-peer recognition);
- ability to manage mobility in incoming and outgoing flows;
- ability to draw up proposals that are then accepted, including projects for the enhancement of knowledge and improvement of equipment and infrastructures.

Within this new structure, human resources should be subject to two lines of authority: that of the Project Manager (appointed by the Department) and that of the Institute Director. There is also a Job Manager, under the authority of the Project Manager, appointed by the Department on the Institute Director's recommendation.

The internal organisation of each institute is similar to old structure: in particular the institute is managed by a director and has several decentralised territorial and/or local units led by a manager ap-

pointed by the institute director. Instead, central administration is similar to that of the old structure, although it has been simplified (see Figure 1). The central Administration office includes two Directions, one supporting planning and infrastructures and the other supporting resource management.

DISCUSSION AND RESEARCH MANAGEMENT IMPLICATIONS

The Italian Context

The Italian innovation system has not been managed by Italian governments with the attention it deserves. If OECD data (2003) about 34 different countries are considered in relation to domestic research and development expenses as percentage of the Gross Domestic Product (GDP), to per capita research and development expenses, and to the number of researchers per thousand and labour force for every 1,000 workers, it can clearly be seen that Italy is in 24th place in relation to the first and third indicators, and in 17th place for what concerns the amount of per capita research and development expenses. Despite operating in a country where the research sector enjoys lower financing than in other industrialised countries, some of the CNR's performance indicators do not diverge considerably from those of other large European research organisations (Table 1). Concerning the first research evaluation period of three years (2001-2003) ended in December 2005, the CNR's 2006-2008 three-year plan states that the results achieved by research units are positive both from the point of view of *benchmarking* (comparing their results to those of similar national and foreign organisations) and for what concerns *compliance* (degree to which the objectives defined in general activity plans are achieved). In particular, a report about the CNR by the Committee for the Evaluation of Research (CIVR) states that 75% of CNR products have an assessment rating ranging between "excellent" and "good", while around 20% are only "acceptable". Therefore, in spite of low investments in the field of research in Italy and low labour cost of researchers in comparison to other European countries, Italian scientists' productivity rate can be ascribed to a number of reasons, among which (Stephan and Levin 1992):

- the satisfaction in solving a problem: *puzzle*;
- the satisfaction and prestige of being the first past the finishing line of competition in scientific research.

In view of positive results despite no little difficulty, was it really necessary to carry out a second reform of the main Italian public research body, started in 1999 and not yet ended, which has been causing organizational instability?

Some indicators should have been and still now should be evaluated with greater care: during the 1999-2003 period, even though resources were cut down, there was a noticeable increase in self-financing of the CNR as well as a progressive reduction of scientific productivity (Coccia 2005). Moreover, another postulate underlying the reforms, i.e. the critical mass search or larger size, does not seem to be supported by evidence: an analysis of CNR institutes, both large and small, over the same period of time shows that larger institutes are not the most productive (Coccia 2005).

In particular, some lessons learned can be summarised in the following propositions:

Proposition 1 (small sized laboratories). In the science sector small sized laboratories are more productive.

In fact, to confirm this result if the universe of CNR's labs is divided into institutes with less than 21 researchers (a proxy of small labs) and institutes with more than 21 units (a proxy of large labs), using data from CNR Reports over a four-year period (1999-2003) and a Cobb-Douglas production function, table 4 shows that the subset of small-sized labs have economies of scale $\beta + \gamma = 1.04$, while larger institutes have diseconomies of scale $\beta + \gamma = 0.69$.

Table 4: Parametric estimates of the Cobb-Douglas model by research institutes

Model	*Estimated relationship*		
Institutes < 21 Researchers (Small)			
$y_i=$	$-2.01+ ***0.79z_i + **0.25x_i - **0.11w_i$	R^2 *adj =28.4%*	*F=337.35 (sig.0.000)*
	(1.26) (0.14) (0.11) (0.042)	*S = (0.67)*	
Institutes > 21 Researchers (Large)			
$y_i=$	$0.49+*** 0.59z_i + 0.10x_i - **0.15w_i$	R^2 *adj =10%*	*F=6.56 (sig.0.000)*
	(1.78) (0.16) (0.15) (0.06)	*S= (0.77)*	

***Parameter is significant at 0.001 **Parameter is significant at 0.05 *Parameter is significant at 0.1

Dependent Variable: *y= average publications with weights according to domestic and international publications in SHS and NES*

Predictors: *(Constant), Dummy year=w, public funds=x; researchers=z*

The second column is the estimation of the constant and of β_i. Under them, in parentheses, their standard error. The third column shows the adjusted R^2 of the regression and under it, the standard error of the regression. The fourth column shows the results of the Fisher test, to its right the significance.

This result, that in the short run the most productive and efficient institutes are the small-sized ones, is consistent with the economic literature, which confirms the high performance of small-sized labs (Coccia and Rolfo 2002; Mairesse and Turner 2002; Carayol and Matt 2004). In fact, small labs have a more flexible organisation and can better manage low public funding conditions such as in Italy, in comparison to large institutions. However, the new Italian governments' science and innovation policy in order to increase the efficiency of labs, since 2000 have been restructuring the CNR by consolidation among institutes and organisation change (from line and staff to matrix). The aim of the consolidation is to create scientific institutes of larger size, similar to the Max Planck in Germany (even if this country has higher funding for civil research), because Italian policy maker think that larger labs=efficient lab. This consolidation has been carried out only from an administrative and not from a scientific point of view: although nowadays there are around 100 new institutes, these often have several (2-10) decentralised units spread on the territory and far from the headquarters. This situation creates some diseconomies of scale because of the increased costs of co-ordination of decentralised units. In fact, administrative burdens at the headquarters, caused by consolidation and project management organization, necessary to manage several decentralised units, is generating inter-organizational bureaucracy (Coccia 2007). In addition, because of these organizational change, table 4 shows that research productivity of research labs has been decreasing over time. Although large sizes may be more economical in some circumstances, there certainly are limits above which larger size becomes a synonym of inefficiency. In short, this hasty and uncertain research policy reform has been reducing the efficiency of labs and increasing problems of governance.

Proposition 2 (scientific crowding-out effect of basic vs. applied research). Scientific crowding-out effect within research labs is the organizational tendency to increase applied research production, which causes reductions in basic research production.

In particular, institutes with low performance in Natural and Engineering Sciences, measured by domestic and international publications which are an indicator of basic research, have high self-financing measured by revenue deriving from technology transfer (which is an indicator of applied research). The opposite is true for high performers' labs.

In fact, the research institutes have two types of funding source: public funding provided from government per annum and external funds provided by outside subjects (such as regions, association, firms, etc.) for conducting specific research projects. Because of high public debts in Italy, the Governments have been shrinking public lab budgets and the Italian Institutes are obliged to carry out a lot of external research projects to self-finance, because it is impossible to conduct research solely with public funds. Herbst (2004) asserts that the changes in public funding mechanisms in research organi-

zations are changes in governance. These changes in funding conditions affect organizational behaviour of research bodies favouring applied research (Slaughter and Leslie 1997) and the so-called academic capitalism through the commercialization of the research in a sort of entrepreneurial university (or research labs) as described by Etzkowitz (2003). In fact, CNR's Institutes now focus their scientific activity on applied research and consultancies to firms and public institutions, rather than basic research. Italian researchers see the market as an important source to gather financial resources that are necessary to the economic survival of their laboratories. A shift towards applied research activities in CNR's Institutes has led to an increase in self-financing (revenue deriving from technology transfer, consultancy to firms, and so on), which crowds-out basic research activities measured by scientific publications, that have been decreasing (both in quantity and quality). This new organizational behaviour of public research labs is a similar to *quasi-business firms* (Etzkowitz 2003) or hybrid research laboratories, *with many characteristics of the business firm, except for the profit motive* (Viale and Etzkowitz 2005), and breeds the effect of low institutes' scientific performance.

Is matrix structure the best solution to organise public research institutions?

When considering the implications of the CNR's new organization structure on its financing method, it is brought to the attention that the previous functional organisation allocated funds directly to one institute through the general budget accountancy office, while the new matrix organisation should allocate financial resources to the departments' projects and then to the Institutes according to their participation in projects. According to 87% of a sample of 100 staff (researchers, technical, and administrative personnel) working in institutes in Piedmont and Lombardy, two large industrialized regions in the north of Italy, the CNR's new organization structure can lead to an increase in the time needed to carry out ordinary administrative and scientific activities (bureaucracy) within research institutes (Coccia and Gobbino 2006), besides slowing down financial flows to its various units. As already stated, a matrix structure is suited to the management of projects but, as far as the US and European scientific organisations analysed before are concerned, it is applied only to specific projects (*ad hoc* temporary structures), in a way that is very similar to the old CNR's Targeted Projects[4]. Moreover this structure is rigid, at least on a yearly period. Managerial literature (Bartlett and Ghoshal 1990; Fassero 2004) agrees, despite having advantages such as flexibility, safety, and control over the project information, the *matrix structure* can be effectively used for *ad hoc* projects, when a larger exchange of information and a greater deal of professional relations among the project's members of staff are required and resources need to be divided up. Moreover, developing a matrix organisation requires time as well as the willingness to take on new roles and learn new behaviours; all this implies major difficulties in its implementation. The matrix organisation certainly has some advantages, but there is also a great deal of potential difficulties and problems, as stated by Mullins (1999):

- staff might be reluctant to accept constant change and prefer the organisational stability from membership of their own functional grouping;
- matrix organization might cause co-ordination problems;
- there may be a problem of defining the extent of the project manager's authority over staff from other departments and of gaining the support of other functional mangers [this problem can be amplified in a public research organization];
- functional groups may tend to neglect their duties and responsibilities.

[4] Targeted Projects were (technical-scientific and administrative) functional units temporarily set up to develop applied research and innovation. They were multidisciplinary units, since each Project included professionals with very different and versatile skills. The Internal Regulations of the Body provide the following definition of Targeted Project: "A Targeted Project is a coordinated set of activities involving the research, development, and demonstration of products, processes, and services, with a given duration, aimed at gaining knowledge and innovations that can be transferred to the production system, to the economic-social tissue of society, and to the political-legislative framework of the country, in relation to priority issues within the national economic planning". The CNR activates Projects on given topics and on the basis of Feasibility Studies approved by the Inter-ministerial Committee for Economic Planning. The research activities of Targeted Projects can include the participation of Research Bodies of the CNR, Universities, Research Bodies and Consortia, Local Authorities, other State Administrations, Businesses and Business Consortia, as well as private parties. Therefore, the CNR guarantees adequate promotion of the chosen research topics, in order to endorse the widest possible participation of the scientific community and production categories.

Therefore, unless they are properly designed and implemented, matrix structures tend to become unmanageable over time and they are likely to create conflicts and confusion within the structure. Moreover, the proliferation of communication channels leads to information snarls, while overlapping functions cause a loss of responsibility in relation to one's own duties (Mullins 1999; Fassero 2004). These problems can be reduced with the introduction of a financial and professional incentive scheme for researchers, similar to the schemes used in private business run using the *project management* system.

New organizational patterns in public research bodies and research management implications

Due to its rigidity, the new setup does not take into account the evolution of the whole public research system in industrialised countries. Despite considerable institutional differences, over the last decade all the national public research organisations (including universities) have been converging on a model that balances scientific excellence objectives and self-financing (Larédo and Mustar 2004). In relation to this, the CNR is no exception: the continuous reduction of public funds has changed the approach of researchers towards scientific research, leading to a preference for applied research. This new pattern of organizational behaviour increases the self-financing of the institutes and that operate as *quasi-business firms* or hybrid research laboratories (Etzkowitz 2003), i.e. focusing on applied research rather than on basic research. Besides problems of crowding-out effect that might arise in the long run, it is nevertheless plain to see that the institutes' reaction to the changes that are occurring varies according to scientific field and relations to the university system and businesses, as stated by Larédo and Mustar (2004) for the French case.

Analyzing the German Max Plank organization, Leilich (2005) shows that the characteristics of research institutes, such as the *field of research* they operate in, their *multidisciplinarity*, and the level of *training of young researchers*, indicate which kind of production function applies and which organisational form would thus be optimal. Leilich (2005) states that institutes mostly have two main types of organization structure:

- *flat hierarchies*: in which all the researchers work directly with the director of the institute;
- *steep hierarchies*: in which senior researchers with wide experience form an intermediate team between the director and other researchers.

While production functions fall into the two following types:

- *A*: *additive factors of production*;
- *B*: *complementary factor of production*.

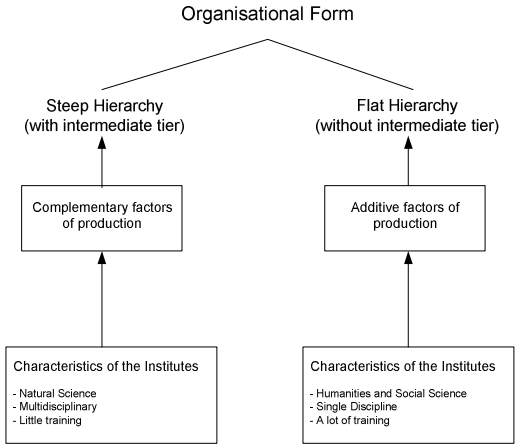

Figure 2: Connection between the characteristics of research institutes and their organization structure. [*Source*: Leilich 2005]

The results of Leilich (2005) research point at a strong link between the characteristics of the institutes

and the adopted type of hierarchy (Figure 2). Institutes specialising in the field of natural sciences, which are characterised by a high level of multidisciplinarity and whose young researchers have a low level of training, display a production function belonging to type B and their structure belongs to the *steep hierarchies* type; on the contrary, institutes specialising in humanities and social sciences with little multidisciplinarity and whose young researchers have a high level of training, display a production function belonging to type A and their organization structure belongs to the *flat hierarchies* type. However, this analysis is only a part of a much wider process, in which individual research groups rather than labs, centres, and institutes, pursue their own strategies and implement their own organisational and managerial models, thus displaying strong similarities to other research bodies in other countries as well as several differences in relation to the institution they belong to (Larédo 2001). Therefore, the organisational rigidity imposed by the last reform of the CNR appears to be not only a contradiction of original aims but it also goes against history by immobilising Italy's main research body into a structure which is elsewhere used very cautiously (even by businesses), thus distancing it from the general evolution of public research systems in advanced countries and thwarting the efforts the researchers have made to make up for severe financial limitations. Within these new public research organizations, public management and research staff have to carry out a role similar to commercial area in business enterprises. In facts researchers to increase the likelihood of external funding, scientists change the content of their research using some strategies such as selecting externally predetermined topics; diversifying research; avoiding risky research; avoiding hot topics (Laudel 2006). In short, this scenario of shrinking research lab budget as well as organizational change has been increasing problems of governance (because of larger size) and reducing efficiency of research institution (measured by scientific productivity). Nowadays organizational behaviour of research institutes has been evolving towards hybrid labs market-oriented similar to consulting companies, rather than research labs science-based. This organizational behaviour is not an Italian specificity but it is also present in Norway (Gulbrandsen and Smeby 2005), Germany and Australia (Laudel 2006). In all, it is necessary to remark that research labs produce scientific research that is a public good and are more complex institutions than private businesses, because they not maximize profit but the prestige. R&D managers, for a suitable organization and governance, have to consider these main scientific factors when the structure is market-oriented through the commercialization of the research.

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